Environmental Capacity in Industrial Clusters project - Phase 3

Annex 3 - Overview of Tees stakeholders, method and responses

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Acronyms

APIS	Air Pollution Information System
AQEG	Air Quality Expert Group
AQMAU	Air Quality Modelling & Assessment Unit
AQS	Air Quality Strategy
AURN	Automatic Urban and Rural Network
BAT	Best Available Technique
BP	British Petroleum
CC	Carbon Capture
CCGT	Combined Cycle Gas Turbine
CCS	Carbon Capture and Storage
CCSA	Carbon Capture & Storage Association
CHP	Combined Heat & Power
CO2	Carbon Dioxide
DCOs	Development Consent Orders
Defra	Department for Environment, Food & Rural Affairs
DESNZ	Department for Energy Security and Net Zero
EA	Environment Agency
EAL	Environmental Assessment Limit
E&B	Environment & Business
ELV	Environmental Limit Value
EU	European Union
GW	Gigawatt
H2	Hydrogen
HSE	Health and Safety Executive
ICI	Imperial Chemical Industries
INCA	Industry Nature Conservation Association
LNG	Liquefied Natural Gas
MEA	Monoethanolamine
MW	Megawatts
N2O	Nitrous oxide
NDA	Non-disclosure agreement
NE	Natural England
NGN	Northern Gas Network
NH3	Ammonia
NOx	Oxides of Nitrogen
NZT	Net Zero Teesside
OEM	Original Equipment Manufacturer
OTNOC	Other Than Normal Operating Conditions
PC	Process Contribution
PM2.5	Particulate Matter less than 2.5 μm in diameter
ppb	Parts per billion
ppm	Parts per million
R&D	Research & Development
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
SCR	Selective Catalytic Reduction
SSSI	Site of Special Scientific Interest
TAG	Technical Advisory Group
UK	United Kingdom
UKHSA	UK Health Security Agency
WHO	World Health Organization

1.0 Introduction

The Teesside industrial cluster is a network of existing and planned infrastructure for decarbonising technologies with a focus on Carbon Capture and Storage (CCS) and Hydrogen Production. The cluster is a tightly packed area with a radius of 7 km located in Stockton on Tees by the River Tees with access to gas and oil from the North Sea and an extensive industrial history.

Discussion has been with various project stakeholders and environmental consultants regarding the potential emissions and air quality impacts from the developments within the Tees Industrial Cluster. This report summarises the findings of the stakeholder engagement. Section 2 outlines the approach to stakeholder engagement adopted by the Environment Agency. The stakeholder meeting summaries are provided in section 3, with section 3.1 for hydrogen or carbon capture companies planning infrastructure as part of the Tees Industrial Cluster, section 3.2 summarising meetings with key trade organisations (Hydrogen Trade Associations, Energy UK and the Carbon Capture and Storage Association), and section 3.3 covering engagement with other regulators. Section 4 provides conclusions and recommendations.

2.0 Engagement Methodology

Online meetings were arranged with internal and external stakeholders between January and March 2024 inclusive. There were 7 workshops and 6 industry meetings in total. The meetings lasted 1-2 hours. The meetings with industry were on a 1:1 basis with Environment Agency staff. Workshops with multiple stakeholders (i.e. trade associations, regulators, local authorities) comprised a presentation delivered jointly by the Environment Agency and consultant, AECOM, followed by breakout groups for discussion of key questions adapted to suit stakeholder(s). Workshops were generally recorded, and a transcript was automatically generated. The following summaries are based primarily on the transcripts. In some cases, the transcripts failed to accurately record technical language. All information provided during the meetings has been taken in good faith and has not been independently verified.

3.0 Stakeholder Meeting Summaries

3.1 Individual Hydrogen and Carbon Capture Operators and Original Equipment Manufacturers

3.1.1 BOC - 23/02/2024

BOC confirmed that compliance with the AQS objectives and EALs should not be an issue based on current monitoring providing levels do not increase. Comments were also made regarding confirmed changes to objectives/limits, such as the $PM_{2.5}$ limit of 12 µg/m³ in 2028 and 10 µg/m³ in 2040, saying that advance warnings would benefit plant operators.

BOC suggested the step change reduction in emissions post SSI Redcar steels works closure in 2015 could give context to the proposed decarbonising emissions.

As all CCS technologies are based on amines, BOC suggested that the Environment Agency provide ELVs for each group of amines, primary, secondary and tertiary, as each group has a known degradation rate and reaction pathway. However, it was noted that there would be unknowns surrounding amine blends as well as difficulties due to technology licensors reluctance to disclose information regarding amines used in their solvents.

BOC raised the question of Environment Agency assurances and national permitting approach if BAT changes during the design, application or permit determination process in the first of a kind project.

Analysis of the cumulative effects from the Teesside Industrial Cluster would require source data submitted in neighbouring site permit applications and monitoring report data, which is public register information. It was suggested that saving this in a central cluster focused location could improve the ease of information access, an admin fee may be required to assemble this.

3.1.2 Clarke Energy - 13/02/2024

A blended engine solution for 20-25% hydrogen by volume is driven by Europe wide policy. Confirmation from Natural Gas last year suggested the transmission system could accept 20% hydrogen by volume. Engines in current production can accept up to 25% hydrogen in Europe and 20% in the UK by volume. UK percentage is lower as the energy content of out fuels is lower and engine derate would occur sooner. Up to 20% hydrogen in these gas engines would not suffer performance implications but would reduce CO_2 by 7%. There is an additional Lambda probe in the exhaust and modifications to the control system compared to purely mains gas variance of that engine, but new systems are implemented in all engines. Modification on existing fleet <5 years old are minor.

Engines for higher hydrogen percentages are available and in pilot plant operations in Europe. These differ from existing engine platforms as the design allows operation on 100% hydrogen through to 100% natural gas and is a direct port injection version, which gives greater combustion control.

Pure hydrogen engines are available for 1 MW and type 4 engines, designed for off-gas application and for markets in areas with interruptible gas in North Africa and Australia. The Jenbacher factory in Austria has a CHP facility, 10-12 MW total, 1 MW is currently supplied by hydrogen. There is a hydroelectric plant on site, excess energy produces hydrogen using an electrolyser. Likewise, there is a data centre in Antwerp which is entering the commissioning phase for 6 MWs of hydrogen fuelled engines to supply power during grid interruptions. These can operate on pure hydrogen for 12 hours before reverting to natural gas operation.

The challenges related to hydrogen use include flame speed, propagation of an irregular flame and combustion efficiencies. Knowing the hydrogen percentage in the fuel is key to ensuring the engines operate appropriately on gas blends as the emission control system uses that inflation along with the desired emission level to control combustion with emission verified with a Lambda probe (situated in the exhaust to measures the quantity of oxygen present in exhaust gases to change the air-fuel mixture). This means that SCR is not needed to achieve ELVs though visual plumes are an existing issue and are dependent on ambient conditions.

Due to the current technology options and lack of certainty of hydrogen availability, power generation market direction and cost-effective options in decarbonisation customers are unsure were to invest. However, given difficulties in electrification, due to insufficient grid capacity, some form of liquid/gaseous fuel will be required but that hydrogen may not be the most suitable fuel in the next 10-15 years, with exceptions. Discussing other gases, while biogas combustion incentives have been removed, anaerobic digestive gases are inexpensive and include biomethane as an alternative to natural gas when considering CO_2 stripping and recovery. Jenbacher has conducted single cylinder trials and are entering production on a test engine using ammonia combustion.

Tests are being undertaken related to exhaust recirculation to reduce ammonia slip in hydrogen and ammonia engines which is not possible for fossil fuels as this could impact the engine. Typically, clean-up is maximised in front end to ensure removal before combustion.

Engine start-up typically takes 5 minutes to reach a high load, a transient engine version can reach full load in 30-45 seconds, however a large CCGT isn't designed to do this and would have high thermal stresses. The largest challenge is maintaining temperature and pressure within the engine, typically in peaking application oil temperature and levels are maintained to provide the ability to start quickly and manage thermal stress.

3.1.3 Kellas Midstream - 06/03/2024

In the medium to long-term they anticipate 100 MW blue hydrogen production increasing to 1 GW with green hydrogen production at the facility but are not expecting to require storage facilities on site with H_2 distribution to a number of operators. A memorandum of understanding (MoU) has been reached to provide Saltholmes with H_2.

Some customers require 100% assurance on green hydrogen but for other customers a green and blue hydrogen can be mixed in the distribution system and highlights the need for a high-level Tees-wide distribution system decision.

Kellas failed to achieve track 1 status and have funding from the Net Zero Fund for their feed study running from August 2023 – October 2024. Due to phased development, Kellas has chosen to apply for local planning, aligning with their company ethos of local engagement. Submission is expected in November 2024 and its plans have been discussed with Natural England and Northumbrian Water (which approved receipt of and treatment of effluent, after samples were provided). The site will require 94 m^3/hr of water increasing to 285 m^3/hr.

3.1.4 Mitsubishi Heavy Industry - 06/02/2024

There is customer interest in the Tees area related to both carbon capture and hydrogen. Considering hydrogen storage at scale, the geology in the Wilton area, and presence of salt caverns, highlights the area as a suitable location for hydrogen production and storage for a number of industrial users. Considerable investigation in the Takasago hydrogen park, Japan, for the generation, storage and combustion of hydrogen at large scales.

Burning hydrogen has been shown to increase NO_x emissions at high temperatures and the efficiencies. Abatement focuses on scrubbing NO_x using SCR. In Japan NO_x emission limits are very stringent so high efficiency SCR units are used achieving emission of 5 ppm to 9 ppm, with new combustion systems being developed that reduce NO_x generation and so the need for SCR. The designing of the high efficiency SCR units is such that ammonia use is minimised and so to is slippage.

Ammonia was identified as a potential fuel for use in small gas turbines rather than using pure hydrogen. However, this is only possible in small gas turbines with SCR systems and lower firing temperatures as larger turbines run hotter and it is not possible to achieve NO_x emission limits in Japan. A full program is under way considering the safety requirements of ammonia as a hydrogen carrier in handling, storage, the management, control and detection of leakages.

There is interest in direct ammonia burning across the UK, Ireland, and EU due to the fact it’s easier to transport and handling. The presence of existing ammonia handling facility in the Tees area could be beneficial. Currently the maximum size of plants using ammonia is $60MW_e$ and has a 1 to 2% reduction in gross efficiency when compared to natural gas which is comparable to pure hydrogen systems. Ammonia engine development is currently focused on marine engines.

Installation of hydrogen capable burners into boilers in Egypt and Germany, upwards of 20MW thermal per burner, and NO_x emissions from boilers are lower/easier to control due to lower temperatures (600 to 700°C in comparison to 1600°c for gas turbines). In Japan the target for these technologies is 20-25 ppm without SCR with 30% hydrogen blend. For 100% hydrogen burners are in development with small nozzles to combat the high flame speed of hydrogen.

The source of ammonia is a large consideration. There are several large blue ammonia (with carbon capture) development in progress in US, however the methods for carbon footprint consideration are still in discussion. There are also green ammonia developments in the Middle East, West Africa and potentially North Africa. Discussing opportunities in Scotland to produce lower cost green ammonia with offshore wind as currently in European countries the costs are too high.

Interest is mainly in new plants, as fuel switching is OEM specific for gas turbines and only possible on Mitsubishi plants. R&D is ongoing for fuel switching on a development in Hull. For boilers, new burners can be installed with information on boiler design so is less reliant on the original OEM.

Mitsubishi has engagement with DESNZ related to hydrogen storage and are in the process of selecting 2 locations for development in areas with suitable geology for salt caverns, however the details are restricted due to confidentiality.

Currently only blue hydrogen is available at scale, there is no hydrogen to power establishment in the market, or regulatory policy that values the combustion of low carbon fuels for electricity generation. There is no benefit for low carbon power produced from gas turbines, the hope is the market will move from capacity to capability with rewards for speed entering the market with low CO_2 emission rather than installed capacity in MW.

New plants are capable of operating on different natural gas/hydrogen blends with no change needed to operate on up to 30% hydrogen and only the combustor system needing to be changed to operate on higher percentage. These changes can take place during regular site works.

Current start-up is undertaken using natural gas, but work is in progress to minimise natural gas combustion. The need to use natural gas before switching to hydrogen is primarily due to regulations as in France which require startup/shutdown to be on natural gas due to explosive risk but in Japan regulations allow startup/shutdown on pure hydrogen. Currently there is no legislation either way in the UK. It was also highlighted that there is no real incentive for generating low carbon electricity, so the driver is purely down to regulation rather than financial.

3.1.5 Sembcorp - 28/02/2024

Sembcorp provide utilities within Wilton International, and they own and operate pipeline tunnels and pipework corridors north of the river up to North Tees and Billingham due to the historical industrial nature of the Tees wide presence of ICI.

The need for regular cluster wide mutual benefit collaborative technical workshops has been identified.

It was shared that Sembcorp participated in the Humber cluster mutually funded technical working group and environmental working group for 15 years. The environmental group funded ambient monitoring stations located on at risk SSSIs for ecological impact data and adjacent villages for human health, recording publicly available data. Ownership of this monitoring has recently passed to Natural England.

Once a robust H_2 supply is secured, sites will invest to 100% H_2, this may take 10-15 years in the Tees Cluster with operators still needing to use natural gas as a backup and startup/shutdown fuel for safety.

Government funding is currently based around the supply of one H_2 pipeline per project from production to the end user. This could result in numerous pipelines in Teesside rather than one pipeline with several connection inlet manifolds, numerous take offs and one operator. Currently the tunnel under the Tees has limited capacity, possibly preventing future H_2 distribution. This means a combined system with H_2 monitoring and metering standards requires urgent development.

The original CO_2 gathering pipeline was sized using predicted emission from early connectors, increased interest in the pipeline and associated facilities has drawn investment and increased the predicted CO_2 rates. CO_2 captured within Wilton was not included in the original pipeline designs and therefore expansion of the capacity may be required which will be potentially challenging due to limited space in the tunnel and pipeline corridors. Operators are therefore looking for options to use captured CO_2 and Environment Agency guidance is required to address the definition of 'CO_2 use' to prevent the release of captured CO_2.

Interest was discussed in electrification, electrification-ready and biogas which are under consideration at Wilton as alternatives. Work is ongoing to provide synergistic solutions and the need for cluster scale discussion of these topics was highlighted as essential.

3.1.6 Siemens Energy - 09/02/2024

Hydrogen is being trailed at a test centre in Berlin up to 100% hydrogen, commercially released units are suitable for 20-30% blends with minor changes necessary. Tests have been completed on an SGT400 13 MW gas turbine in France on up to 100% hydrogen. At 100% hydrogen 70-75% load was achieved, 75% hydrogen at 100% load. At the highest hydrogen levels, emissions were below 25ppm without SCR, due to changes of combustion design. At test scale on a core engine with natural gas combustion, NO_x emissions were less than 10ppm. Increasing hydrogen increased thermal NO_x but emissions remained below 25ppm which is in line with the Environment Agency guidance in discussion. There is increased exhaust water vapour from 5-8% however atmospheric conditions and stack exhaust temperatures will determine the visibility.

SGT400 was selected because smaller (i.e.1 MW) gas turbines are difficult to scale. Currently hydrogen blends are being used with the aim of 100% hydrogen capability by 2030. The dates for which are driven by markets and demand and the SGT400 has progressed the furthest. The same system upgrades will be required for 100% hydrogen and blends in between therefore the design and planning will be for 100%. However, blends may occur depending on hydrogen availability. Given the interest in hydrogen plants in the Tees cluster and potential for hydrogen storage there may be a robust supply and 100% fuel switching in the area.

There is a non-linear correlation between hydrogen percentage and CO_2 reduction, 50% hydrogen by volume achieves a 27% CO_2 reduction.

The partial conversion of existing plants and potential for full conversion to use hydrogen will be depending on technological development and hydrogen availability over the next 5-15 years. At levels up to 30% hydrogen existing technologies are suitable, however a switch is required above that level with it being highlighted that 50/50 blends won’t meet net zero goals.

Units running on biogas, emissions are slightly lower than natural gas as the CO_2 and nitrogen act as a dilutant and cool the flame. Ammonia can be cracked back to hydrogen and nitrogen and then combusted in the hydrogen combustor. Technology to burn cracked ammonia is more advanced.

Ammonia combustion can be gas or liquid. Burning gaseous ammonia can cause 100% conversion from ammonia to NO_x, this can be scrubbed out but it’s on the combustion pathways with N_2O which has a huge global warming impact. Burning liquid ammonia is very challenging. Ammonia has different combustion challenges to hydrogen so would require a different combustor; the technology is less advanced but there are concepts which claim 25 ppm is achievable. Hydrogen will provide similar component life to natural gas, ammonia would have a reduced component life due to the extra nitrogen and NO_x on the turbine materials, new materials and coatings may be required.

Expect commercially available hydrogen units with the next 5 years. Ammonia fuelled technology is further away but 50% cracked ammonia with natural gas could be possible on some current models. The interest from industry on burning ammonia is location dependent, if hydrogen production is available there will be less interest in ammonia combustion. If the location is remote and hydrogen via pipelines isn't feasible then there might be interest. Most of the interest is driven by the Middle East where ammonia import is an alternative to LNG.

There is increased enquiries into methanol for passenger ships, testing methanol combustion in a SGT400 is currently ongoing at a test rig in Berlin. This combustor would allow for methanol, diesel, biodiesel, natural gas and natural gas with up to 20% hydrogen blend with minimal changes. Ammonia would be limited to bulk carriers with small crews due to ammonia leak risks and the combustor would require large changes to move to 100% hydrogen. Ammonia currently is widely shipped globally but is limited to a small skilled workforce, to increase the scale will mean less experience handling hazardous chemicals and the risks increase.

Trial work at manufacturers shows if ammonia gets caught in the lubricating oil there is ammonia build up in tanks and the unit is shut down for potentially 24 hours. It can add complications.

Currently due to the ongoing development, to run 75% load in a 50 MW gas turbine you are derating to 40 MW to meet the NO_x emissions. If NO_x limits are increased derate is reduced, this work is ongoing. Abatement will not be required, however without guidelines there is nothing to compare the values to so there is the potential that early adopters may still need to install SCR as a catch all. However, requirements will depend on Environment Agency ELVs.

The amount of hydrogen required for power generation is significant, the 13 MW unit in France burns 1.1 tonnes/hour, a 50 MW unit would burn over 4 tonnes/hour. This would consume 1/3 of the UK's annual hydrogen production today in that unit alone. Trialling smaller models to match current hydrogen availability would be more realistic currently. However, there is a market for all sizes of gas turbine.

The market has changed in the past 10-15 years from high base load efficiency to unit flexibility. This has implications for plant design as greater flexibility requires more startup/shutdown operations. In China start up on units with 60% hydrogen has been achieved, in France start up on hydrogen was not possible due to site HSE and explosion risks in a failed startup scenario. This will be dependent on the technology, HSE and regulators and consideration is required for the need of dual fuelled systems. Startup typically takes 10-15 minutes depending on load levels.

3.2 Trade Organisations

3.2.1 Carbon Capture & Storage Association (CCSA) - 13/02/2024

Current Baseline

It was highlighted that there is currently no ambient monitoring for amines in the Teesside area. Amine concentrations are anticipated to be low for emissions but an understanding of industry levels from these technologies to identify if there is going to be a problem and how these can be sampled is required.

The sensitive ecosystems and the designation was discussed in the context of the effect the SSI Redcar steels works closure in 2015 had on Coatham dunes and the reliance on predictive data in the absence of monitoring.

Permitting

During discussions CCSA had questioned whether the type of industry and emission source should be considered during permitting to engage sustainable development as permits are not currently assessed selectively based on industry.

They had suggested using non-UK sources, such as occupational standards and public toxicology standards, to help determine ELVs and EALs for amines to help with permitting. As well as the potential to use historic usages of amines, such as pH and corrosion control of steam in power stations, to give insight into present day consents.

It was noted that typically applicants will use a generic solvent in planning for later clarification once a solvent is identified. The Environment Agency confirmed an approach is in discussion for assessing this at the permitting stage. Frustrations with changes to the regulatory process were discussed with the need for a guide on what is considered acceptable. An agreed approach being required related to solvent disclosure and protection of proprietary knowledge / issuing licenses to solvent companies.

Cumulative Effects

A key message was the need for an amine baseline and discussion on worst-case scenarios when presenting cumulative impacts. Currently cumulative assessments for each project have to consider all other facilities which are within the planning system, permitted or in situ within 15 – 30 km of the site dependent on the installation, excluding facilities in phases prior to planning. A worst-case scenario is taken using the EALs when assessing cumulative effects of these developments. However, this uncertainty may be limiting developments as this reports a false amount of available headroom when new developments could have negligible process contributions if they controlled their ammonia slip. The uncertainty of EALs may be limiting development, the process contribution of new developments could be negligible if ammonia slip is managed and using EALs for permitting may be falsely presenting available headroom.

It was suggested that emissions could potentially be offset, reducing background concentration levels to allow for more headroom, by taking ownership of farmland and removing agricultural processes from the area. However, there currently is no evidence to suggest a significant change in pollutant concentrations would occur with the removal of agricultural sources, and as air quality is close to or exceeding levels for nitrogen / acid deposition, a reduction in these levels may not provide any headroom.

Another suggestion was for individual companies to assess new projects in the area to determine their significance criteria. The Environment Agency could then provide an approach and/or potentially host the data for numerous plant proposals and provide a goal for process contribution within a wider impact assessment.

Other Comments

It was mentioned that AQMAU has developed a model of CO_2 emissions under OTNOC for human health impacts which led to discussion on the identification of these OTNOC scenarios. Outside start up and shut down, these are typically limited by the specification of the pipeline as there may be scenarios where venting is necessary. There is also variability between the plants and processes used for carbon capture as plants that are designed to reach full capture quickly will have additional expenses such as maintaining solvent temperatures. There are also cases where it is outside the plants capability to handle CO_2 emissions which may also be considered as OTNOCs, i.e. if there is no capacity in the network when supplying CO_2 venting would occur before the CO_2 could be compressed. At this stage a second CO_2 pipeline is not being considered as the current pipeline is considered to have sufficient capacity with allocation determined by DESNZ.

The levels of significance for amines and the differences between amines, the EAL setting process and the importance of communication with the Environment Agency on new targets, the CO_2 pipeline and the definition of carbon capture rate.

3.2.2 Energy UK - 14/02/2024

Current Baseline

Carbon capture will reduce CO_2 emissions having a regional/global effect. However, there are concerns related to the more localised effects that emission of amines and NO_x may have and impacting local air quality.

Permitting

It is currently unknown if the UK will follow the example put forward by Japan with plants allowed to start-up and shut-down on pure hydrogen or if a similar approach to France will be implemented, which required natural gas be used due to fears related to explosions.

Cumulative Effects

The workshop highlighted a point of concern discussed in the previous CCSA workshop on calculating cumulative impacts for the cluster and the potential for emissions offsetting.

Other Comments

There is generally considered to be a move to air-cooled systems in the UK due to limited water availability, but this may be more sensitive to climate change (i.e. warmer winters and summers).

3.2.3 Hydrogen UK and Hydrogen Energy Association - 22/02/2024

Current Baseline

Several opinions were expressed in relation to who should undertake monitoring for new or novel emission including:

- the Environment Agency, as it isn't one company's responsibility.
- Local authorities, as they have the obligation to monitor currently and the focus on roads may need to change with reduced exceedances and removal of AQMA's, repurposing existing monitoring to focus on industrial locations. Potential difficulties were highlighted in relation to council budgets and the need for the councils to work together to provide valuable data.
- Ambient monitoring by industry is not desirable due to difficulties in assigning responsibility, suggesting source monitoring provides more clarity.
- Monitoring could be done by someone like the Industry Nature Conservation Association (INCA), i.e. a statutory body with reach into industry.

Concerns were raised related to the absence of standardised monitoring protocols for some species, especially novel emissions associated with CC, some of which have limits of detection which are higher than expected ambient concentrations. The need for improved monitoring guidance to aid the development of new industry was therefore highlighted.

Permitting

Discussions identified that work is ongoing to develop our understanding of amines and nitrosamines and highlighted that the Environment Agency's need for specific chemical data during permitting is challenging. This may slow progression as specific information may not be available for the new technologies, at this scale, and so older technology/less efficient solvents may be used as they are older and better understood. A solution to enable progression is therefore required.

Cumulative Effects

Concerns were raised about the level of accuracy required when predicting impacts at ecological sites, especially those located away from the source. Achieving 1% of the critical load is possible individually but how cumulative impacts should be assessed/managed is a key challenge. The workshop members perceived differences in approach and scrutiny between Development Consent Orders (DCOs) and local planning applications from Natural England.

Difficulties calculating cumulative impacts if all projects lie just below the 1% threshold. The comment was made that blue hydrogen would mostly utilise a closed carbon capture system and nitrogen deposition appears to be driving the control technologies to achieve the 1% threshold.

Emissions offsetting was discussed along with the potential that it's use could be very expensive, may limit agriculture/food production, the importance of catchment, and difference between nitrogen deposition vs nutrient neutrality.

Other Comments

The top three blocks to progress were identified as:

- the need to manage nutrient deposition and neutrality.
- in combination effects at cluster scale; and
- the desire for certainty from regulators.

There are projects looking at developing the hydrogen network to meet offtake demand, Cadent, northern gas network (NGN) and national gas are investigating new lines, time scales and repurposing existing lines, however the certainty of investment is difficult and there is a need to manage government and public expectation.

Questions were raised about using the salt caverns in the area for hydrogen storage with discussions currently ongoing related to their purchase, but no information was forthcoming due to discussions being covered by NDA's.

The potential for hydrogen/ammonia to be shipped into Teesside from large plants currently under construction in the Middle East was discussed. However, it was highlighted that emissions from shipping and cracking ammonia in the UK would require consideration. It would also require bulk storage at ports, though Teesside has existing ammonia imports and storage facilities.

Current government policy requiring competition in hydrogen network is considered to represent a limiting factor to the wider rollout of hydrogen distribution system. An overarching body may therefore be required to oversee the pipelines infrastructure etc while individual companies supply the hydrogen. It was highlighted that there is an existing gas supply network that served industrial sites across Teesside which became defunct as industry closed but could be restored/used for hydrogen and so reduce transport issues. However, once more this would require a government initiative to join and maintain the existing infrastructure or alternatively a cluster group for coordination.

The participants identified that climate change is more of a concern for buildings than industrial processes. Historic climate data is typically used to design/consider impacts on pressures within distribution pipe networks. There may be some impacts, highlighted flooding having potential impacts on site viability, water temperature and its use as cooling water and ambient temperatures which may change design.

Nutrient neutrality was highlighted as an issue with a proposal that emissions into the river and estuary from industry could be reduced by putting a joint discharge straight to the sea. Physical and technical infrastructure could improve water emissions levels in the estuary. These are governed by the water companies next investment cycle and discussed the required consideration of the affordability for taxpayers, industry, water companies and third-party treatment organisations, permitting from the Environment Agency and requirements from Natural England.

3.3 Regulators

3.3.1 Environment Agency Internal Workshop - 28/11/2023

Current Baseline

The key points raised related to air quality and the current background concentrations related to the differences in headroom and process emission issues between water and air quality. While water is a finite source, air quality standards are a maximum to be achieved not a safe value so any process that increase emissions was a concern especially given the potential for increased NO_x, ammonia, $PM_{2.5}$ and water vapour emissions from hydrogen combustion and amine emissions from CC plants, with subsequent nitrogen nutrient deposition a major concern due to impacts on ecological receptors. More stringent $PM_{2.5}$ targets are to be introduced in 2028 and 2040 and while current levels are comfortably achieved there is not much headroom against the 2024 target. Likewise, WHO set a $5mg/m^3$ industry target within the next 5 – 10 years.

Controlling air emissions, such as by using SCR and exhaust washing units to reduce NO_x and ammonia and amine emissions, must be considered against the effects of increased water demand/emissions to water.

The potential effect that amine and its breakdown products e.g. nitrosamines, pose is currently being considered by UKHSA and the Environment Agency. As amines tend to be present at very low concentrations that may be at/below detection limits they tend to be monitored as part of another substance. This highlights the difficulty in measuring amine background concentrations as they don't exist on their own in nature and there are unlikely to be other significant anthropogenic emissions of amines as they are novel, and are only investigated for REACH regulations, collecting information, and developing monitoring methods is difficult and relies on knowing what to look for. As such it is important that the chemistry of the amine emissions/mix is known to allow the breakdown products to be predicted and so target monitoring for them. Without industry communicating the starting points and chemistry, EAL development is problematic though AQMAU are currently working on a methodology for predicting the dispersion of amines and byproducts. Standard emission monitoring cannot be used for nitrosamines as they are not emitted but created in the atmosphere, AQMAUhave produced pre application advice.

The effect of climate change impacts on extreme weather was highlighted and its impacts on the efficiency of CO_2 removal efficiency/amine regeneration in CC plant. The need for cooling water as well as risk of flooding and subsequent impacts on water quality for cooling etc. Changing ambient air temperature would affect photochemical reaction rates. The move by industry to use hybrid/air cooled systems was noted due to pressure related to water use/reduced water availability but that air cooled systems are less efficient at higher ambient temperature meaning combustion plant need to reduce load so as not to overheat.

Extreme weather may affect pollutant dispersion and atmospheric mixing with impacts not being just isolated to the Tees area/due to emissions that arise in the Tees area. As such a greater understanding of the potential changes to weather patterns and understanding cluster interaction and potential hotspots due to climate change is needed.

Permitting

The impacts on habitats were raised as a key concern for the area especially in terms of how they are considered in the planning and permitting process. As exemplified by NZT with Natural England objecting as the process contribution of ammonia were 4% so requiring acid washing to be added as abatement to reduce emissions. However, the application was based on using MEA, whereas the proprietary solvent they intend to use would have a much lower PC. However as applicants are claiming commercial confidentiality it means that abatement must be applied as a permit can only be made for what is considered in the application. To change the solvent would require a permit variation, and justification of the significance of the change with the air quality impact assessment having to be revisited to consider emissions.

RWE's existing trial plant was discussed and highlighted that solvents were interchangeable without significant changes to the CC plant and only minor downtime. However, there would be efficiency impacts in terms of CC and amine regeneration. MEA is an older solvent with lower CC/additional heat required for regeneration so any new/novel solvent should be more efficient. MEA is considered a worst-case and has an EAL, so is used to gain funding. However, the effects on emissions/breakdown products would need to be assessed and while MEA is used as a worst-case substance this is generally in terms of CC efficiency and not amine chemistry/toxicity. Once solvent chemistry is understood these emissions could be permitted in the same way as other chemical processes.

Guidance written by E&B provided to CCSA allows that commercial confidentially will be considered for proprietary solvent. The legal position is that commercial confidentially can be used for the names of substances in the solution and the ratios. However this does not cover emissions and everything in the absorber must be modelled. This could require a significant number of emission products to be assessed, many of which may not have toxicology data / EALs, which may not be present but have to be considered to demonstrate no impact.

At the moment carbon capture is only required on power stations greater than 300 MW_e, but new legislation is in progress which will remove the 300MW_e limit meaning combustion plants of all sizes may require CC from 2025.

Cumulative Effects

The workshop highlighted that in the absence of any baselines, existing CC plants are being assessed as stand-alone projects with no historical consideration of in combination effects. This raises the risk that a first come first serve approach may limit later developments, especially if the assessment assume MEA as a worst-case.

Other Comments

The importance for ongoing work to be undertaken with industry to identify the best solvents for CC, identifying possible byproducts, chemistry and possible EALs. Highlighting difficulties with limited information on toxicity between substances and the reliance on estimations. The need to have a system for publicising plant emission data and carbon capture rates for different solvents.

3.3.2 Local Authority Workshop - 31/01/2024

Air Quality

The workshop identified new AURN $PM_{2.5}$ monitors are to be installed in both Redcar and Cleveland Council areas to increase the Defra urban background monitoring network. However, the locations are still under consideration with the aim for installation/operation to be completed within a year. No other pollutant monitoring is to be added and monitoring will not be in industrial areas.

The Apace project was referenced with BP, in association with a consultancy, considering the installation of monitoring downwind of industry within the Tees area however details are limited at this time.

Indoor air quality was highlighted as becoming more of a concern for the councils in the Tees area. However, this was primarily related to domestic fuel burning and increased $PM_{2.5}$ levels rather than anything directly associated with industry.

Permitting

It was identified that the councils are only able to provide limited technical advice at the planning stage so raised the importance of developers requesting pre-application advice, from the Environment Agency. However, it was noted that detailed permitting advice and enhanced pre-application has an associated cost.

With high-level discussions on pre pre-application the aim is information sharing, highlighting issues in current permit applications of similar schemes and to aid organisations with informed business planning. However, the Environment Agency could not provide specific guidance on what would be allowed/permittable especially given the long lead in times many of these projects have, permitting may take place long after planning is submitted/approved.

Cumulative Effects

Information gathering on carbon capture plants is in early stages and the workshop highlighted the difficulties in assessing in combination impacts due to lack of information. As such, at this time no air quality assessment had been undertaken to identify the impacts if all large combustion plants in the Tees Valley were to deploy carbon capture. It was highlighted that the air quality standards are a maximum limit not a safe level and that human health can be impacted while achieving the limit. The need to include additional mitigation will be considered on an individual basis, such as the requirements for NZT to use acid washing to remove ammonia to reduce nitrogen deposition associated with the development. However, each application is considered on an individual basis and the local authority can only comment on what is provided at planning.

Other Comments

The potential for decarbonising domestic heating networks or using waste heat from industry in the area was discussed, highlighting that the Cadence hydrogen trial was scrapped because of concerns that there was not a “robust supply” and the hydrogen village trial has been rejected due to local opposition. At the time of the workshop, the local authorities present did not know if there were any plans to adopt hydrogen as a fuel for any council buildings and suggested that it may be a question for the council’s climate change team as more information may be available.

Other concerns raised related to traffic, construction impacts and additional flaring associated with the new industrial developments or retrofitting/changes in technology/fuel use. Visual and noise aspects of these processes were also identified as being of particular concern to residents. While it was noted that green hydrogen was unlikely to require a flare, blue hydrogen production plants will.

3.3.3 Natural England Workshop - 19/02/2024

Current Baseline

The impacts of amine in air are currently not well understood when considering the effects on ecology though they are considered to be largely similar to ammonia, the contribution to nitrogen deposition still requires consideration. AQMAU has a process for considering amine interaction with nitrogen deposition and outlining Natural England’s part in an amine working group as part of the Air Quality UK

Technical Advisory Group, which considered nitrogen deposition and direct amine impacts.

Permitting

Natural England identified a perceived lack of understanding and so discrepancy planning applications submitted to Natural England and the permitting applications submitted to the Environment Agency. It was therefore suggested that Natural England and the Environment Agency need to work together to reduce the gap between the planning and permitting processes.

Cumulative Effects

The key challenge identified is locations where relevant environmental thresholds are already being exceeded by background levels. This makes justifying any further emissions to air difficult without detailed technical or site management mitigation.

Industrial stakeholders had identified that the Coatham Dunes SSSI was originally designated due to the interesting vegetative communities that developed between the steel works site and dunes, with the steel works present before the SSSI was designated. It was agreed by Natural England that the original steel works would not have been subject to, or potentially approved, under current habitat regulation assessment. As such there is a perception amongst industry stakeholders that air quality in the area was significantly worse, as a result of historic industry, and so impacts of new industrial processes will not cause a degradation in ecology / effect regeneration programs. However, Natural England do not believe that there is sufficient evidence to support this and highlighted that current levels are still too high and that critical loads in APIS have been reduced over time. It was identified that an internal discussion to clarify/conform Natural England's position on this point could be valuable.

Natural England discussed the possibility of emissions offsetting by removing existing emissions as a potential way forward. They referenced a case in Wales where mitigation included removing an existing pig farm though this was primarily to offset emissions to water rather than to air. While agriculture represents a significant source of nitrogen displacing agricultural emissions needs to be considered in significant detail specifically considering the footprint of the pollutants. It is something that if this were to be undertaken it should be a collaborative approach by a group of companies, rather than individual developers, and they would need to produce a nitrogen deposition plan for the area to ensure that it is effective.

The importance of considering atmospheric deposition and discharges to water when looking at functionally linked areas or pools which are not tidally washed so the combined inputs are larger. It was noted that in tidal areas, water quality impacts are often more significant than air quality.

Current cumulative assessments are completed based on operators running at their maximum EAL's, however, under normal operation conditions emissions will be below this level. This means that the cumulative effect of numerous plants may be less significant than cumulative studies suggest. The development of an alternative method to assessing cumulative impacts may, therefore, be beneficial.

Other Comments

The workshop identified a potential disconnect between the list of companies consulted and the limited number of responses of the questionnaire provided in Phase 2. Stakeholders appeared to have little information to share in the early stages of the project and that by consulting with trade associations the approach in Phase 3 have been more workshop based and levels of feedback had, therefore, improved.

3.3.4 UK Health Security Agency (UKHSA) workshop - 06/02/2024

Current Baseline

The problem with amines and nitrosamines is a lack of evidence base as they haven't been used at scale. The importance of the non-threshold nature of air pollution was identified with the workshop discussing if there were any internal UKHSA sources that could address the unknowns of amines and nitrosamines. It was suggested that Defra could work with the Air Quality Expert Group (AQEG) however they have a focus on existing emissions and concentrations.

The repurposing of local authority monitoring to consider ammonia, amines and NO_x around the industrial cluster was proposed including previous cases where developers have contributed to comprehensive monitoring programmes for public reassurance and permitting avoiding low funded existing council monitoring being repurposed given that NO_x and $PM_{2.5}$ will remain key pollutants for consideration until roadside emissions are significantly reduced.

A number of contributors suggest shifting the monitoring focus from perceived society risk areas to these new technology areas and improved monitoring systems are required, however the funding for this is unknown. Given that the industrial clusters are a legacy of the chemical industry growth, DESNZ identified priority clusters for the decarbonisation of existing industry prior to decarbonisation of the UK in general, with new industry attracted to the area aiming to benefit from the clusters location.

Permitting

The difficulties identified include process changes due to technological evolution, decarbonisation direction and business driven decisions rather than regulatory advice. While in principle, a lot of industry could switch to fully green electricity the challenges lie with the grid connection time, stability and number of connections required in the area. Work is in progress on an electrification ready permit condition which may encourage the switch if/when feasible. Currently full electrification is not possible due to practical impacts of the grid and grid resilience with green energy production very reliant on climatic conditions and influenced by climate change. Financial incentives rather than regulatory controls could be key in driving the switch to low carbon/electricity on operations.

Cumulative Effects

The workshop highlighted concerns that the H1 assessments for permit applications are undertaken on an individual basis and so do not consider the combined impacts. The difficulties in assessing cumulative impacts without disadvantaging/preventing future development was identified. An iterative approach was proposed as a way forward for developing technologies, e.g. NZT has committed to subsequent permit variations to incorporate operating information.

Other Comments

The demand for a hydrogen distribution network was identified as primarily being to serve industry with domestic trial in Redcar using 100% hydrogen being dropped due to local opposition. The only remaining hydrogen village trial being in Scotland. Numerous projects are looking to produce hydrogen themselves rather than relying on a larger hydrogen producer/hydrogen pipeline. There is, therefore, a potential need for an overriding group or industrial cooperation to facilitate the rollout of a hydrogen distribution network and expand the CO_2 pipeline. There is a current consideration of a safety case for 20% hydrogen blend in the gas grid. Adoption of hydrogen is anticipated to continue, despite concerns of hydrogen blending in the gas network for domestic use.

Development in the cluster will be aided by the embedded infrastructure, cultural acceptance of operations and skilled workforce in the area. The short-term solution by government instruction is NZT using a gas fired power station with carbon capture to balance the grid. It is not clear yet what technology will dominate, i.e. hydrogen combustion or natural gas combustion with CC technology and this may be influenced more by the cost of the technology and need to maintain it in the future. Other technologies, including small modular reactors, are in development which may better suit the industries in the area. However, the deciding factor may be dependent on government investment.

4.0 Conclusions and Recommendations

Careful consideration of the effectiveness of the engagement methods carried out in Phase 2 was taken before deciding on an engagement strategy for air quality. It was agreed that a combination of group workshops and one to one meetings was the most effective way to gather information from industry, trade organisations and regulators. Thirteen events were held in total. Attendance of these events was generally good. Participation in these events was productive although most developers have yet to detail the composition and potential pollutants within their emissions and understand possible effects on air quality.

The following key themes emerged through this engagement.

Emissions and monitoring

- The introduction of low carbon technology has the potential to alter current emissions within the Tees cluster. Burning hydrogen is anticipated to increase NO_x, ammonia and $PM_{2.5}$ emissions and subsequently nitrogen deposition. Hydrogen production with CC or applying CC to existing or new industrial processes will introduce new pollutants such as amines which are currently not monitored in ambient air and for which emissions monitoring standards do not exist.
- Background air quality monitoring for ammonia, amines and other novel pollutants associated with new industrial processes attracted to the area is required. Who is responsible for the monitoring also needs to be determined.

Habitats

- Ongoing work to increase the number and total area of protected habitats is increasing the pressure on existing and new industry to comply with nitrogen deposition and nutrient neutrality limits.
- An option to offset ammonia emissions by reducing emissions in another area, e.g. agriculture, is of interest to both industry and Natural England. This would need to be assessed in greater detail to ensure that any offset reduced nitrogen deposition at the ecological sites impacted by emissions to air.

CO2 gathering pipeline

- Most of the proposed projects interested in the Tees Industrial Cluster area, require the CO_2 gathering pipeline with off-shore storage, to decarbonise. However, operators are looking at numerous options for the re-use of captured CO_2. Guidance is required to limit the definition of “CO_2 use” to prevent industrial captured CO_2 being released back into the environment.
- The NZT CO_2 gathering pipeline was sized based on the predicted emissions from several early engagers. The CO_2 pipeline project has attracted the interest of an unprecedented number of decarbonising projects which may result in the need to expand and increase the CO_2 pipeline capacity or a new CO_2 pipeline. There is insufficient capacity within the pipeline tunnel beneath the river Tees for this number of hydrogen and CO_2 pipelines. Existing users of the tunnel and early H_2 developers will be able to block further development.

Permitting

- Operators have been submitting permit applications to use MEA as their solvent even though they intend to use a proprietary solvent at some stage in the future. This means they will need to vary their permits to be able to use a proprietary solvent which could create a substantial amount of permitting work and create further delay to the operations of capture plant.

- Permits to emit air pollutants are based on first come, first served basis. The cumulative impacts of ten new industrial processes, each contributing less than 1% critical load, may block a significant number of future and essential decarbonising projects. A revised approach to assessing cumulative impacts may be required especially for novel pollutants for which there are no EALs or background monitoring.

Hydrogen distribution

- A more cost effective, resource efficient and quicker roll-out of hydrogen would be achieved through the construction of two separate hydrogen distribution systems, for blue and green hydrogen, with inlet maniform connections, agreed hydrogen standards, multiple hydrogen off-takes and one operator.

All information provided during the meetings has been taken in good faith and has not been independently verified.

All stakeholders were supportive of these early discussions on air quality in the Tees Industrial Cluster. Addressing these issues promptly could help mitigate potential delays and ensure compliance with legislation and regulatory standards. This will help provide investors with confidence in the long-term sustainability of low carbon technology in the Tees Industrial Cluster.