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By email to NPTandCrossBorderCO2@energysecurity.gov.uk

Response to call for evidence on non-pipeline transport and cross-border CO_2 networks

Dear Sir or Madam

Fuels Industry UK represents the eight main oil refining and marketing companies operating in the UK. The Fuels Industry UK member companies – bp, Essar, Esso Petroleum, PetroIneos, Phillips 66, Prax Refining, Shell, and Valero – are together responsible for the sourcing and supply of product meeting over 85% of UK inland demand, accounting for a third of total primary UK energy (based on the Department of Energy Security and Net Zero Digest of UK Energy Statistics 2022).

The refining and downstream oil sector is vital in supporting UK economic activity. It provides a secure supply of affordable energy for road and rail transport, aviation, and marine applications, as well as for commercial and domestic heating. It also supplies base fluids for use in lubricants, bitumen for use in road surfacing, and graphite for use in electric vehicle batteries and as electrodes in steel and aluminium manufacture.

Fuels Industry UK welcomes the opportunity to respond to the call for evidence on non-pipeline transport and cross-border CO_2 networks.

Our responses to the consultation questions are given in Attachment 1.

Yours sincerely

Chris Gould

Energy Transition Lead, Fuels Industry UK

Appendix 1: Fuels Industry UK Response

1. **Who are you responding on behalf of, and what is your interest in this call for evidence?**

Fuels Industry UK

Fuels Industry UK, which changed its name from the United Kingdom Petroleum Industry Association (UKPIA) in August 2023, is the only trade association that brings together companies involved in refining, renewable fuel production, terminal operations and filling stations. Our members contribute significantly to the UK's extensive and resilient fuel supply chain today and are preparing for the future by planning and investing in projects that reduce emissions for tomorrow's Net-Zero economy.

2. **If you consent to members of the team reaching out for clarifications on responses provided, please provide contact details.**

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3. **Do you give permission for your anonymised evidence to be shared with external advisors for the purpose of technical analysis?**

Yes

4. **Please provide views on the potential long-term vision for the NPT sector.**

Fuels Industry UK broadly agrees with the potential long-term vision for the NPT sector.

There needs to be a recognition that the initial cluster approach focused on pipeline-based transport and storage through Track 1 [1,2] ,before moving to Track 2 [3,4] is likely to be the lowest cost option to implement at scale to assist in starting this nascent industry.

[1] https://hynet.co.uk/
[2] https://eastcoastcluster.co.uk/
[3] https://www.vikingccs.co.uk/
[4] https://theacornproject.uk/

Non-pipeline transport of CO_2 is likely to be higher cost [5], with unit costs decreasing as higher volumes are moved, although we recognise that there are significant capital costs involved in pipeline construction. For example, the operational costs per tonne of moving CO_2 by ship are likely to be lower than that of rail or road tanker solutions. This needs to be considered to allow areas without pipeline access to compete on a level playing field with those linked to the original clusters.

One solution to address this by enabling unit cost reductions may be to create regional intermediate storage locations, or hubs, where CO_2 can be aggregated from rail and road tanker solutions, before being shipped to the final storage reservoirs. The building of CO_2 volumes in this way would minimise costs for participants looking to store CO_2, and there is likely to be a role for central planning in creating these facilities at nationally strategic locations.

As we have previously mentioned, the start of the CCUS industry is to be pipeline based. Track 2 [6] clusters which are mandated for NPT receipt are expected to progress after the Track 1 clusters. Once this capacity is installed, a further increase in storage demand may then be expected to come from the NPT sector augmenting it. We would also encourage the government to expand the mandate for NPT receipts to the track 1 clusters to encourage wider NPT uptake.

The UK is short of CO_2 production for food applications [7] and an NPT hub would be the ideal way of accepting CO_2 from producers, purifying it and either re-selling food grade CO_2 back out or drying it and placing it in the pipeline for storage.

If installing a carbon capture plant, especially if for a stream up to 2-3te/hr (which is still quite a significant stream equivalent to around 0.025 MTpa) around one third of the cost of the installation will be associated with compressing and cleaning the CO_2. Each capture plant needs to install very significant individual items of equipment [8] in order to achieve the said cleaning and purification, and if much of this can be performed centrally at an NPT hub, then the likely uptake of smaller capture plants will be significantly enhanced. This is the model for the current plastics and glass recycling industry, where poorly sorted material is input, and clean products are produced. Arranging NPT of CO_2 is a key industry enabler for this approach, and we would encourage support for this technology.

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[5] https://www.researchgate.net/publication/351524141_Transport_Cost_for_Carbon_Removal_Projects_With_Biomass_and_CO2_Storage

[6] https://www.gov.uk/government/publications/cluster-sequencing-for-carbon-capture-usage-and-storage-ccus-track-2

[7] https://www.thegrocer.co.uk/supply-chain/co2-crisis-whats-happening-to-uk-supplies/664015.article

[8] https://assets.publishing.service.gov.uk/media/5a74bd2ee5274a3cb2866ca7/K24_Full_Chain_-_Equipment_List.pdf

5. **Which regions and sectors of the economy will benefit most from NPT solutions unlocking CCUS? Which regions and sectors of the economy will continue to struggle to deploy CCUS? Should the government look to prioritise any particular regions or sectors of the economy for NPT?**

It is fairly self-evident that the regions that will initially benefit most from NPT solutions unlocking CCUS are those with significant CO_2 production and that do not have direct access to pipeline transport, outside of the initial cluster-based approach.

Regions that do not have significant CO_2 production, or are remote from pipelines, will have to rely on road rail and shipping transport solutions to suitable CCUS facilities as these are less likely to be able to justify the higher capital costs of pipeline solutions. The resulting higher operating costs could potentially create a disincentive to invest in these regions, with investors preferring locations with existing pipeline CCUS access or closer to suitable NPT receipt facilities. This potential skewing of operating costs needs to be considered by government to ensure a level playing field for investment in CO_2 producing facilities across the UK; NPT solutions already face higher operating costs than the initial pipeline based CCUS clusters and will need more, rather than less support to be economically viable in the early years of the CCUS sector development.

Equally smaller CO_2 producing sectors may not be able to make the economic case for developing pipeline access to CCUS as larger facilities. As a result, they may have to rely on higher operating cost road or rail solutions, with their costs being higher if they are located further away from a suitable CCUS facility.

Therefore, the government should consider the need for a strategic approach to CCUS aggregations, creating hubs, where CO_2 can be aggregated from rail and road tanker solutions, before being shipped to the final storage reservoirs. This would minimise costs for participants looking to store CO_2 and minimise market distortions between UK regions. There is a potential role for large CO_2 sources such as refineries to act as aggregators in this scenario, subject to the development of appropriate support to enable final investment decisions to be made.

6. **Please provide details of your potential NPT or cross-border solution. Please provide any information on the timing of the project through the initial phase and into the future, and the minimum viable project.**

Fuels Industry UK does not have any NPT projects in its own right so cannot comment on this question in detail.

7. **Please provide the technical and operational considerations for the major pieces of infrastructure, equipment, and transportation. Considerations may include information on the sizes and numbers of the above, CO_2 temperature and pressure conditions, loading/un-loading times and NPT journey lengths and duration. Please also provide the rationale for the technical and operational decisions.**

Fuels Industry UK does not have any NPT projects in its own right so cannot comment on this question in detail. However, we do understand what would be required, even at smaller scales.

The standardisation of process conditions including the pressure and temperature used in CO_2 transportation is going to be a key technical compatibility to be resolved through the market development. It will not be possible to have cross cluster transport, including by NPT if the requirements are different at different collection systems. We note the work already carried out in this area, as articulated in the CCSA-ZEP report [9] in such categorisation based on process conditions.

Figure 1: Potential CO2 Categorisation based on process conditions

	Low pressure	Medium pressure	High Pressure
Temperature (°C)	-55 to -40	-30 to -20	0 to 15
Pressure (Barg)	5 to 10	15 to 20	35 to 50
Density (kg/m^3)	1170 to 1120	1080 to 1030	930 to 820
Tonnes cargo weight per m^3	1.2 to 1.1	1.1 to 1.0	0.9 to 0.8

Note: There is some rounding in these numbers

In terms of loading or unloading procedures, industry practice would generally expect ship loading and unloading times to conform to existing general gas ship

[9] https://www.ccsassociation.org/all-news/ccsa-news/carbon-capture-and-storage-association-zero-emissions-platform-publish-joint-report-on-co2-transport-by-ship-in-europe/

terms and conditions [10]. These typically require 72 hours for cargo loading and discharge, any time beyond this being subject to demurrage costs reflecting elements of the incremental costs that the ship incurs. Similar terms exist for the ship speed between ports; for example, it would not be reasonable to expect high utilisation of shipping systems in the early stages; ships are built as single units that can be capable of moving 300-1,000ktes per annum (ship size and route dependent), whereas demand for shipping services can come in small increments. This mismatch of capacity vs demand is likely to drive lower than normal utilisation rates on ships for a period in the market, particularly in the initial phase but we would expect these to reduce as the market matures.

For a smaller operator, unless the T&S pipeline is located close to the facility, an NPT solution is most likely to be the easiest and cheapest option. This is most likely to be the case especially for a FOAK installation, where the scale is smaller, and the cost of pipeline connection is yet to be justified.

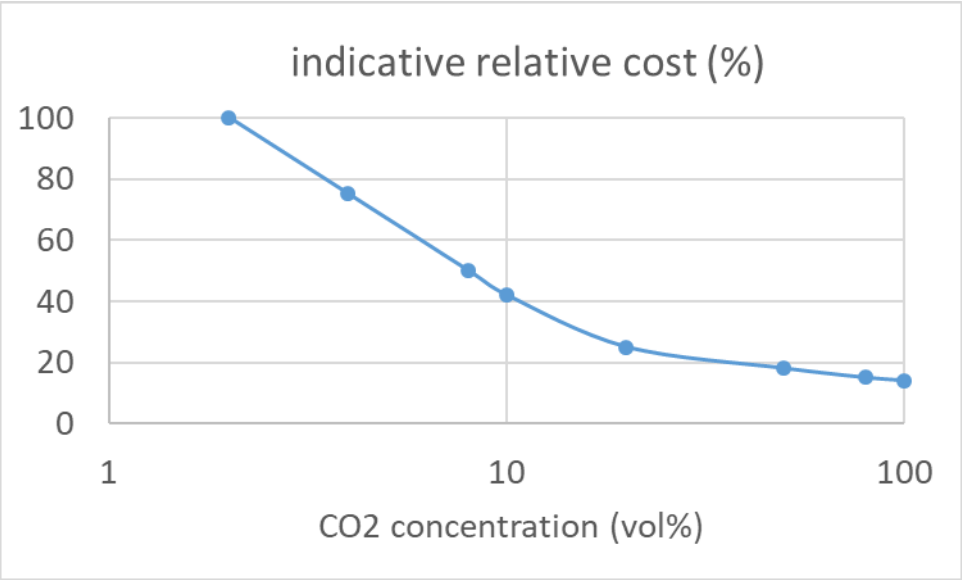
As we note in our response to the 2024 consultation on updates to the CCS network code heads of terms [11] and articulate in our response to Q36, the current proposed specifications as written are overly restrictive. The CO_2 being placed into the pipe is a by-product of user operations intended for long term storage. Therefore, outside of key safety or operational requirements, the specifications should be relaxed as far as possible. This is also relevant for the NPT of CO2, where they may be challenges for smaller operators to meet the quality requirements. The purity set out by the prior consultation will be expensive to produce, and a dry only specification to enter into a pipeline system, is required.

However, to balance the higher production costs, collecting CO_2 also comes at a cost, especially if the CO_2 stream being collected is dilute. The CO_2 collection cost curve is likely to be of the general form below (note the logarithmic scale along the base).

[10] https://www.repsol.com/content/dam/repsol-corporate/en_gb/productos-y-servicios/chemicals/general-terms-and-conditions-for-sales-and-purchases-of-chemical-products-for-lpg-and-chemical-tankers.pdf

[11] www.fuelsindustryuk.org/media/2nrhbacv/ccus-network-code-heads-of-terms.pdf

Figure 2: Indicative relative cost relating to CO2 purity



Source: Petroineos Analysis

CO_2 collection costs are likely to drop substantially as the CO_2 concentration in the stream to be collected approaches 100%. Additionally, the cost of site purification increases substantially with reducing scale as that is a very substantial part of the supply chain costs, especially when the collector is small scale and thus the capital and maintenance costs for the purification equipment are high.

It is reasonably expected that for practical purposes, all CO_2 transport will be managed using liquid CO_2 transport. Therefore, the regional collection hubs will probably be best organised to accept low purity liquid CO_2 and to transport dry CO_2 into a fixed pipeline system either on site or via ongoing transport. This would minimise collector costs, especially capital costs and would minimise the CO2 drying costs, by providing such services at scale and on a communal basis.

Therefore, regional collection hubs are also anticipated to be regional purification and drying hubs, which manage the CO_2 to suitable specifications for ongoing transport and sequestration.

Since CO_2 sources have been located for other reasons, to have CO_2 capture be used, the logistics must be managed to the CO_2 sources seamlessly and the

capability already exists through tankers, drivers and companies such as Linde [12], BOC [13], Air Products [14] and supporting hauliers if high pressure iso-tanks [15] are used.

In terms of purification suitable for pipelines and transport requires dry CO_2 with substantial volumes of other materials reduced rather than eliminated; Purification incurs additional operating costs. Purification of a material simply to place in long term storage does not make economic or practical sense. Therefore, simple separations and 100% availability are key requirements; this is similar to experience in our industry operating fuel tanker terminals.

Receipt: Truck unloading bays, where CO_2 is stored in high pressure tanks, but at ambient temperature.

Decantation: drawing liquid CO_2 from the base of such a tank (after settling for several hours) will produce a CO_2 product, with circa 100ppm water and only ppm level of other gases, as air sits in the headspace and water floats.

Off-take: Such CO_2 could be processed into dry ice or purified for food use or dried for pipeline disposal.

Drying: if the CO_2 stream, at 70 barg pressure is heated to more than 32°C, it will boil with almost no energy input required. It can then be dried over a molecular sieve absorbent as is industry standard. Refrigeration of the resulting dry gas to 15°C, returns the CO_2 to a liquid, suitable for either pumping into a pipeline or into rail transport for pipeline entry.

While processing this is very feasible at scale, all of the peripheral equipment, heaters, chillers, venting, safety systems, waste disposal and release and analytical testing is capital intensive, especially as it is all high-pressure equipment. Aggregating CO2 streams for a number of users will ameliorate these costs immensely.

[12] https://www.linde.com/
[13] https://www.boconline.co.uk/en/index.html
[14] https://www.airproducts.co.uk/
[15] https://qualitank.co.uk/about-iso-tanks/

8. **For the above NPT chain, please provide information on the expected ownership/operatorship (e.g. leasing, owned, shared ownership, etc) and expected commercial/contractual arrangements. Please include when equipment is to be shared between multiple entities or for sole use.**

Fuels Industry UK does not have any NPT projects in its own right so cannot comment on this question in detail.

However, we have studied some of these questions, and it would be anticipated that a gas company e.g. Linde, would run such a terminal with a gate fee for CO_2 disposal, where they provide collection from the supplier. Since telemetry [16] is industry standard in industrial gases for re-filling cryo-vessels, it can just as easily be applied to emptying them.

Alternatively, the CO_2 capturing entity could fill high pressure iso-containers and store them ready for uplift.

In terms of ownership of the CO_2, one simple option to consider is a purchase agreement based around a formula driven according to the carbon futures price and the cost of disposal. In this way, the liability of the CO_2 is accepted by the purchasing party. The need for significant regulation should not be required, (such as the RTFO [17]) other than the reporting of CO2 transferred between entities and the management of fiscal meters.

Therefore, this would equate to a business extension opportunity for industrial gas suppliers and so should be simple to roll out, under a term contract arrangement for CO_2 disposal services. If Intermodal transport is required or rail freight, the standard suppliers could manage these activities. In such instances, it is common practice for the mass of gas transferred to be managed by placing the truck and/or isocontainer on a weighbridge [18].

Therefore, once the pipeline for CO_2 is constructed for CO_2 disposal, such regional collection hubs could spring up quite readily, but if the costs of transport and disposal exceed the carbon price, development in the sector may be more limited.

[16] https://www.westairgases.com/blog/what-you-need-to-know-about-telemetry
[17] https://www.gov.uk/guidance/renewable-transport-fuels-obligation
[18] https://www.weightron.com/news/what-are-the-different-types-of-weighbridges

9. **Please provide information on the elements in the NPT chain with the longest lead times which could be rate determining in the deployment of the NPT chain. Please provide any information that you have on timelines for delivery of your NPT chain (e.g. project delivery Gantt charts).**

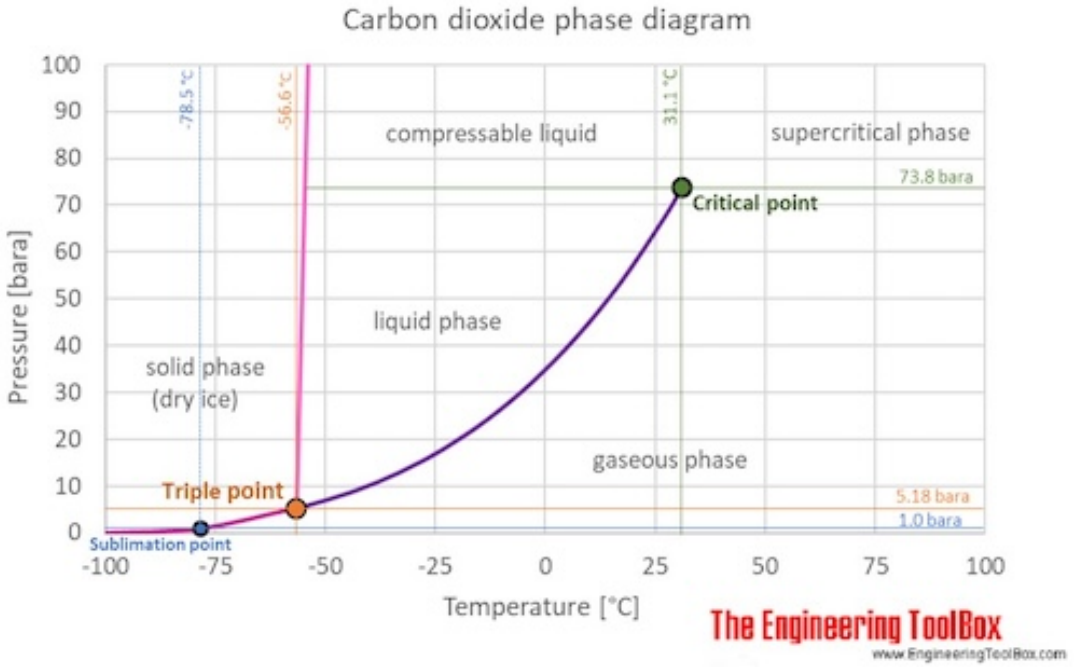
Fuels Industry UK does not have any NPT projects in its own right so cannot comment on this question in detail.
Planning permission, organisation of contracts and permitting is likely to be the most onerous issue, as construction of such a collection facility and a connection to an existing pipeline should be less than 1 year to build and commission.
Fuels Industry UK is aware that there are numerous delays to projects due to planning and regulatory approval processes that are beyond the control of our members. As a general policy, government should focus on addressing backlogs and delays experienced in planning processes, ensuring that there are sufficient resources to meet statutory timelines.

10. **What are the expected transport emissions and fugitive emissions expected within the NPT value chain? Please provide any information on how these emissions can be minimised.**

Fuels Industry UK does not have any NPT projects in its own right so cannot comment on this question in detail.

Liquid CO_2 can be stored in off-the-shelf, industry standard high-pressure tanks without significant emissions. A static tank, even through the heat of summer, if in full sunlight, will vent only a fraction of its contents per year, provided it does not exceed 30°C. This is evident from the phase diagram, below.

Figure 3: Carbon Dioxide Phase Diagram



Other emissions are by making and breaking couplings; however, with modern dry break couplings [19], these volumes are trivial.

Information available on shipping emissions [20] suggests that while shipping is one of the lowest carbon emitting forms of transport, carbon emissions are still present.

Figure 4: Comparison of CO2 Emissions by Different Modes of Transport

Comparison of typical CO_2 emissions between modes of transport, in grams/tonne-km

Source: ICS Fuelling the Fourth Propulsion Revolution: Full Report, based on IMO, Second GHG Study, 2009

**AP Møller-Maersk, 2014*

KEY POINT:

Maritime transport has lower emissions in comparison with other transport modes; consequently, a shift towards maritime transport is beneficial for the climate.

Source: https://www.ics-shipping.org/shipping-fact/environmental-performance-environmental-performance/

[19] https://www.lantechsolutions.co.uk/drybreak-couplings/

[20] https://www.ics-shipping.org/shipping-fact/environmental-performance-environmental-performance/

Higher emissions come from road haulage, which will be typical of any tanker, from the burning of diesel. However, these emissions would be covered by existing transport carbon emission reduction schemes, such as the RTFO.

11. Could the costs associated with the full NPT value chain prevent investment and deployment of NPT solutions? If so, why?

In theory there is no reason why the costs associated with the full NPT value chain would prevent investment and deployment of NPT solutions. However, an end-to-end system approach must be taken to evaluate these costs to ensure appropriate investment decisions are made.

Regions that do not have significant CO_2 production or are remote from pipelines will have to rely on road, rail or shipping transport solutions, at potentially a longer distance, to suitable CCUS facilities. These higher operating costs could potentially create a distinctive to invest in these regions, with investors preferring locations with existing pipeline CCUS access or closer to suitable NPT receipt facilities. This potential skewing of operating costs needs to be considered by government to ensure a level playing field for investment in CO_2 producing facilities across the UK.

New CO_2 producing plants, will naturally take CO_2 disposal costs into consideration and may, in future, chose to locate next to CO_2 disposal infrastructure. Equally smaller CO_2 producing sectors may not be able to make the economic case for developing pipeline access to CCUS as larger facilities. As a result, they may have to rely on higher operating cost road or rail solutions, with their costs being higher if they are located further away from a suitable CCUS facility.

Therefore, the government should consider the need for a strategic approach to CCUS aggregations, creating hubs, where CO_2 can be aggregated from rail and road tanker solutions, before being shipped to the final storage reservoirs. This would minimise costs for participants looking to store CO_2 and minimise market distortions between UK regions.

When looking at the complexity of the NPT supply chain, it is clear that there are many more costs than for the initial CCUS cluster. These higher costs, when borne solely by the emitter, cannot but limit ambition for decarbonisation. If nothing else, they imply that the ETS price required to incentivise decarbonisation of a remote facility are substantially above that of current clusters. Given the shape of the ETS

Futures markets [21,22], higher decarbonisation costs can only be justified further into the future.

These costs have been estimated by various entities over time, often with very optimistic views of capital and operating costs along with high utilisation rates. The Welsh CCUS evaluation report [23] similarly tends to focus on limited CO_2 storage size, typically not much more than the expected vessel size; this may be lower than expected in reality given the various uncertainties from weather and ship and or port delays. These reports may therefore generate unrealistically low transportation costs, and these costs should be updated to more accurately reflect the real-world costs.

Industrial gas suppliers today perform a value chain in reverse of that planned with the NPT approach. We cannot comment on costs, but in theory the costs of collection and delivery into the pipe should be similar to the costs of delivery of liquid CO_2 to customers today. The key requirement is to mitigate the costs associated with the pipeline disposal and transport distances, as this would add costs onto the CO_2 NPT system.

12. If available, please provide any assessments that have been carried out to show an NPT solution is more economically viable than a piped solution for your NPT value chain, or that a piped solution is not technically viable.

Fuels Industry UK does not have any NPT projects in its own right so cannot comment on this question in detail.

However, we are aware that DNV have carried out some work in this area which may be of interest [24]. And Oxford Institute of Energy Studies have also published a summary of CCSA and ZEP thinking on the question of scaling CO_2 shipping to carry the higher volumes associated with CCS [25].

[21] (https://www.ice.com/products/80216150/UKA-Futures/data?marketId=6880837
[22] https://www.ice.com/products/197/EUA-Futures/data?marketId=7075802)
[23] (https://www.gov.wales/sites/default/files/publications/2021-10/a-carbon-capture-utilisation-and-storage-network-for-wales-report.pdf)
[24] https://www.dnv.com/focus-areas/ccs/carbon-shipping/
[25] https://www.oxfordenergy.org/publications/what-do-we-need-to-know-to-make-co2-shipping-for-ccs-a-reality/

13. Please provide evidence on the costs associated with NPT. Where possible disaggregated to the nodes delivered by NPT service providers (e.g. after capture plant and before delivery to the T&S network). Where possible, please provide information in relation to the devex, capex and opex of the operation. Please include the stage and Association for the Advancement of Cost Engineering (AACE) Cost Class at which this cost data has been generated, and please share the methodologies and assumptions that have been utilised to generate this data.

Fuels Industry UK does not have any NPT projects in its own right so cannot comment on this question in detail.

However, we are aware that the Global CCUS Institute [26] have carried out some work in this area, which may be of interest to DESNZ [27]. We are also aware of some work that Clarkson's have carried out on expected CO2 shipping costs [28] in conjunction with the CCSA.

14. What are the main financing risks with a disaggregated chain, and how do these differ to the full chain piped approach?

A disaggregated chain may have a complex risk profile with regards to reliance on a number of emitters who are planning on using the NPT service. Reliance on a single, steady, CO_2 emitter may be beneficial while the emitter is operational but could be problematic if that emitter ceases operation. Equally there is increased flexibility and resilience in having a wider base of emitters using the NPT service, but the supply could be less stable. These pros and cons need to be carefully evaluated in establishing appropriate business cases ahead of an FID.

However, if one anchor user is available, prepared to make a long-term commitment (aligned with installing their CO_2 capture equipment) then it should be possible to start an NPT hub at relatively low cost and expand as more capacity is required.

The financing risks are therefore driven by problems typically encountered in any process industry, such as cost of capital, risk of technical failure, cost of pipeline disposal, the cost of CO_2 emissions, and the cost of diesel for trucks. Typical business

[26] https://www.globalccsinstitute.com/
[27] https://www.globalccsinstitute.com/resources/publications-reports-research/technology-readiness-and-costs-of-ccs/
[28] https://www.ccsassociation.org/resources/

practice suggests projects only develop if they are profitable; the business model must therefore be such that it is profitable, then financing risks will manage themselves.

15. What are the main financing risks associated with operational flexibility, and how do these differ to the full chain piped approach?

As we discuss in our response to Q14, if there is greater reliance on one or more key CO_2 producers to make the project viable from an economic perspective then there may be a greater financial risk for the project in the event that the producer ceases operation, than compared to a project involved with a larger number of emitters.

16. Which archetype do you think would be most attractive to investors? Why?

It is clear that there still needs to be some level of government risk taking with NPT solutions in order to allow the sector to be attractive to investment and projects to proceed, at least in the early phases of NPT development.

The LCCC [29] is an effective interface for the early cluster development, and we would encourage the government to consider extending its use as the NPT systems develop.

17. What types of financing are best placed to deliver NPT value chains?

The development of NPT is likely to be a high-risk environment in which to invest.

It is clear that there still needs to be some level of government risk taking with NPT solutions in order to allow the sector to be attractive to investment, in the early phases of NPT development.

The LCCC is an effective interface for the early cluster development, and we would encourage the government to consider extending its use as the NPT systems develop.

[29] https://www.lowcarboncontracts.uk/

18. Do you agree the rationale for economically licensing NPT service providers does not exist? Or do you believe that some elements in the NPT value chain may still require some kind of economic licencing?

Fuels Industry UK **does not** agree that the rationale for economically licensing NPT service providers does not exist, at least in the early phases of NPT development.

In other words, we agree that there will be a need for economic licensing of NPT service providers at some level across the value chain, at least before a market-led approach can fully develop in order to prevent possible market distortions.

It is clear that there still needs to be some level of government risk taking with NPT solutions in order to allow the sector to be attractive to investment and for projects to proceed, at least initially. The LCCC is an effective interface for the early cluster development, and we would encourage the government to consider extending its use as the NPT systems develop. We recognise the ambition to move to a more market based, entrepreneurial, approach in the CCUS vision, and this may be more appropriate once the CCUS sector including NPT becomes established.

As we articulate in our response to Q4, one option we would urge the government to consider is regional aggregation hubs where NPT CO_2 is temporarily stored before shipping to the final CCUS storage location. These hubs would reduce costs for users, particularly those relying on road or rail transport. Given the fact that these would have a potential to create a dominant position within a particular region, we would expect them to need to be economically licensed based on the same rationale as for the initial clusters. The need for economic licensing can be reviewed as the sector develops, and a more market led industry is established.

19. Considering the expected deployment timelines for potential NPT projects within the CCUS programme, can the risks associated with the deployment of an NPT value chain be effectively managed commercially between the different actors within the NPT value chain? If not, please provide evidence and rationale why these risks cannot be managed commercially.

In principle, the risks associated with the deployment of an NPT value chain can be managed commercially.

However, government involvement may be necessary to take appropriate risk mitigation to allow NPT development to be commercially attractive in the early phases of introduction, with an appropriate risk profile.

20. Please provide details on how you believe that the CCS Network Code would need to be updated to facilitate NPT.

The metering requirements under the CCS Network Code [30] are onerous, requiring very accurate metering of CO_2. This may not be possible when using NPT systems and may need to be reviewed.

As we note in our response to the 2024 consultation on updates to the CCS network code heads of terms and articulate in our response to Q36, the current specifications as written are overly restrictive and not based on sound science. The CO_2 being placed into the pipe is a by-product of user operations intended for long term storage. Therefore, outside of key safety requirements, the specifications should be relaxed as far as possible. This is even more relevant for NPT transport, where it would potentially be more difficult to meet these requirements. In other words, the specification of impurities should be minimised as far as possible to reduce CCUS costs, recognising that the material will be injected into long term storage in ground reservoirs.

Flow variability would need to be managed on the pipeline and provided that there is sufficient buffer storage at the NPT hubs, these systems could be managed to manage surges in demand on the pipeline.

A voluntary code of practice for transport providers covering operational elements would enable integration of NPT with minimum intervention or restriction. If the CCS Network Code is used it should be updated to be flexible, modular and allow for changes to accommodate different modes, commercial and technical approaches and enable the market transition towards a self-sustaining model.

21. What changes to the Track-1 capture BMs do you envisage being required to make the capture BMs work for NPT solutions? What considerations would be required for power-BECCS and GGR BMs when developing for NPT? Please flag in your response which of the capture BMs you are answering in reference to.

Fuels Industry UK cannot comment on this question in detail; however, we would encourage DESNZ to engage directly with participants in the Track 1 clusters to gain a more detailed insight into their experience and the issues associated with incorporating NPT into the BMs. We would also request that the mandate for Track 1 clusters is reviewed and expanded to accept NPT receipts if required.

[30] https://www.gov.uk/government/consultations/carbon-capture-and-storage-ccs-network-code-updated-heads-of-terms

It should also be recognised that GGR equipment should be sited at a source of low carbon electricity, rather than at a pipeline or NPT locations. In other words, evaluation of the associated operational costs may not be straightforward and not exclusively related to access to NPT infrastructure.

22. How important should consistency in approach between capture BMs be? How important is consistency between NPT users and piped users within a specific BM (e.g. ICC via pipeline and ICC via NPT)?

Fuels Industry UK agrees that there should be consistency of approach between capture BMs as far as possible but considering the higher costs of NPT solutions. It is possible that NPT solutions will need higher, rather than lower government support to be economically viable and for projects to proceed.

23. If NPT solutions are assessed against pipeline solutions, would this raise any concerns?

As we discuss in our responses to Q4 and Q22, unit costs of transport by shipping, road or rail are likely to be higher than those of pipeline solutions. The appropriate business models should be flexible enough to ensure that all emitters have access to facilities, recognising that cost bases may be different.

24. If government is to allow all archetypes of NPT, how should an assessment of an NPT value chain be considered to allow comparisons?

An end-to-end assessment of the NOT value chain costs and opportunities / benefits need to be made, in order to allow appropriate comparisons.

It is clear that there still needs to be some level of government risk taking with NPT solutions in order to allow the sector to be attractive to investment and for projects to proceed, at least in the early phases of introduction. The LCCC is an effective interface for the early cluster development, and we would encourage the government to consider extending its use as the NPT systems develop.

25. Please provide views on the potential vision for cross-border CO_2 T&S networks in the UK.

Fuels Industry UK broadly agrees with the potential vision for cross border CO2 T&S networks in the UK.

However, we would urge the government to consider the strategic nature and value of the CCUS infrastructure in the context of international competition. There should not be a reliance on a purely market driven approach, if UK CCS capacity is constrained.

A failure to take this issue into account risks non-UK producers offering higher prices for CCS capacity than UK producers, effectively squeezing out UK emitters from UK infrastructure. It is entirely possible that future carbon markets (such as the EU ETS price relative to the UK ETS price) could give rise to these market conditions. Equally similar market conditions could arise for UK CO_2 exports, which may be priced out of non-UK infrastructure. The squeezing out of UK emitters by non-UK ones in a capacity constrained environment would be a sub-optimal outcome for the UK economy and a poor use of national resources.

In a capacity constrained system, UK refineries should not be made uncompetitive and squeezed out of a UK carbon storage market because other governments are putting a higher price or subsidy on carbon capture so non-UK CO_2 displaces UK CO_2 from UK carbon storage locations.

However, we recognise that as the market develops, capacity limitations will send a signal for further T&S capacity increases in the industry, encouraging further investment and capacity debottlenecking as required.

These strategic and competition risks need to be considered while the CCS schemes develop both within and without the UK.

26. With regard to Questions 18 and 19 and in the context of establishing cross-border CO_2 T&S networks, do you have a view on:

i) whether an economic licensing framework for CO_2 T&S might need to evolve to accommodate cross-border T&S networks?

There is likely to be a need for an evolution of the economic licensing framework for CO_2 T&S in any event, as the nascent market develops over time. Cross-border T&S networks are one element of this evolution.

As we discuss in our response to Q25, we would urge the government to consider the strategic nature and value of the CCUS infrastructure in the context of international competition. There should not be a reliance on a purely market driven approach, if UK CCS capacity is constrained.

A failure to take this into account risks non-UK producers offering higher prices for CCS storage than UK producers, effectively squeezing out UK emitters from UK infrastructure. It is entirely possible that future carbon markets (such as the EU ETS price relative to the UK ETS price) could give rise to these market conditions. Equally similar market conditions could arise for UK CO_2 exports, which may be priced out of non-UK infrastructure. The squeezing out of UK emitters by non-UK ones would be a sub-optimal outcome for the UK economy and a poor use of national resources.

UK refineries should not be made uncompetitive and squeezed out of a UK carbon storage market because other governments are putting a higher price or subsidy on carbon capture so non-UK CO_2 displaces UK CO_2 from UK carbon storage locations.

However, we recognise that as the market develops, capacity limitations will send a signal for further T&S capacity increases in the industry, encouraging further investment and capacity debottlenecking as required.

These strategic and competition risks need to be considered while the CCS schemes develop both within and without the UK.

ii) how cross-border CO_2 volumes should be viewed within a commercial landscape currently designed for domestically captured CO_2 volumes?

Fuels Industry UK cannot comment on this question in detail.

As we discuss in our response to Q25,

we would urge the government to consider the strategic nature and value of the CCUS infrastructure in the context of international competition. There should not be a reliance on a purely market driven approach.

A failure to take this into account risks non-UK producers offering higher prices for CCS storage than UK producers, effectively squeezing out UK emitters from UK infrastructure. It is entirely possible that future carbon markets (such as the EU ETS price relative to the UK ETS price) could give rise to these market conditions. Equally similar market conditions could arise for UK CO2 exports, which may be priced out of non-UK infrastructure. The squeezing out of UK emitters by non-UK ones would be a sub-optimal outcome for the UK economy and a poor use of national resources.

UK refineries should not be made uncompetitive and squeezed out of a UK carbon storage market because other governments are putting a higher price or subsidy on carbon capture so non-UK CO_2 displaces UK CO_2 from UK carbon storage locations.

These strategic and competition risks need to be considered while the CCS schemes develop both within and without the UK.

iii) how service providers could manage the risks on a commercial basis that would allow for a merchant delivery model?

Fuels Industry UK cannot comment on this question in detail.

iv) whether there are any specific changes needed to the current suite of capture business models if CO_2 cross-border T&S networks are established?

Fuels Industry UK cannot comment on this question in detail.

As we discuss in our response to Q25, the government should consider carefully the strategic nature of cross-border CO2 networks to ensure that there remains a level playing field for UK operators given that carbon pricing structures may be different in different international jurisdictions.

UK refineries should not be made uncompetitive and squeezed out of a UK carbon storage market because other governments are putting a higher price or subsidy on carbon capture so non-UK CO_2 displaces UK CO_2 from UK carbon storage locations.

27. With regard to Question 20 do you think any changes will be required to the CCS Network Code to ensure cross-border CO_2 T&S networks can be established?

The metering requirements under the CCS Network Code are highly onerous, requiring very accurate metering of CO2. This may not be possible when using cross-border networks and may need to be reviewed.

As we note in our response to the 2024 consultation on updates to the CCS network code heads of terms and articulate in our response to Q36, the current specifications as written are overly restrictive and not based on sound science. The CO_2 being placed into the pipe is a by-product of user operations intended for long term storage. Therefore, outside of key safety requirements, the specifications should be relaxed as far as possible. This is even more relevant for NPT transport, where it would potentially be more difficult to meet these requirements. In other words, the specification of impurities should be minimised as far as possible to reduce CCUS costs, recognising that the material will be injected into long term storage in ground reservoirs.

28. To what extent would enabling NPT users and cross-border users incentivise storage exploration and appraisal activity? If not, why doesn't it?

Fuels Industry UK's view is that expanding the user base by enabling NPT users and cross-border emitters (including import opportunities) should assist the incentivising of storage exploration and appraisal activity. We recognise that enabling NPT users and cross-border users would increase demand for them, encouraging future investment in the sector.

Any expansion of storage capacity should be subject to the same rules governing the safe and secure long-term storage of CO2 as the initial infrastructure. In other words, there should be no dilution of the initial requirements that ensure CO2 reservoirs are reliable and fit for long term CO2 storage.

A failure to do that is likely to undermine confidence in the CCUS industry as a whole, both for UK and non-UK users.

29. Could a store which is solely reliant on NPT users be viable? What are the technical challenges to operating a store solely reliant on NPT users? How would this operating model impact the risk profile of the project?

In principle, we cannot see any reason why a store that is solely reliant on NPT users would not be economically viable.

CCS reservoirs are likely to need a steady supply of CO_2 to effectively operate, rather than a variable one. This is true of pipeline, and NPT pipeline fed reservoirs.

Therefore, a solely NPT fed reservoir may need some form of intermediate storage to smooth out the flow of CO2. For shipping, this could be substantial, recognising that there could be delays to shipments caused by bad weather, port delays or lack of ship availability. For well-head NPT solutions, this could potentially include a ship-based CO_2 storage solution into the well-head.

30. Please provide evidence for the potential viability of shipping CO_2 straight to the wellhead for CO_2 injection. Please expand on the risks/barriers and benefits of straight to wellhead shipping.

While Fuels Industry UK has no direct experience of shipping CO_2 straight to the wellhead for injection, we understand that there has been experience of enhanced oil recovery by CO_2 injection in the upstream industry for over 40 years. [31]. This experience should be used in determining the feasibility of injection into CO_2 stores, including the design of any receipt and injection equipment. The design considerations should also extend to the ship equipment as well, to ensure a robust capture system with minimal fugitive emissions.

31. What regulations need to be considered or amended for NPT value chains to deploy (excluding those regulations which are covered in the CCUS policy landscape section)?

Fuels Industry UK's members operate under a suite of legislation that governs the handling, manufacturing and transport of hazardous materials in the UK. Our extensive experience of these regulations ensures operations proceed while managing their impacts on people and the environment and will continue to be the case in the future.

Our experience with the clusters to date suggests that it is not so much the regulations themselves that need to be considered or amended, but the available resource and application of them. This needs to be carefully considered to ensure that risks are appropriately considered in a timely and effective manner.

For additional CCS process unit on refineries the planning requirements should account for favourable impact on (having lower) CO_2 emissions in the planning decision framework.

[31] www.globalccsinstitute.com/archive/hub/publications/118946/technical-aspects-co2-enhanced-oil-recovery-and-associated-carbon-sto.pdf

32. Do the current processes to comply with existing health and safety or environmental regulations or controls create barriers to NPT deployment when transporting CO_2 via road, rail, barge, ship, or processing CO_2 at intermodal facilities? If so, what are those barriers, and what would you suggest as an alternative?

As per our response to Q31, Fuels Industry UK's members operate under a suite of HSE and environmental regulations that governs the handling, manufacturing and transport of hazardous materials in the UK. Our extensive experience of these regulations ensures operations proceed while managing their impacts on people and the environment and will continue to be the case in the future.

Our experience with the clusters to date suggests that it is not so much the regulations themselves that need to be considered or amended, but the available resource and application of them. This needs to be carefully considered to ensure that risks are appropriately considered in a timely and effective manner.

However, we would welcome clarity as soon as possible by the HSE on the categorisation of CO_2 for transportation. There are considerable risks associated with this substance in the event of an accidental release (for example in the event of a road tanker leak) which could have significant health and safety consequences. These risks need to be carefully considered to ensure public protection while enabling NPT to occur in an effective manner. It may be worth noting that to date there has been no release of cryogenic gas from liquid gas carrier ships.

33. Are there any specific changes to UK legislation, existing regulations or permitting processes which are necessary to support the development of cross-border CO_2 T&S networks?

Fuels Industry UK's view is that there are no substantive changes required at this time to support the development of cross-border T&S networks as the existing requirements should be fit for purpose for materials being handled, regardless of whether they are produced in the UK or not.
However, we would ask that the UK ETS regulations are checked from a legal perspective, to ensure that they recognise CO2 exported and appropriately stored as such, in order to reduce a producers obligation accordingly. Equally the regulations should also recognise imports that are appropriately stored as not counting against a UK ETS obligation (recognising that there may need to be some recognition for fugitive emissions). This simply requires adequate fiscal metering to

be in place and the recognition of which streams can be counted against the UK ETS and which must be counted against other countries equivalent systems.
Confirmation of the ability and potential approach to providing a licence exemption would reduce policy risk and would be viewed as a positive step towards enabling cross-border CO_2.

- Given the potential efficiency benefits associated with cross-border CO_2 for UK projects, the Secretary of State can fulfil their obligations under Section 1(1) of the Energy Act 2023 [32].
- An exemption from economic regulation and the need for an economic licence is a key requirement for both NPT and cross-border. That is provided for under The Energy Act.
- Unbundling of licences will be required to support the interaction between economically regulated onshore networks with unregulated and unlicenced NPT solutions.

34. What do you see as the biggest regulatory barriers to the growth of cross-border CO_2 T&S networks?

Differences between the UK and EU ETS legislation, including measurement and verification are a potential regulatory barrier in the development of cross border CO2 T&S networks.
This is a nascent industry, and appropriate government resource should be put in place to identify and appropriately modify legislation underpinning potential barriers as they emerge. We would encourage UK based pipeline systems to be in place and operating first, then close collaboration with the industry to enable the correct regulatory requirements (if any) to develop at the same time; Premature and inappropriate regulation could stifle the nascent industry.

35. What are your views on the best approach to creating interoperable CCUS networks?

Fuels Industry UK recommends that one way to assist with enabling interoperable CCUS networks is by having suitable forum to share technical knowledge and identify any barriers to their implementation. These forum could be convened at a UK level when looking to join or expand clusters and include NPT operators, or at an international level for cross-border matters.

Eventually a common set of requirements and procedures would emerge to harmonise CCS schemes, removing barriers to interoperable CCS networks.

[32] https://www.legislation.gov.uk/ukpga/2023/52/contents

36. How should the UK design the standards and specifications for CO_2 T&S which offers network users sufficient flexibility in store choice but also provide sufficient protection to core T&S infrastructure? How can the UK ensure that its T&S network design does not impede access to an interconnected and interoperable European system?

The current specifications as written [33] are overly restrictive and not based on sound science. The CO_2 being placed into the CCS system, whether a pipeline or an NPT approach is a by-product of user operations intended for long term storage. Therefore, outside of key safety requirements, the specifications should be relaxed as far as possible.

The minimum 95% CO_2 composition is fully supported, yet having explicit limits on each of the major sulphur components is not. There is no safety requirement on sulphur compounds, (provided it is dry, as determined by a maximum water content as discussed below) therefore such specifications should be set to high values in order to promote as much user capacity into the system as possible.

The specifications look far more like product specifications to an end user rather than input specifications for a disposal route to long term storage. Meeting the current specs will add significant cost and regulatory burden upon CO_2 suppliers and may make it unattractive to connect.

One significant exception is water as outlined above. Water provides carbonic acid with the CO_2 which is corrosive. Similarly, if NO_x, SO_x or NH_3 are present (carbamic acid) again water will create corrosive components. However, all of these components in the absence of water confer no greater risk to steelwork than the CO_2. For example, SO_2 and SO_3 (for sulphuric acid production) are both handled safely in carbon steel pipework provided no water is present [34].

As a result, the specification should be simplified to critical elements such as water below 10ppm and a minimum Co2 content of 95% rather than being an overly restrictive set of requirements that do not incentivise access to long term storage.

Since the main function of the CCS system including through NPT is transmission of carbon dioxide produced as a by-product of user operations to long term storage, rather than re-use of the CO_2, then the input specification should be set to accept as much CO_2 at as low a price as possible.

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[33] https://www.gov.uk/government/consultations/carbon-capture-and-storage-ccs-network-code-updated-heads-of-terms

[34] https://sciencing.com/happens-so2-reacts-steel-23499.html

Consequently, the analysis terms presented in the CCS network code heads of terms consultation are significantly in excess of what would be expected. Appropriate monitoring of water content should be sufficient, and the rest managed by engineering standards. For example, if CO_2 is held in a tank in advance of entry into the CCS system and only liquid CO_2 is drawn from the base, then excess water floats and permanent gases such as air, argon, NO as well as H2S, methane, ethane and hydrogen reside in the headspace above the liquid. Accepting that 100ppm of water will remain soluble, to be polished out by the CO_2 provider, backed by a moisture meter, there should be no need for additional ongoing analysis. Since even excess water floats (Liquid CO2 has a density of ~2.2 and has properties similar to liquid butane i.e. is water shedding) this is a reliable way of rejecting most impurities and it naturally forces CO_2 suppliers to buffer (almost batch CO_2 supplies) thus smoothing the delivery of CO_2 into the system, alleviating many of the capacity constraints listed previously. Clearly it does force the pipeline to maintain a minimum working pressure at all times of 10 barg, but that will not be onerous and is in common with the requirements of many existing pipelines.

It might be appropriate to have a weekly or daily sample for quality, taken on a manual basis to check for gross impurities yet perform minimal measurement online. For cost reasons, it may be advantageous for the operator to manage such analyses centrally and back charge the CO_2 suppliers, but this would be very much more efficient than individual monitoring as is currently suggested. CO_2 is a very different molecule that natural gas and so such analysis and engineering systems should be designed to take advantage of its properties.

An additional and critical point clearly missed by the theoretical approach taken to setting the CO_2 specification published here: collected CO_2 is invariably formed using a basic solution which absorbs acidic components. Therefore, there is little need to measure these components as the protection mechanism is the working solution inherent in the process. On other words, the amine or potassium carbonate absorption solvent typically retains strongly acidic materials such as SO2, SO_3, NO_2. As a result, there is no need to analyse for these materials in the CO_2, as they form what are known as heat-stable salts in the working solution and thus being involatile, are retained.

A very noticeable absence is a waiver policy towards the input specifications. For example, while gross water would never be waivered, if one supplier slipped excess H_2O occasionally, such as 12ppm, yet on balance across the network the average was within acceptable limits, then there should be some mechanism for ongoing acceptance of CO_2 provided that the temporary nature of the deviation was being

remedied. Again, flexibility to accept CO_2 except for all but safety / stability critical issues should be the focus of service provision and virtually all of the specifications listed are not safety critical if the pipeline is appropriately managed.

In conclusion, in our view there needs to be significant re-evaluation of the proposed specifications in order to ensure they are fit for purpose while incentivising CCS development.

Specifications and standards can be discussed at the forum we propose in our response to Q35. A suitable forum would share technical knowledge and identify any barriers to their implementation. These forum could be convened at a UK level when looking to join or expand clusters and include NPT operators, or at an international level for cross-border matters.

37. Are there any technical or operational limitations that may exist that could be a barrier to domestic NPT or cross-border T&S network deployment? Please explain.

One operational limitation that may exist is gaining critical mass prior to effective start-up of the T&S network.

There is a unit cost question and a project management timing challenge for domestic NPT. (For cross border there is a cross-border trading and regulation overlay). Once going there are no technical and need not be any operational barriers (other than incomplete value chains) This needs to be carefully considered in the project development

Technical or operational limitations can be discussed at the forum we propose in our response to Q35. A suitable forum would share technical knowledge and identify any barriers to their implementation. These forum could be convened at a UK level when looking to join or expand clusters and include NPT operators, or at an international level for cross-border matters.

38. Is there any specific foundational infrastructure that must be operational in the UK before UK stores can offer storage to domestic NPT or international customers? If so, what should the UK prioritise?

It would be fairly self-evident that there needs to be investment in shipping infrastructure including ship loading or unloading equipment. There also needs to be infrastructure in place for the loading of road, or rail tankers containing CO_2.

We would also suggest that proven CCS infrastructure should be in place and operational in the UK before the industry can evolve further into the use of NPT. Given the timelines involved, we would expect this to be delivered through the Track 1 and Track 2 cluster processes. We would therefore urge the government to continue to prioritise these as a matter of urgency, to provide the foundation for the nascent CCS industry in the UK.

39. Do you foresee any infrastructure innovations which could speed up the deployment of NPT and cross-border T&S networks and/or reduce associated costs? Please provide any supporting evidence.

Fuels Industry UK is not currently aware of any infrastructure innovations which could speed up the deployment of NPT and cross-border T&S networks and/or reduce associated costs at this time.

However, there is significant research in this area, both within and out with the UK and we would encourage government to promote and share this research as far as possible as it develops. We would caution that the scaling up of research projects into full-scale operation is not always easy, or linear.

40. What are your views on other flexible users of CCUS networks, e.g. flexible use of technologies such as DACCS? Do you foresee that NPT and buffer storage could be complimentary to operate alongside a flexible piped user (e.g. projects that could ramp up or ramp down CO_2 output, potentially including technologies such as DACCS).

Fuels Industry UK supports the approach that the needs of flexible users in CCS networks should be accommodated as far as possible.

We agree that NPT and buffer storage would be expected to be complimentary to operate alongside a flexible piped user, particularly in the clusters. All interconnected systems, whether pipelines or wires need buffer storage to operate effectively. As we discuss in our response to Q4, one solution to address this may be

to create regional intermediate storage locations, or hubs, where CO2 can be aggregated from NPT solutions, before being shipped to the final storage reservoirs. This would minimise costs for participants looking to store CO2, and there is likely to be a role for central planning in creating these facilities at nationally strategic locations.

We are aware of some users who may look to use NPT in the early phases of their projects, particularly BECCS in conjunction with low carbon fuel manufacture. Once the technology and project become established, they can then look to secure a permanent pipeline connection to a final CCS store.

41. Does the UK have the relevant skills and capability to deliver NPT? Does the UK have a competitive advantage to deliver certain elements of the NPT value chain?

There is a broader challenge associated with the skills and capability required for the energy transition generally, including at a refinery level. This challenge extends to the delivery of pipeline-based CCS initially, as well as the development of NPT.

We have compiled a report on the skills required in the downstream sector including the broader energy transition [35], which recommends significant government focus in this area.

We recognise that the UK does have a competitive advantage in terms of access to ports, potential storage reservoirs and maritime experience (for example the IMO is headquartered in London).

It is unclear at this time whether the UK has a competitive advantage to deliver the NPT value chain, over and above those previously stated. Indeed, as suggested by the head of the Climate Change Committee in April 2024 [36], delays in delivering a clear government policy in this area risk the UK losing ground to international competitors in the energy transition. We would therefore urge the incoming government following the July 2024 election to prioritise delivering clarity of energy transition policies including the delivery of CCS as soon as possible.

[35] https://online.flippingbook.com/view/861718875/
[36] https://www.bbc.co.uk/news/uk-politics-68863796

42. What other areas should government be considering for successful deployment of NPT?

We do not have any additional comments on this question, other than to urge the incoming Labour government following the July 2024 election to prioritise the energy transition including the delivery of CCS as soon as possible.

43. Please respond with any other comments that are not contained in the above questions.

We do not have any additional comments on this question, other than to urge the incoming Labour government following the July 2024 election to prioritise the energy transition including the delivery of CCS with NPT as soon as possible.