Paper 6/3 Industry session
For information

1. Purpose

1.1 To provide Commissioners with background information on agenda item 4, an information gathering session hearing from representatives of energy intensive industry.

2. Background

2.1 This note provides detail of the participants who have been invited to give evidence as part of this session along with a list of suggested questions. Further background information is also included in the Annex to help inform the session.

What	Agenda item 4: Industry information gathering session
Who	• Dr Richard Leese, Director, Mineral Products Association • Michael Smith, Chief Executive Officer, NECCUS • Professor Martin Tangney, President, Celtic Renewables • Richard Wooley, Head of Energy and Climate Change, Chemical Industry Association
Why	An opportunity to examine the future of energy intensive industry in Scotland in light of the 2045 net-zero target. Participants will be able to answer questions covering the challenges and opportunities of decarbonising industry, along with what needs to happen to maintain the jobs currently associated with the sector. A selection of possible questions are included below: • What are the positive examples of energy intensive industry, in the Grangemouth area taking steps to reduce the carbon footprint of their business? What can wider industry learn from the successes (or failures) to date ? (lessons learned) • What would you understand the balance of responsibility between private sector companies and Government to be for bringing about the low-carbon transition? Should Government be taking a more interventionist role or should companies be left to themselves? (economic development) • Are companies doing enough at the moment to secure a positive future for their industry? What action can Government take to either support them or force them to commit to transition? (economic development) • Do you see the low-carbon transition as a way of maintaining jobs/economic output in the region, or are there opportunities for growth resulting from the transition? What are they? (economic development) • To what extent is the need to bring about a low-carbon transition appreciated throughout the sector, for example among smaller

	companies in supply chains? What needs to be done to help guide the direction of their business planning or investment? (economic development) • Some EII processes may need to radically adjust to enable the low-carbon transition. Are there sufficient skills and expertise in Scotland that can be applied for this change to happen? Or what are the gaps? (skills) • If there is a skills transfer that needs to be made to facilitate the low-carbon transition, then how should it be brought about, and who's responsibility is it? • What will the impact of the low-carbon transition be for workers – in terms of skills, and type of roles that will be available for them in future? Are there any particular sub-sectors or workers in certain jobs that are particularly vulnerable (quality of work/social inclusion) • Does the low-carbon transition and any skills transfer present opportunities for addressing inequalities in the labour market that currently exist? (social inclusion) • Can you see any strategic opportunities for Scottish EII to be a world leader in the development of a net-zero economy? What support is needed from Government to realise these? (economic development) • Do you think the Grangemouth region requires additional support from Government to help secure a positive future, or is the current support in the form of growth deals etc sufficient? (economic development) • To what extent do the various public and private sector bodies currently work together to secure the future vision for the region (such as enterprise agencies, skills bodies, council, national government, private sector)? Could they be coordinated better? And is the vision ambitious enough?
Additional background information	• Annex A: submission from Chemical Industries Association • Annex B: submission from Confederation of Paper Industries • Annex C: Centre for Energy Policy briefing • Annex D: submission from REINVENT research team (considered in private) • Annex E: submission from Mineral Products Association

	• Annex F: submission from Mike Smith, NECCUS

Annex A – submission from Chemical Industries Association

About us
CIA is the organisation that represents chemical and pharmaceutical companies located throughout the UK.

The UK chemical and pharmaceutical industries have a strong record as manufacturing's number one export earner (on a value-added basis) and a provider of essential inputs to UK value chains. This includes products and technologies which are key enablers of climate change solutions. We therefore have a strong contribution to make both to rebalancing and greening the economy.

However, the chemical industry is energy intensive, competes globally for market share and inward investment, and has already done much to improve the energy efficiency of our existing production assets. Our contribution is therefore critically dependent on secure and competitive energy supplies and carbon reduction schemes which do not leave us internationally exposed. Energy is our number one issue.

The main economic opportunities and challenges, for EII and Grangemouth, presented by the transition to a net-zero economy.

Energy reduction is in our DNA
UK consumers face comparatively high and rising electricity prices, due to the pass-through costs of the Carbon Price Support, subsidies for renewable power (i.e. Contracts for Difference, Feed-in Tariffs, Renewables Obligation, Capacity Market) and the cost of increased network capacity to balance, transmit and distribute it. Furthermore, our gas prices will rise if the decarbonisation of heat is levied on the consumer as the decarbonisation of power was. Because of the high cost of energy and its associated emissions (i.e. the cost of the EU ETS and CCL) in the UK, reducing energy use makes good business sense.

Energy efficiency is a win-win solution reducing costs as well as emissions; improving energy efficiency is in our DNA. The UK chemicals industry has reduced emissions significantly since 1990 (whilst growing) and is committed to further reductions; but this is increasingly challenging with available technologies and feedstock. For example, INEOS has invested in energy efficiency at Grangemouth for decades, the latest example being a new energy plant, but investments need to have a strong business case for a company to stay competitive. The exhaustion of low-hanging fruit energy efficiency and emission abatement options in the UK chemical sector means we are more and more reliant on significant infrastructure developments (i.e. the development of clean energy and carbon capture, use and storage (CCUS) networks), the deployment of which are largely out of our control.

The below documents summarise the pathway and barriers to deploying the technologies that would be required to decarbonise our industrial base (e.g. affordable: clean power, bio/syngas, hydrogen and CCUS):

- Chemicals Sector - Joint Industry - Government Industrial Decarbonisation and Energy Efficiency Roadmap Action Plan[1]
- Industrial Decarbonisation & Energy Efficiency Roadmaps to 2050 – Chemicals[2]

[1] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/651230/chemicals-decarbonisation-action-plan.pdf
[2] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/416669/Chemicals_Report.pdf

In the Grangemouth context, CCUS and off-setting do not currently have viable business models. The business case for reducing or capturing emissions associated with production, or off-setting those emissions, has to be improved. We would welcome the opportunity to work more closely with the government, to develop effective CCUS and off-setting business models for industry.

Global trade and carbon leakage

Our chemical products are traded globally, so we must stay competitive at a global level or we will lose market share and/or margin to competitors. We already face significantly higher energy and feedstock prices than US and Middle Eastern producers, in addition to the highest electricity costs in the EU (65% above the EU median). This drives us to invest carefully and operate efficiently to stay in business.

The fundamental challenge to achieving a just transition for our industry, is the creation of a global level playing field at the same time that we decarbonise our energy and feedstock sources. If we are successful, then we can continue to offer high quality manufacturing jobs to support the Scottish economy. INEOS Chemicals alone has >1000 staff at Grangemouth, and many direct contractors. This activity supports many more in the supply chain, and their wages make a big difference in the Scottish economy.

If Scottish EIIs become uncompetitive then investment will go elsewhere, with a clear risk to jobs in Scotland. This will have the impact of increasing global emissions, as domestic manufacturing is replaced by production in regions that do not face the same stringent carbon and environmental legislation as operators in the UK.

The Sustainability Research Institute at the University of Leeds has developed a model to reallocate the emissions from industries to the final consumer of products.[3] The Institute's model shows that decarbonisation in the UK has, so far, been achieved largely through offshoring industry:

The UK reports Greenhouse Gas Emissions from a territorial basis, including all the emissions that occur within the territory of the UK. However, the UK is one of the largest net importers of emissions embodied in trade in the world. While emissions continue to decline (albeit at a relatively slow rate) within the UK, the emissions associated with the imports of products consumed by the UK continues to rise. These emissions are not included in the UK 2050 carbon target.[4]

Care should be taken not to damage an efficient and innovative industry, or to push it to regions in the world with lower environmental standards.

The foundation of a low-carbon economy

The chemicals industry is an enabler for emissions reduction in other sectors. The Chemistry Council's proposal for a UK chemical sector deal provides a vision to build a better world by being at the forefront of commercialising sustainable chemistry innovations.[5] The proposal outlines a £200bn opportunity for UK industry to drive economic growth from disruptive technology, to support the creation of new jobs in the regions and to facilitate a move to net zero; through the development of materials for Clean Growth and the Future of Mobility, two of the Grand Challenges in the UK's Industrial Strategy.

As an industry our products underpin the creation of a zero-carbon world. An independent report found that for every tonne of GHG emitted by the global chemical industry, its products and technologies enable over

[3] http://www.emissions.leeds.ac.uk/

[4] http://www.emissions.leeds.ac.uk/files/Policy%20Brief%20%20Consumption%20based%20emissions.pdf

[5] http://ukchemistrygrowth.com/wp-content/uploads/2019/11/Chemistry-Council-Sector-Deal-041119-1.pdf

2 tonnes of GHG emissions savings.[6] The top chemical industry products that enable these carbon savings include: building insulation, fertilisers and crop protection, lightweight components for cars and planes, low temperature detergents, biofuels and materials for wind turbines. These chemical products and technologies are all made in the UK, supporting low-carbon jobs and generating UK exports.

Materials produced at INEOS, Grangemouth, contribute directly to carbon emissions reduction downstream because: their production often has lower carbon emissions than the materials they replace; they can enable a wider range of design innovation, and; in many cases, they are better able to be recycled with lower carbon emissions. This provides an opportunity for growth, as all sectors of the economy drive towards net zero.

The actions necessary to realise these opportunities and to mitigate against adverse consequences.

All pathways to net zero require the use of new low-carbon chemical production routes that cost 20-80% more than 'business as usual', and up to 115% for some of the last emissions that must be cut. These differences cannot be borne by companies facing international competition, so supporting policy will be essential. 2050 is only one investment cycle away, and any further delays will hugely complicate the transition.

The following policies are priorities for energy intensive industry to meet the net zero target by 2050:

1. Consumption emission reduction targets: Territorial emission reduction targets for domestic industry penalise UK manufacturers in favour of more carbon intensive manufacturers overseas, leading to the offshoring of our consumption emissions. The UK government must therefore focus on monitoring and reducing consumption emissions. Measures to encourage the consumption of low-carbon goods would help level the playing field for UK manufacturers during the transition to net zero, mitigating the offshoring of emissions. It would also create an incentive for manufacturers overseas to lower their carbon footprint.

2. Climate policy cost-mitigation measures: If a carbon price is levied on sectors such as chemicals, which are exposed to carbon leakage and have no remaining emission abatement options, then climate policy cost-mitigation measures should be provided, such as: offsets through Article 6 of the Paris Agreement, benchmark adjustment and cost-containment measures. Further, compensations and exemptions covering the pass-through cost of climate policy on energy bills must be made available more easily to all EIIs, and the Carbon Price Support (CPS) should be replaced with legislation to regulate coal off the UK's grid, to minimise the cost burden to consumers.

3. Streamline carbon monitoring, reporting and pricing regimes: The current reporting and pricing regime comprises complex and overlapping requirements, including: the Energy Saving Opportunity Scheme (ESOS), Streamlined Energy and Carbon Reporting (SECR), Climate Change Agreements (CCAs), the EU Emissions Trading Scheme (EU ETS), the Carbon Price Support (CPS) and the Climate Change Levy (CCL). Complying with numerous schemes drains staff resources and demands significant additional expenditure, disproportionate to the value added.

4. Support domestic shale extraction: The Committee forecast that the UK would require 600 TWh (55bcm) of natural gas in 2050. This equates to a 32% reduction in UK gas demand from today. Based on forecasts by the Oil and Gas Authority for UK Continental Shelf offshore gas production, the UK would be

[6] https://www.cia.org.uk/Portals/0/Documents/Publications/Low%20carbon%20brochure_2015_MR.PDF?ver=2017-01-09-143808-563

reliant upon imported gas to meet 86% of demand by 2050. Such a level of imports represents a significant increase from 50% today. The UK should source gas with the lowest upstream emission footprint. According to UKOOG, UK indigenous gas (including shale gas) emissions are at least half that of LNG or long-distance pipeline (see Appendix 1 and Appendix A[7]).

5. Significant and long-term financial support: Step change technologies like hydrogen and CCUS, required to decarbonise heat and process emissions, have a high capital and operational cost that would make operators uncompetitive. Current funding is comprised of small, distributed pots of funding (i.e. the Low-carbon Hydrogen Fund, the Industrial Fuel Switching Competition, the Hydrogen Supply Programme, the Industrial Energy Transformation Fund, and the Industrial Strategy Challenge Fund) which are burdensome to apply for and insufficient for the transformation required. Significant and long-term financial support for low-carbon infrastructure development and operation, as well as on-site technology deployment, are required to provide incentives and certainty to the private sector and prevent the offshoring of emissions. Funded pilot projects should be deployed as a priority, to test and demonstrate the feasibility of these technologies, and allow the market to begin to drive cost and efficiency improvements.

6. Kick-start hydrogen demand: Kick-start hydrogen demand through: the amendment of the Gas Safety Management Regulations to enable greater hydrogen injection into the grid, and; through policy support for hydrogen vehicles. This will cross-subsidise the development of a hydrogen market, allowing market forces to engage to bring down the cost of supply.

7. Fair and appropriate energy cost sharing: Energy costs (including network charges) must be fairly and appropriately distributed amongst consumers. As advised by Dieter Helm's Cost of Energy Review, legacy climate policy cost should be ring-fenced and itemised in consumers bills and industrial consumers should be made exempt from legacy and future costs8. The UK should then benchmark domestic energy costs relative to competitor nations and proactively maintain a competitive investment environment for UK business.

8. Cost and carbon effective energy assets relative to "firm" provision: Future energy asset investment must be cost-effective and technology neutral, as per Helm's Review.[8] Transition away from technology-specific subsidy mechanisms (e.g. Nuclear RAB) to a single capacity auction route, based on carbon price signals and intermittency de-rating. To ensure we decarbonise the grid at the lowest cost to all consumers and protect the competitiveness of our industries.

9. Reform outdated energy regulatory frameworks: The energy regulatory framework should rapidly move away from increasingly outdated and rigid industry structures, geographic monopolies and regulatory funding frameworks. This would enable the energy system to adapt in a more agile manner to the evolving landscape, reducing the cost burden on consumers.

10. Ensure effective competition: Ensure that competition is effective in the energy retail market as well as the services surrounding the supply of electricity, including demand management services, data collection and provision. This would enable the market to drive down costs for all consumers.

11. Improve the transparency of energy supply costs: Improve the clarity, accessibility and simplicity of all elements of cost associated with the provision of power. This would allow the energy market to regain consumer confidence and would facilitate effective competition amongst providers.

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[7] Appendix 1 and Appendix A of: https://www.northyorks.gov.uk/sites/default/files/fileroot/Planning%20and%20development/Minerals%20and%20waste%20planning/Examination%20Library/High%20court%20judgement/3997%20UKOOG%20resp%20High%20Court%20Judgment%20consultation%2010.7.19.pdf

[8] https://assets.publishing.service.gov.uk/

12. Give Ofgem a remit to protect industrial consumers: Provide Ofgem with a remit to ensure fair costs for the industrial class of consumers. This will help ensure that UK industry remains competitive. If UK industry is offshored due to high energy cost, it would ultimately drive up costs for other consumers, who would inherit industry's share of the cost of maintaining the network.

Annex B – CPI submission

PRODUCED BY THE UK PAPER INDUSTRY TO INFORM THE ZERO-CARBON POLICY DEBATE

Executive Summary

As the global economy moves away from a dependence on high-carbon fossil fuels and finite resources, to a low-carbon, circular and bio-based economy, the UK is leading this transition with a net-zero 2050 target. Paper-based Industries, being based on renewable and recyclable forest fibres, are at the forefront of addressing this challenge.

However, the UK economy doesn't exist in isolation and it's critical that other countries follow this lead – without international action the estimated £1 trillion cost to the UK is simply a waste of money. With domestic emissions being such a small and declining proportion of world emissions (around 1%), a global response is critical. In this context, the UK must redouble attempts to secure international action, as well as drive change at home.

A decarbonised economy will mean major changes for Energy Intensive Industries (EIIs). From an industrial perspective, measures to support and drive the transition to net-zero need to be realistic and ensure that domestic based manufacturing can be internationally competitive during the transition.

This paper addresses a particular set of issues around the use of natural gas as an energy source, highlighting that alternative technologies are either not yet proven, unrealistic or currently uneconomic. Until these alternatives are ready, natural gas, as the lowest carbon fossil fuel, has an important role to play as part of the energy transformation – a role that should not be lightly cast aside in a rush to decarbonise.

Why natural gas?

Natural gas is widely used for good reasons; it's easy to use with an existing distribution network and combustion equipment already installed; energy dense; efficient and clean with almost no sulphur dioxide emissions, low nitrogen oxide and particulate emissions; and has 43% lower carbon emissions than coal and 30% less than oil. Global supplies are plentiful with a huge potential to further displace higher carbon fuels. There's no sign that countries outside the UK will stop using gas.

It follows that simple policies that drive up the cost of natural gas in the UK risk making gas intensive domestic manufacturing uneconomic. In a fiercely competitive and price sensitive operating environment, uncompetitive UK gas costs will simply cost jobs and wealth creation as domestically made goods are swapped for imports.

We urge that the promised Treasury review into the cost impact of this new policy fully considers the impact on Energy Intensive Industries (EEIs). Support and protection from low cost high-carbon imports should be delivered from day one and not rushed through in response to a crisis at a later date, as has been the case with a number of policies.

The seven main options being proposed as alternatives to fossil gas are considered in turn, (breakthroughs in energy and carbon efficiency; on-site renewable energy sources; replacing natural gas with low carbon gas; fuel switching to electricity; fuel switching to biomass; carbon capture and storage; and industrial clustering and recovering waste heat). At present none of these alternatives offer a commercially feasible alternative to natural gas. It's not just the capital investment cost that's an issue, it's also the ongoing running costs caused by switching to more expensive energy sources.

Natural gas is the sector's most important fuel and cannot easily or practically be replaced – the reasons are further explored in this paper. For the UK recycling industry - largely driven by gas – there are currently no realistic alternatives.

CPI urges policy makers to ensure that support is available to help UK industry transition to a low carbon future by working in partnership to understand issues and find solutions.

UK Papermaking
Papermakers use both virgin and recycled fibre to deliver an ever-growing range of bio-based products. Most virgin fibre is made outside the UK in countries with huge and sustainable forest resources. The production sites use forest residues as their primary energy source and so produce carbon neutral paper and pulp.

Recycling has always been integral to the paper industry and a great example of the circular economy. For the UK, with relatively low forest cover, but a huge urban forest of paper to be recycled, recycling forms the basis of the industry. Around three quarters of paper made in the UK is produced from recycled fibres.

These mills use natural gas as the primary energy to produce heat, and so unilaterally increasing the cost of gas would make their operation uneconomic. This is just at the point when policy makers are seeking to increase domestic recycling to reduce the reliance on exports of unrecycled materials to countries in the Far East, and also realising the opportunity for paper-based products to replace single use plastics.

The UK Policy Context
The 2008 Climate Change Act set a legal target that, by 2050, direct UK emissions of greenhouse gases must be at least 80% lower than they were in 1990. In 2019, the Act was revised to set a target of net carbon neutral by 2050 – only after five years will there be any consideration if others are following the UK lead. No detailed consideration was given to the huge cost on the UK economy to deliver this policy (estimated at £1 trillion by the then Chancellor). Post-Brexit, the Government has committed that UK climate change ambitions will be more ambitious that those of the European Union.

The Committee on Climate Change (CCC) advises Government on the appropriate level for emissions targets and how these can be met, reports to Parliament on progress, and identifies further measures required to meet future targets. For EEIs the work of the CCC is potentially challenging in two ways:

- The over-riding priority is to set and deliver the carbon budgets, and BEIS is required to develop policies to ensure the budgets are delivered. While cost is considered, it's ultimately a secondary issue and is considered over the whole of the economy. For EEIs this can be a huge problem as the cost of policies can drive up energy cost disproportionately in the UK.

- The focus is direct UK emissions only. Emissions in other countries linked to manufacturing of goods destined for use in the UK are not considered on the basis that this is a concern for individual countries and global negotiations. When the full impact of UK consumption on global emissions is

considered, the reported progress with the reduction of direct UK emissions largely disappears. To drive to the ultimate, the UK could reduce direct emission to zero but still increase global emissions by importing power and goods manufactured outside the UK. The role of the CCC must be changed to also consider embedded carbon in imports.

Decarbonisation Roadmaps

Papermaking is one of eight heat intensive sectors invited to work with Government to explore the potential within the sector to decarbonise production (while remaining competitive) as the UK moves towards national decarbonisation targets. CPI and the Paper Industry Technical Association (PITA) jointly lead the interaction between Government and industry, leading to the production of the original report and the subsequent action plan to progress specific topics. The published Roadmaps explore the technical potential for decarbonisation and progress actions to deliver energy efficiency and decarbonisation in each of the sectors.

For the purpose of this analysis the assumption is that national policies will have decarbonised the electricity grid by 2050 – meaning that grid distributed power will be zero carbon – though it should be noted that UK electricity is already amongst the most expensive in Europe and adding extra demand may increase this cost further, especially if natural gas can play no role.

As the sector has already moved away from coal and oil though as with the rest of the economy noting continued use for transport) this leaves natural gas as the only fossil fuel still being widely used. The remainder of this paper considers if ending the use of natural gas is technically and commercially feasible, and the effect on papermaking if policy makers drive up the cost of gas to make use in the UK uneconomic compared to using gas elsewhere.

A continued focus on energy efficiency

Significant and strategic investment by papermakers over a number of years mean that around three quarters of UK made paper is produced at sites with high efficiency Combined Heat and Power plant, with major recent investment in new plant.

Papermaking carbon dioxide emissions from fuel combustion have reduced by 67% since 1990, the base year for the first Kyoto commitment period. Correcting for a shrinkage in the size of the sector, this means that carbon efficiency has improved by 58% over the same period. This is due to fuel switching (from coal and oil to natural gas and solid biomass), investment in CHP, investment in energy efficiency techniques and technologies and – in the last few years – by a reduction in the carbon content of UK grid electricity.

Papermaking energy efficiency has improved by 32% over the same period – in other words, each tonne of paper produced now requires the consumption of 32% less energy than it did in 1990.

Why is gas so important in UK papermaking?

In general, countries with large forestry resources tend to have Paper-based Industries based on virgin fibres, while countries with smaller forestry resources (such as the UK) tend to have Paper-based Industries based on recycling fibres. Of course, the whole system comes together to deliver sustainable, renewable based products as part of the growing bio-based economy.

This split has major implications for energy use. Mills making and using virgin fibre are integrated into a local forest economy and have access to low grade forest residues and papermaking by-products used to

make energy. Generally, these mills have heavily invested in green energy and are largely self-supplying, often provide energy to users outside the mill.

Conversely, mills making and using recycled fibres (or utilising virgin fibres made elsewhere) don't have direct access to forest-based green energy, with natural gas being the main source of energy – for larger mills often used in high efficiency gas-fi red CHP plant; for smaller mills, used in gasfired heat boilers with electricity drawn from the grid.

It follows that the industry is not suited to a simplistic energy use plan that covers all mills, especially if the physical recycling of paper collected in the UK is to be delivered in the UK as part of a circular economy.

Market economics demand that mills continue to focus on energy efficiency, with major improvements already delivered including huge investment in gas-fi red CHP and modern boilers.

And of course there's a reason that natural gas is so popular – it's relatively cheap, abundant, energy dense with diverse supply routes, easy to use in conventional equipment, and benefits from an existing distribution network. Critically, using natural gas produces lower emissions of fossil carbon than coal and oil, and so has been seen as a transition fuel to a zero-carbon economy, a role being reassessed in the net-zero carbon discussion. The rest of this paper explores the main options being proposed as alternatives to gas and explores ways that gas use could be reduced in the sector.

Alternatives to gas
The main options considered are: (1) Breakthroughs in energy and carbon efficiency; (2) On-site renewable energy sources; (3) Replacing natural gas with low carbon gas; (4) Fuel switch – electricity; (5) Fuel switch – biomass; (6) Carbon Capture and Storage; and (7) Industrial Clustering.

Some of these options can be realised within the paper sector. Others rely on the decarbonisation of the energy sector. To date, none of the options identified seems to deliver, on its own, a satisfactory alternative to natural gas that is both technologically and financially viable to meet the 2050 challenges. However, combining different options can potentially lead to a progressive move towards ambitious carbon emission reductions. Solutions will inevitably be site-specific as they will depend on local, regional and national circumstances.

Option 1: Breakthroughs in energy and carbon efficiency
Several promising areas for innovation continue to be explored to assess their potential to help drive the decarbonisation, and energy efficiency of papermaking. The technology readiness levels (TRL) of these solutions vary. Some are still at their infancy, but others are making substantial progresses and are close to or at commercialisation

Financing programmes are needed to bring these new technologies to the UK, such as the Innovation Fund foreseen under the EU ETS (or a similar scheme under a UK alternative), new financing programmes in the multiannual financial framework, and sustainable financing programmes such as the Industrial Energy Transformation Fund.

It's also worth highlighting again the role of Combined Heat & Power (CHP) plant in ensuring that gas (and other energy sources) are used as efficiently as possible. CHP is intrinsically more energy efficient than stand-alone energy and heat production but is capital intensive and operationally more complex. Some types of papermaking have a power/heat requirement that matches to CHP better than others and indeed all larger UK mills where the balance is clear already have CHP. However some of this plant is close to the end of its operational life and there may be unrealised opportunities at smaller sites that could be delivered

with the right support. Such projects would predominantly be gas-based but do offff er efficiency savings as part of an energy transition.

In summary, ensuring that UK sites are operating in the most energy efficient manner will continue to drive carbon and energy savings, but (with current technologies) this will not fully decarbonise the industry.

Option 2: On-site renewable energy sources
The use of on-site renewable energies can reduce the need to import energy sources, such as natural gas or electricity. Several solutions could be envisaged:

1. Bioenergy from solid by-streams
Energy recovery from solid by-streams (sludge and rejects) accounts for about 1% of energy fuels used in the Paper Industry. It can take the form of conversion to energy carriers (such as gasification, pyrolysis, anaerobic digestion and secondary fuels production) or direct conversion to energy (incineration).

Moreover, several paper mills are already producing biogas from anaerobic waste-water treatments. In some cases, biogas accounts for 5% of a paper mill energy consumption. Potentially, this figure could go up to 10%.

In most of the cases, technology is mature and could be more widespread across the sector. More than 50% of solid by-streams are composed of organic matter and, when used for energy purposes, this counts as renewable energy. In some cases, this has contributed in reducing carbon emissions in paper mills by a substantial amount.

However, energy recovery often faces strong local opposition, and a number of mills already use waste materials for different processes such as soil improvement or animal bedding. Additionally, research continues to commercialise other ideas that could be alternatives to simple energy recovery.

2. Heat Pumps
Heat pumps are an interesting and developing technology to reduce external energy input and can be potentially deployed in paper mills. Developments are still needed for temperature above 180 °C, but some preliminary studies suggest that heat pumps could supply steam up to 160 °C, starting from ground water of 10 °C or higher temperature waters where the heat is currently economically unrecoverable.

Pilot projects have already proved successful and plans for demonstration units in paper mills are ongoing in Europe. Research and development eff orts are still needed to reduce capital expenses and increase the output temperatures. However, the huge issue is that this technology increases the use of electricity, which is often not an economic option.

3. Geothermal
Ultra-deep geothermal energy could also potentially deliver the necessary heat for papermaking. Projects could also be developed in partnership with local authorities or technology providers. The technology is currently being tested in other sectors, although it currently looks very expensive. Moreover, drilling underground for several kilometres would require quite specific geological conditions and societal acceptance, as well as solving technical challenges to ensure projects deliver long-term energy and a return on the high capital investment.

4. Solar & Wind
Deploying photovoltaic panels, solar heating or small wind turbines is theoretically possible, depending on the size and the geographic conditions of the paper mill. Examples of roof-top photovoltaic are already

present in some paper mills, while a large-scale solar heating scheme is currently being installed in a first-of-a-kind project in Europe. However, considering the high volumes of energy currently needed for papermaking, energy produced by on-site solar and wind is unlikely to supply the full energy demand in a given paper mill.

In summary, all of these technologies offer opportunities but are very site specific.

Option 3: Replacing natural gas with low carbon alternatives
A seemingly simple solution would be replacing natural gas with "decarbonised" alternatives such as hydrogen or biogas, to be delivered to the point of consumption via existing infrastructure.

The gas industry has identified three options:
K Paper Industry

1. Hydrogen from carbon capture and sequestration: carbon would be separated from natural gas, with the carbon being re-injected into depleted gas fields or stored elsewhere.

2. Hydrogen from power-to-gas: electricity would be used to generate hydrogen and/or synthetic gas.

3. Biogas: biomethane would be produced by gasification of energy crops or organic wastes. In all these cases, the final product would be injected in the existing natural gas grid and/or part of local distribution networks.

The Paper Industry could potentially be a good enabler of these solutions, as it could use biogas, hydrogen, or a combination of the two, in combustion plants. It's not clear how existing plant would cope with this changed fuel stream. For simple boilers, changes may be limited to new burners, but for more complex CHP plant, there would likely need to be substantial changes to the whole of the combustion section and operational controls. This being said, there are several considerations to be made:

- In none of the studies commissioned by the gas industry would natural gas would be 100% carbon free and/or neutral by 2050 across the whole of the UK.

- The transition from natural gas to hydrogen requires careful planning in adjusting infrastructures and combustion equipment for end-users. To date, there is no plan for a national hydrogen network, though some regional initiatives are under consideration.

- The practical on-site implications of switching from gas to hydrogen are not well understood. Major work will be required to pipe networks to safely handle the smaller molecules of hydrogen and mitigate increased explosive risk.

- If volumes remain small, hydrogen would be better used in products delivering higher added value (such as fuel cells) rather than as a combustion fuel.

- Taking natural gas and converting to hydrogen adds an additional step to the process, with an unavoidable increase in cost.

- Although biogas production is projected to increase, by 2050 the biogas share in natural gas consumption is still expected to be relatively low (below 30%). It might ultimately make more sense to use it locally, potentially reaching 100% share of local demand, rather than having a minor share in the upstream gas distribution

In summary, technologies to substitute natural gas for biogas and hydrogen are being promoted as a way to decarbonise the existing gas network. However the economic impact of switching from natural gas are huge, and for hydrogen there are a number of technical issues (around explosive risk and operation of combustion plant) that are not fully understood. Importantly the alternative fuel would almost certainly be more expensive, meaning an ongoing increase to the operational cost of sites.

Option 4: Fuel switch - electricity

The key issue is that grid supplied electricity is expensive. Papermaking requires low-temperature steam (<180°C). From a technical point of view, steam can be generated using electricity, thus replacing natural gas. Electrical boilers are a well-established technology and could be the first step towards the deployment of new electro-technologies and solutions.

Demand-side flexibility is potentially an important methodology to help better manage the increasing amount of intermittent electricity on the grid. On-site energy generation and industrial use of power is managed to allow grid supply to be drawn when there is an excess of renewable energy on the grid, while power is generated and use minimised when the grid is short of power. Part of this system could integrate electric boilers to generate steam. By switching the energy source, this solution allows paper mills to provide a service to the electricity sector in helping manage intermittent renewable electricity - without affecting paper production.

That being said, use of electricity for demand-side programmes and full electrification are two different concepts. In the first case, industry provides a service to the network, by absorbing excesses of renewable electricity. In the second case, it becomes a liability to the electricity sector, as it brings additional baseload demand to the electricity transmission networks. Replacing natural gas with electricity would increase the industry's baseload demand by a factor of almost 2.5 across Europe.

Matching this additional demand would require major investments in both reinforcing transmission lines and an increase in electricity generation. Delivering additional final electricity demand would in fact require an even larger use of primary energy due to energy conversion and network losses.

Such an increase in baseload demand would have to be matched by an increase in decarbonised electricity generation and by a programme to reinforce high voltage transmission lines. This aspect should be seen in the wider picture, where electrification could be a better option to decarbonise other sectors.

Last but not least, a 100% switch to electricity would require replacing current assets, thus making the exercise particularly CAPEX intensive. This should be seen in conjunction with electricity prices being already considerably higher than natural gas; in the UK the cost of grid supplied electricity is prohibitively expensive and mills could not fully electrify and be financially viable. And an increase in electricity generation and infrastructures to accommodate the additional demand from electrification would have an impact on the cost of using electricity.

In summary, while an increased role of electricity in paper mills is to be expected, a full electrification of paper mills doesn't seem to be economically viable in the foreseeable future unless the cost of grid supplied electricity can be driven down.

Option 5: Fuel switch - biomass

The Paper Industry has a long tradition in sustainably sourcing and using biomass. From an energy perspective, biomass already accounts for almost 60% of fuel used in the Paper Industry across Europe. However, the opportunity for the further use of biomass seems limited. This is due to a combination of factors, the most relevant being:

• Limited access to biomass feedstock

• Lack of public acceptance by neighbouring communities and local planners

• Physical lack of space and storage facilities on sites

• Logistic constraints caused by the physical location of installations

• Higher emissions and more vehicle movements arising from an additional supply chain

In summary, the possibility to switch to biomass, although technically possible, is expected to play only a marginal role in further decarbonising the recycling of paper.

Option 6: Carbon Capture and Storage (CCS)
Carbon emissions from the combustion of natural gas could be captured and then stored. However, general issues on CCS apply to the Paper Industry as well: storage location, infrastructures, public acceptance, economics, etc.

Moreover, emissions from gas-fi red paper mills are relatively low – and often originate in different combustion facilities across the site. This makes CCS particularly expensive, as the ratio of volumes over costs of CO2 captured would be low. CCS deployment would also have to be assessed from an overall energy balance perspective, as carbon capturing generates efficiency penalties that might off set efficiency gains from cogeneration.

In summary, CCS doesn't seem to be a primary solution for the Paper Industry. It should be first developed to reduce emissions in other industrial sectors, especially those with large combustion units. One option to study should be the possibility to decarbonise industrial clusters by developing shared infrastructures to transport the captured CO2.

Option 7: Industrial clustering and recovering waste heat
Across the UK a number of initiatives have sought to bring operational synergies and energy savings by clustering complementary industries together, with support promised from the Industrial Strategy Challenge Fund to deliver a world-first decarbonised cluster in the UK. In this context industries with higher temperature waste heat (say steel or glass plants) could supply paper mills, with paper mills in turn using lower temperature heats to supply a district heating system.

In a slightly wider sense there are some examples of waste-fired CHP where the papermaking makes use of the heat and power and helps provide part of the solution for local waste management planning. However such opportunities are very location specific and expensive – additionally natural gas is normally used as a reserve fuel required to support the operation of such plant.

In practice such ideas are hard to deliver; planning systems don't offer flexibility; companies are reluctant to enter into the long-term supply contracts require by investors; and the cost of moving existing installations to new sites is prohibitive.

In summary, while this idea has merit it won't deliver for most existing sites, though it could be helpful if new operations can be attracted to the UK to make use of low-cost waste heat.

In conclusion

Simply pushing up the costs of using gas is a recipe to further decarbonise the UK by driving away industry and substituting UK production with imports from other parts of the world where carbon costs are lower and regulation of carbon emissions is less strict.

Indeed, Government should be encouraging businesses to invest in the UK, where carbon legislation is strict, so that these emissions can be managed down as quickly as possible, even if this means a short-term increase in domestic emissions to drive a faster fall in overall global emissions. Focusing on domestic emissions alone, and ignoring the growing levels of embedded carbon imported into the UK in imported goods, risks making the UK a climate hypocrite.

Focusing on domestic emissions alone, and ignoring the growing levels of embedded carbon imported into the UK in imported goods, risks making the UK a climate hypocrite. The previous 80% decarbonisation target accepted that gas should play a role as an interim fuel – a position that should be retained as alternatives continue to be developed and become commercially viable. EIIs have long investment cycles and if the UK is to attract new investment there needs to be confidence that plant can economically operate throughout an investment cycle. Investments made now are likely to operate well into the 2030s and, at present, the alternatives to gas simply aren't economic.

Papermaking is hugely capital intensive and consequently risk-averse, meaning new technologies need to be well proven before widespread adoption. For a global industry deciding where to invest, demanding the use of new and unproven technologies simply drives investment to locations with lower carbon costs and importing even more manufactured goods.

- Energy and carbon efficiency improvements will continue to reduce the overall energy demand;
- On-site Renewable Heat production, through the integration of innovative technologies such as heat pumps or solar thermal, will reduce the demand for natural gas, thus delivering important co-benefits in terms of reducing carbon emissions, reducing primary energy consumption, and increasing the share of renewable energy sources;
- On-site valorisation of bioenergy from solid by-streams could reduce the demand for natural gas, thus delivering the benefits previously mentioned. Moreover, when seen in combination with the previous points, the relative role of bioenergy will be more important, though alternative uses for such by-products may limit this opportunity;
- More flexible CHP units and operational changes will enable the use of excess electricity produced from renewable electricity. By seamlessly switching the energy source, this solution would enable paper mills to provide a service to the electricity sector, by enabling further use of renewable electricity, without affecting paper production. None of these options currently suggest that the use of natural gas could be reduced to zero by 2050 while keeping UK Energy Intensive Installations internationally competitive.

To move towards a decarbonised industry, there needs to be a partnership with Government to deliver:

Innovation

- Support research, development and deployment of new solutions
- De-risking financing programmes, to mitigate the first-mover disadvantage
- Make the identified areas eligible for sustainable financing programmes

On-site renewable energy sources

- Research, Development and Deployment of cost competitive collection and use of biogas and of renewable heat solutions to be integrated in paper mills
- Promote dialogue between heat producers, developers, industry and public authorities, in order to understand and address barriers (knowledge gap, financing, public acceptance…)
- Promote energy recovery technologies, in compliance with the Waste Framework Directive

Energy supply

- Ensure the timely availability of clean and affordable energy supply. This requires the availability of both clean energy and related infrastructures
- Develop local and regional plans and partnerships to develop biogas production
- Allow industry to compete in the electricity market, on equal footing, in providing flexibility solutions

Annex C – Centre for Energy Policy – Reframing the value case for CCS (Policy Briefing)

A pdf copy of this briefing has been included in the dropbox for this session. It is also available here.

Annex D – REINVENT research team – Policy brief on industrial decarbonisation (considered in private – awaiting publication)

Annex E – submission from Mineral Products Association

MPA have asked to share their existing to emission reduction plan for the cement industry. A pdf copy of this is stored in the dropbox for the session. This plan is currently in the process of being updated to reflect the new net-zero target.

Annex F: submission from Mike Smith, NECCUS

Note: Submission from Mike Smith – CEO – NECCUS. These views are my own and don't represent the perspectives of the wider NECCUS alliance membership

What would you understand the balance of responsibility between private sector companies and Government to be for bringing about the low-carbon transition? Should Government be taking a more interventionist role or should companies be left to themselves?

This transition will require a collaboration between the private sector and government, with each party holding clear roles and responsibilities. To create a net-zero industrial cluster, government will need to take responsibility for:

- the regulatory and legislative change which will be required,

- it will need to define policy to support the fiscal mechanisms needed to underpin new investment,
- it can provide a 'pull' for low carbon intensity products by its own buying power, coupled with a 'push' for the creation of these products by carbon taxes.
- These represent a mix of enabling and interventionist actions

The private sector in return needs to take responsibility for:

- Making the additional investments in the low-carbon transition in a phased, timely and cost effective manner,
- Integrating these investments into their existing industrial process to ensure continued high operating uptimes and high quality products
- Encouraging the sharing of this infrastructure across the local industrial cluster
- Supporting investments elsewhere in the low-carbon value chain via transparency around their own actions, opportunities for co-investment, and clear commercial frameworks

The most likely reality is that no single private sector company or government agency is going to have ownership across the entire Net Zero value chain for heavy industry; therefore the fostering of high quality partnerships between private sector companies and a variety of government agencies is key.

Other public-private collaborative partnerships have highlighted the need for significant effort upfront in their design and shared objectives as a key success factor. Similarly, the development of transition roadmaps which are underpinned by robust models of the energy and industrial system can be very helpful in defining pathways through a highly complex and uncertain transition.

Are companies doing enough at the moment to secure a positive future for the industry? What action can Government take to either support them or force them to make the transition?

Most energy intensive heavy industries are characterised by the creation of low-margin, undifferentiated, bulk commodities (e.g. cement, glass, bricks, chemical feedstocks, basic plastics) which often require complex processes to create. These same products are also fundamental to the needs of a modern society.

The nature of these products make it very difficult to consider changes which could: reduce the already low margin on the product, impact the need for very high efficiency and operational uptime, impact the nature of the industrial complex in hard to pre-define ways – with potential QHSE consequences.

These aspects often lead to a risk averse culture and need for high certainty in outcomes before change and new investment can be made. Conversely, once a change or investment has been shown to be beneficial by a peer or competitor, these industries often very rapidly adopt these changes in order to continue to compete – a fast-follower mentality.

At present, my personal belief is that most heavy industries recognise the need to change and are starting to think about potential feasible low-carbon improvements. However, for this to lead to actual rapid change to ensure the Net Zero 2045 target is met, mechanisms to insulate industries from key risks to their: margin, operational uptime and efficiency, QHSE performance; should be considered by government for the period of transition.

Do you see the low-carbon transition as a way of maintaining jobs/economic output in the region, or are there opportunities for growth resulting from the transition? What are they?

I believe the first priority is to maintain existing jobs and economic output, particularly for industries which provide vital basic commodities for a modern society and where the demand for those goods are unlikely to change in a Net Zero world. However, this can be done in a way which creates opportunity for growth – both in the existing industries and in 'halo' industries which can be developed around them.

In terms of existing industries. As already mentioned, many energy intensive heavy industry products are undifferentiated – making it hard for one company to encourage the consumer to buy their product over a competitor on anything other than cost. However, leadership in a low carbon transition can offer opportunity for differentiation by creating a Net Zero product which competitors cannot match.

Examples already exist in other industries around how leaders in creating sustainable, organic, fair trade, or low energy intensity products have grown and created additional jobs and economic output. In terms of new 'halo' growth opportunities. The Net Zero transition will require new industries to develop to support industry particularly around Hydrogen as a clean fuel for industry, and the transport and storage of carbon captured from the industrial process. These will both create jobs and economic output, but also will need a service sector to support them. This service sector could utilise existing skills and manufacturing capabilities in Scotland, and via Scotland taking a global lead in the move to Net Zero, the sector can then export these services to other countries as they decarbonise.

The final area in which growth opportunities can be developed is in the utilisation of the waste products captured by Net Zero industries. A clear example is the CO2 which will need to be captured by industry, and which can be a feedstock to other innovative products. CO2 utilisation is an area of rapid academic research and entrepreneurial development at present, with Scotland already providing world leading research outcomes. The ideal location for new CO2 utilisation companies to establish themselves is next to a source of high quality CO2 captured as a waste product from an existing industry, with easy access to industrial infrastructure, clean energy, and high quality logistics. Areas such as Grangemouth potentially offer all of these enablers.

If the commission is interested in learning more about this area, I would draw its attention to the CCU Living Lab event taking place at the Dynamic Earth centre in Edinburgh on Jan 30th and 31st. This EU collaborative event is bringing together CO2 utilisation researchers, entrepreneurs, SME's and existing industrial players to develop Net Zero solutions. Falkirk Council and Scottish Enterprise should be commended for their support of this event.

To what extent is the need to bring about a low-carbon transition appreciated throughout the sector, for example among smaller companies? What needs to be done to help guide the direction of their business?

I believe the need for a transition is widely recognised, but that smaller companies are looking to their larger peers to provide leadership, direction, and opportunities to share the cost and burden of new investments and infrastructure wherever possible.

As already highlighted, the development of transition roadmaps which are underpinned by robust models of the energy and industrial system can be very helpful in defining pathways through a highly complex and uncertain transition, and thus guide the direction of individual businesses. These can also define low-regret actions which businesses can take quickly, and areas of collaboration between the public and private sector to ensure robust infrastructure is put in place.

Existing industry forums and societies, should also be provided with support to develop an enabling environment for their members to share positive and negative experiences during the transition. Shared

learnings are often a key enabler to reducing the cost of technology deployment of the kind necessary for a low-carbon transition.

What will the impact of the low-carbon transition be for workers – in terms of skills, and type of roles that will be available for them in future?

Workers as members of society will be exposed to the wider societal changes that the move to Net Zero will require. However, as workers in energy intensive, heavy industries the impact on the skills required and types of roles available will be predicated on the success of the low carbon transition.

In a successful transition which preserves existing 'evergreen' industries while developing halo industries around them, the long term opportunity for skill development and roles should be positive. New skills building on existing skills sets will be required, and the competition for these skills and the roles available will increase, particular if opportunities like CO2 utilisation can be fulfilled. In this scenario, there will however still be a period of change and uncertainty during the transition. The complexity and interconnected nature of the transition will create unintended consequences for the workforce on a short-term basis. Whilst it is not possible to accurately predict these unintended consequences, government should be primed to provide short-term support and intervention to smooth over this critical period.

Does the low-carbon transition and any skills transfer present opportunities for addressing inequalities in the labour market that currently exist?

A successful transition which creates jobs and opportunity is an opportunity to address inequalities in the labour market and impact socially deprived areas with low employment rates. To do this requires focus from both industry and government.

A potential analog for the impact of a successful transition on social inclusion can be seen by the work ongoing at present by the offshore wind industry and the sector deal it has established with the UK government. This sector deal, although only recently approved, is already having an impact on areas such as the Humber where traditional industry has dwindled, social inequality increased and skilled jobs become rare. This area is seeing the offshore wind industry invest in schools and colleges, further education skills development, apprenticeships, re-skilling of workers from other industries and ultimately the creation of new jobs attracting workers across the social spectrum.

Do you think the Grangemouth region requires additional support from Government to help secure a positive future, or is the current support in the form of city deals etc sufficient?

The UK government has identified Grangemouth as one of 5 significant industrial clusters across the UK which collectively should be focused on to deliver the low-carbon transition. As such, all of these areas, are anticipated to take the lead in developing a Net Zero industrial value chain. This will require additional support. Central government is in the process of providing support to energy intensive industries, and support for new parts of the low-carbon transition like CCUS and Hydrogen. Grangemouth, should be a focus area for this support. Investment in fuel switching to clean fuels like Hydrogen and Renewable derived electricity, coupled with investment in carbon capture, utilisation, transport and storage, are essential to the creation of Net Zero industry as recognised by bodies such as the Committee on Climate Change.

Additional support from government is needed to ensure initial investments in these areas are made on a timetable which can ensure they are replicated and scaled up more widely on a timeframe to achieve Net Zero.