Joint Office of Gas Transporters

UNC Workgroup Report	At what stage is this document in the process?

UNC 0607S:

Amendment to Gas Quality NTS Entry Specification at the St Fergus NSMP System Entry Point

01 Modification
02 Workgroup Report
03 Draft Modification Report
04 Final Modification Report

Purpose of Modification:

This enabling modification will facilitate a change to the current contractual Carbon Dioxide limit at the St Fergus NSMP System Entry Point, through modification of a Network Entry Provision contained within the Network Entry Agreement (NEA) between National Grid Gas plc and North Sea Midstream Partners Limited (NSMP) in respect of the St Fergus NSMP Sub Terminal.

The Workgroup recommends that this modification should: *(delete as appropriate)*

- be subject to self-governance procedures
- ~~be [further] assessed by a Workgroup~~
- proceed to Consultation

The Panel will consider this Workgroup Report on [15 June 2017]. The Panel will consider the recommendations and determine the appropriate next steps.

High Impact: None

Medium Impact: None

Low Impact: Transporters, Shippers and Consumers

Contents

Timetable

Modification timetable:

Initial consideration by Workgroup	05 January 2017
Amended Modification considered by Workgroup	dd month year
Workgroup Report presented to Panel	15 June 2017
Draft Modification Report issued for consultation	15 June 2017
Consultation Close-out for representations	dd month year
Final Modification Report available for Panel	dd month year
Modification Panel decision	dd month year

Any questions?

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1 Summary

What

This is an enabling modification that seeks to facilitate an increase in the carbon dioxide limit with the Network Entry Agreement (NEA) at the North Sea Midstream Partners (NSMP) sub-terminal at St. Fergus between National Grid Gas plc and NSMP Ltd. It is proposed to increase the limit from 4mol% to 5.5mol%.

Why

The Rhum gas field can be up to 6.5mol% CO_2, the effects of which are mitigated via blending with low CO_2 gas from Norway to St Fergus via the Vesterled Pipeline. This is not sustainable due to the prohibitive cost of procuring this service from Norwegian shippers, potentially leading to the early cessation of production from Rhum and Bruce fields.

The alternative processing and treatment solutions to remove the excess carbon dioxide have been considered upstream of the NTS (both offshore and onshore at the NSMP sub-terminal), however these would require significant investment and time to implement. Rhum would become cash negative and cease production before any project became operational.

How

In accordance with the UNC Transportation Principal Document Section I 2.2.3 (a), the Proposer is seeking to amend the NEA described above via this enabling modification. On satisfactory completion of the UNC process the parties to the NEA will be able to amend the agreement.

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2 Governance

Justification for Self-Governance

Self-Governance is proposed because the higher CO_2 gas is unlikely to have a material effect on the following self-governance criteria:

*(aa)*existing or future gas consumers. The dilution from low CO_2 (<2mol%) gas from the SEGAL sub-terminal and SAGE sub-terminal (<4mo%) and low CO_2 gas from Norway via Vesterled means that the gas export into the NTS will remain below 4mol% under most operating scenarios; and

(bb) competition in the shipping, transportation or supply of gas conveyed through pipes or any commercial activities connected with the shipping, transportation or supply of gas conveyed through pipes. By ensuring continued supplies of UK gas into the system security of supply will be enhanced, competition will be maintained and flow of gas into the NTS will be enhanced; and

(cc) the operation of one or more pipe-line system. Continued flow of Bruce and Rhum gas (up to 5% of UK domestic gas supply) will maintain flow rates in the NTS and extend system life ensuring security of supply and the opportunity to develop additional flows into the system in the future; and

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(dd) matters relating to sustainable development, safety or security of supply, or the management of market or network emergencies. The modification will enhance security of supply by ensuring that fields do not prematurely cease production and more indigenous gas will flow into the market, giving greater coverage for market or network emergencies.

Requested Next Steps

This modification should:

- be subject to self-governance
- proceed to Consultation

The workgroup has considered the modification proposal at length and has concluded…

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3 Why Change?

With the increasing maturity of UKCS as a gas production area, all producers are being asked by the Oil and Gas Authority (OGA) to focus on maximising economic recovery (MER) from existing fields.

The current CO_2 limit at the St Fergus NSMP sub-terminal is 4.0mol%. The commingled stream that arrives at the terminal via the Frigg UK Association (FUKA) pipeline system is derived from a number of Northern North Sea and West of Shetland fields including the BP operated Rhum field. The CO_2 content of the Rhum gas is between 6.2% - 6.5mol% and the Rhum field currently relies on blending with other fields in order to meet Gas Entry Conditions. As this gas is blended with other Shippers' gas within the FUKA pipeline (including the low CO_2 gas from the Laggan/Tormore fields), by the time it enters the NTS the CO_2 content is below 4.0mol%.

On occasions when the Laggan/Tormore fields trip and temporarily cease to export low CO_2 gas into the FUKA pipeline, high CO_2 content gas from the Rhum field can remain in the pipeline. Restarting gas export from the Laggan/Tormore fields then leads to a short duration increase in the CO_2 content of gas arriving at the St Fergus NSMP sub-terminal above 4.0mol% as the increasing pipeline pressure from the Laggan/Tormore restart pushes the high CO_2 Rhum gas along the pipeline and into the sub-terminal. In order to mitigate this intermittent risk of exceeding the 4.0mol% when Laggan Tormore restarts, a guaranteed daily flow of additional low CO_2 blend gas is procured from Norway to the St Fergus NSMP sub-terminal via a commercial arrangement. This gas is transported daily to the St Fergus NSMP sub-terminal via the Norwegian Vesterled pipeline. The commercial mechanism with the Norwegian shippers is costly and Rhum cannot endure having to continually purchase blend gas to cover the brief periods when additional blending gas may be required. The two other sub-terminals which are adjacent to the NSMP sub-terminal contribute blending gas which reduces the combined CO_2 content of the export gas before the gas reaches consumers.

Rhum has been delivering natural gas into the NTS as part of a commingled stream since 2005. St Fergus NSMP sub-terminal delivery to the NTS has not exceeded 4.0mol%. Rhum production flows of c.4.5 mcmd is, on average, about 15% of the total flow through FUKA and Rhum and Bruce combined account for approximately 5% of the UK National Supply.

Historically Rhum was able to export gas into the FUKA system above 3.8mol% CO_2 without increasing the CO_2 content of sub-terminal NTS delivery gas above 4.0mol% by blending the gas with low CO_2 gas from the Bruce/Keith fields (now almost depleted) and from the Alwyn area field (rates now much lower and not far from 4.0mol% CO_2 content. The suspension of Rhum production in 2010 to comply with EU sanctions against Iran (Rhum is jointly owned by the Iranian Oil Company) has created a disparity in the relative remaining gas volumes and production rates of Rhum gas relative to the Bruce/Keith and Alwyn fields resulting in the requirement for additional firm delivery to the NSMP sub-terminal of low CO_2 volumes of Norwegian blend gas.

The import of firm volumes of low CO_2 Norwegian gas commenced in 2015; this is imported via the Vesterled pipeline (from Heimdal in the Norwegian sector to the NSMP terminal) to offset the decline in

blending sources within the FUKA pipeline and ensure the CO_2 content in the export gas from the sub-terminal into the NTS remained below 4.0mol%. This activity was viewed as a short-term measure until the Laggan/Tormore fields and the associated Shetland Gas Plant started up (February 2016). While Laggan/Tormore gas provides low CO_2 gas directly into the FUKA system, modelling of pipeline flow behaviour and the subsequent observation of actual pipeline flows, has led to a requirement for an increase in the volume of firm Norwegian gas which has to be delivered on a daily basis. This is because when there is an unplanned trip/outage of the Laggan/Tormore fields, gas from the Rhum field that is already in the FUKA pipeline causes an increase in the CO_2 content of FUKA pipeline gas. On restart and ramp-up of Laggan/Tormore production, the "slug" of high CO_2 content gas already in the FUKA pipeline is accelerated into the St Fergus terminal causing a pulse of higher CO_2 gas which requires the firm delivery of Norwegian gas to blend down to <4.0mol% prior to entry into the NTS.

Once delivered into the FUKA system, the Rhum gas delivery rate at the terminal is largely determined by the flow rates into the FUKA system from the Alwyn area (up to 6 mcm/d) and from the Laggan/Tormore fields (currently up to 14 mcm/d) in addition to the Bruce and Rhum flow rates. Hence a slug of up to 10 mcm of Rhum composition gas (between 3.8-6.5mol% CO_2) could in principle arrive at the NSMP sub-terminal at rates of up to 20 mcm/d. As an unplanned outage of the Laggan/Tormore fields cannot be predicted, the St Fergus terminal operator has requested a constant volume of Norwegian gas at sufficient quantity to constantly cover the risk of a Laggan/Tormore restart generating a pulse of higher CO_2 gas causing a breach of the CO_2 specification in the NEA (4 mol%). A constant flow of Norwegian gas is required to guarantee meeting the NEA specification limit of 4.0mol% CO_2 as it would take too long for a reactive increase in Norwegian gas flow to reach the terminal. The cost of continuous provision of this gas at the flow rates required to cover Laggan Tormore field re-starts is prohibitive.

The provision of processing and treatment solutions to remove the excess CO_2 upstream of the NTS (both offshore and onshore at the NSMP sub-terminal) have been considered however, these would require significant investment and substantial time (3+ years) to implement. The Rhum field will become sub-economic and cease production before such a project could become operational. While the planned life of the Rhum field is until at least 2023, longevity is limited by the economic life of the host platform at the Bruce field. There is insufficient production from the Bruce field to cover the operating costs for the Bruce platform which is reliant on a throughput related cost share arrangement with the Rhum field to cover such costs. If Rhum field cannot flow at sufficiently high rates (either due to the cost of providing Norwegian blend gas or due to curtailment to meet current CO_2 specifications) there will be insufficient flow to cover Bruce platform costs and the Bruce, Rhum and Keith fields will cease production.

In addition, as gas at other St Fergus System Entry Points has a CO_2 content significantly lower than 4.0mol%, modelling demonstrates that gas with higher CO_2 content at the NSMP System Entry Point could be blended with gas from the adjacent sub-terminals without impacting the system or consumers. It should also be noted that CO_2 is not a defined parameter in the Gas Safety (Management) Regulations 1996, and no amendment of GS(M)R is required.

Deleted: Therefore, no immediate impact on consumers has been found thus far.

What the effects are, should the change not be made

The significant cost of securing additional firm blend gas from Norway will lead to the early Cessation of Production from the Rhum and associated Bruce and Keith fields. This problem could be addressed by treating the gas for removal of CO_2 at the wellhead or at the terminal, but the investment to bring the quality in line with current specification would be significant, take many years to complete and would make these fields uneconomic.

This modification seeks to establish a change to the existing NEA parameters as a more efficient and economic approach to facilitate delivery of potential new supplies to the System, subject to ensuring no adverse impact on consumers or on the operation of the pipeline system. Therefore, in light of the

preliminary views achieved so far, the Panel's engagement is sought to assess the impact of the requested change, in order to confirm that a higher CO_2 limit at St Fergus NSMP sub-terminal would be beneficial for the GB gas market.

If the change is not made then the resulting impacts will most likely be:

- Early abandonment of Rhum, Bruce and Keith, loss of 600 jobs and U.K. tax revenues.
- Stranded reserves (~50% reserves) that would otherwise be economic to produce.

4 Code Specific Matters

Reference Documents

None.

Knowledge/Skills

No additional skills or knowledge are required to assess this modification.

5 Solution

This modification seeks to amend a Network Entry Provision within the existing St Fergus NSMP System NEA. This amendment would increase the CO_2 upper limit for gas delivered from the St Fergus NSMP Sub Terminal System Entry Point into the National Transmission System to 5.5mol% from the current limit of 4.0mol%.

Comment [RH3]: New para from BP needs to be put in

6 Impacts & Other Considerations

Does this modification impact a Significant Code Review (SCR) or other significant industry change projects, if so, how?

No impact identified.

Consumer Impacts

No impact/positive impact. Consumers can currently receive gas at 4mol% from both the SAGE and St Fergus NSMP sub-terminals. Occasional increases in CO_2 content of export gas from St Fergus NSMP sub-terminal are currently permitted by NTS as the adjacent terminals provide additional low CO_2 gas which commingles with the NSMP sub-terminal gas, to maintain NTS gas below 4mol%.

For Information; NSMP gas including Rhum is GS(M)R compliant with or without Laggan Tormore flows from the Shetland Gas Plant. Rhum gas on its own is GS(M)R compliant.

If Rhum gas flows at normal export rates and is commingled with all FUKA sources excluding Laggan/Tormore, the composition of the combined export gas is ~4.5mol% CO_2. With Laggan/Tormore fields flowing and Rhum at peak rates, the CO_2 content of the commingled gas in the FUKA pipeline is <2.7mol%.

Consumer Impact Assessment

(Workgroup assessment of proposer initial view or subsequent information)

Criteria	Extent of Impact
Which Consumer groups are affected?	*Please consider each group and delete if not applicable.* • Parties located in close proximity to St Fergus
What costs or benefits will pass through to them?	*Please explain what costs will ultimately flow through to each Consumer group. If no costs pass through to Consumers, please explain why. Use the General Market Assumptions approved by Panel to express as 'cost per consumer'.* Though the gas may still be within GSMR spec and therefore legally and contractually compliant, a slug of CO_2, which might be associated with a rate of change of Wobbe index, could result in a risk of Peterhead CCGT trip and a subsequent cash out on gas and electricity markets
When will these costs/benefits impact upon consumers?	*'immediately on implementation'*
Are there any other Consumer Impacts?	*Prompts:* *Are there any impacts on switching?* *Is the provision of information affected?* *Are Product Classes affected?* With the increase in CO_2, downstream customers will be liable for the inherent CO_2 cost, however small. Please refer also to Carbon Cost Assessment

General Market Assumptions as at December 2016 *(to underpin the Costs analysis)*	
Number of Domestic consumers	*21 million*
Number of non-domestic consumers <73,200 kWh/annum	*500,000*
Number of consumers between 73,200 and 732,000 kWh/annum	*250,000*
Number of very large consumers >732,000 kWh/annum	*26,000*

Cross Code Impacts

None identified.

EU Code Impacts

None identified.

Central Systems Impacts

None.

cost of securing additional firm blend gas from Norway and remove the probability of early Cessation of Production from the Rhum and associated Bruce and Keith fields. This will have a positive impact on the security of supply for the UK as a whole. Recovery of oil and gas from the specific fields will be maintained, while the continued flow of gas into the pipeline systems ensure a more efficient and economic operation of the pipeline system and the increased utilization of the existing infrastructure capacity will extend the useful life of existing assets and enable further new developments to access the pipeline infrastructure in the future. ... [1]

Comment [RH4]: This section still to be completed at May workgroup meeting, see also actions to contact consumer representative organisations

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Workgroup Impact Assessment

The Workgroup identified a number of areas requiring closer assessment and collated them into a number of key themes, as follows:

- **Further Background to the Change**
- **Frequency of occurrence and the penetration into the NTS**
- **Anticipated Impact on Gas Quality**
- **National Grid NTS' Assessment of its Operational Risks**
- **Impact on Consumers**
- **Impact on Storage Operators**
- **Carbon Cost Assessment**
- **Wider Considerations**
- **Conclusions**

Further Background to the Change

Historic operational procedures & flows at the site

Historically Rhum was able to export gas into the FUKA system above 3.8mol% CO_2 without increasing the CO_2 content of sub-terminal NTS delivery gas above 4.0mol% through blending with low CO_2 gas from the Bruce/Keith fields (now almost depleted) and from the Alwyn area field (rates now much lower and not far from 4.0mol% CO_2 content). The suspension of Rhum production in 2010 to comply with EU sanctions against Iran (Rhum is jointly owned by the Iranian Oil Company) has created a disparity in the relative remaining gas volumes and production rates of Rhum gas relative to the Bruce/Keith and Alwyn fields. On the restart of Rhum production in 2014 this has resulted in the daily requirement for additional firm delivery to the NSMP sub-terminal of low CO_2 volumes of Norwegian blend gas.

Current operational procedures & flows at the site

A schematic illustrating the St Fergus sub-terminal entry to the NTS can be found below that shows the configuration of the various connections and how gas flows combine and feed into the NTS entry point.

Figure 1 Segal should be 2%

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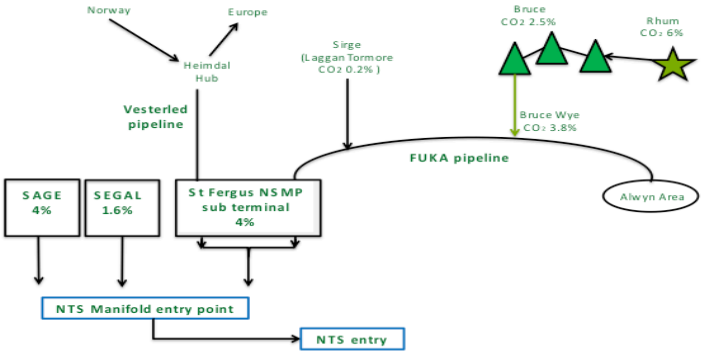

Figure 2 Segal should be 2%

Problems arise when an unplanned trip occurs at Laggan Tormore and there is insufficient blend gas to manage the requirement to reduce the CO_2 limit to 4mol% before reaching the NTS entry point.

There are no CO_2 removal systems at the terminal so the Rhum owners currently manage the risk by purchasing Vesterled gas on a daily basis to ensure there is a sufficient supply of gas available for blending should Laggan Tormore experience an unplanned trip. If this safeguard were not in place then the whole FUKA system would have to be shut down.

As a subsea tie-back the Rhum field can only be produced when the Bruce platform is operational. As a consequence, although Rhum gas can be up to 6.5mol% CO_2 it benefits from blending with lower CO_2 Bruce gas. The requested NEA change to 5.5mol% takes into account this blending and is set at a level to accommodate any CO_2 spike in FUKA pipeline gas resulting from a start-up of Laggan Tormore fields after a production trip while ensuring that the gas export into the NTS remains below 4mol% under most operating scenarios. Setting the NEA limit to 5.5mol% rather than 6.5mol% will require that on occasion e.g. during planned field/terminal outages, the Rhum field will either ramp back or shut down production or source firm quantities of low CO_2 blend gas.

Frequency of occurrence and the penetration into the NTS

Number of occurrences where St Fergus NSMP Terminal CO2 limit could have been over 4mol%

The 5.5% limit would only be needed operationally if an offshore trip at the low CO_2 Laggan Tormore field occurred. When Laggan Tormore restarts after such a trip it pushes a volume of high CO_2 gas from Rhum towards the terminal in a stream of other UKCS gas and thus causes a temporary CO_2 spike, which if the CO_2 limit is 4mol% would result in the shut in of all UKCS gas in the FUKA pipeline system and not just the Rhum flows.

Since the startup of twin compressor operation in May 2016, the FUKA operator has recorded **13** separate “total” outages of the Laggan/Tormore fields (see table below).

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	Double Compressor Trips at SGP since 2 Compressor Operations (May 16)		
	Date Start	Date End	Total Time (Days)
1	21/05/2016 03:00	21/05/2016 09:00	0.3
2	21/06/2016 20:50	24/06/2016 12:00	2.6
3	26/06/2016 03:00	26/06/2016 10:45	0.3
4	14/07/2016 16:30	15/07/2016 09:00	0.7
5	18/07/2016 18:10	18/07/2016 23:48	0.2
6	07/08/2016 05:32	08/08/2016 22:03	1.7
7	03/10/2016 00:00	04/10/2016 10:30	1.4
8	06/10/2016 13:18	07/10/2016 05:00	0.7
9	08/01/2017 00:51	08/01/2017 09:57	0.4
10	06/02/2017 03:09	06/02/2017 14:46	0.5
11	09/02/2017 11:17	09/02/2017 16:38	0.2
12	11/02/2017 15:04	12/02/2017 11:48	0.9
13	14/02/2017 15:37	15/02/2017 06:42	0.6

Total	10.5
Average (Days)	0.8

By their nature, unplanned outages cannot be forecast, however the historic uptime of facilities could be considered as an indicator of reliability. The Shetland Gas Plant (SGP), which processes fluids from the Laggan and Tormore fields, is essentially new. As highlighted, since May 2016 a total of 13 trips have been recorded (to end Feb 2017) giving an aggregate of 10 days outage overall. This equates to a 4% downtime. However, it is understood that SGP has now commissioned an additional compression capacity, which should help maintain and possibly further improve reliability. A contracted new field that is currently under development will also provide additional blend gas into the FUKA pipeline. It is expected that the reliability will be high from new equipment once the initial commissioning and "fine tuning" have been completed. The reliability of another older infrastructure providing gas into the pipeline (existing FUKA entrant) has been higher at over 98% over the last 1 – 2 years.

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As mentioned earlier, Laggan Tormore gas had been unavailable only 4% of the time. The cost of purchasing this contingency blend gas to cover these unplanned outages is prohibitive to Rhum and no longer sustainable. If another contingency mechanism cannot be found then it will lead to the early closure of both the Rhum and the Bruce fields.

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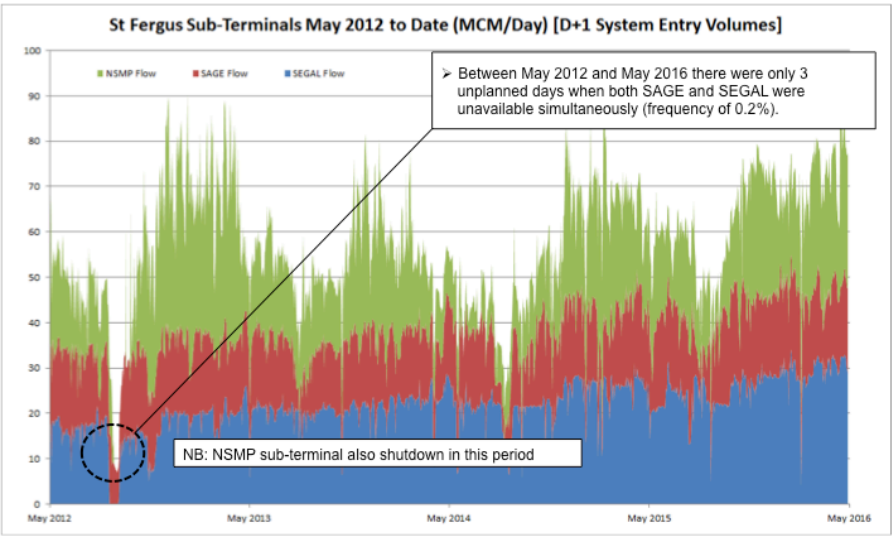
St Fergus Sub Terminal System Entry Volumes (May 2012 to May 2016)

A blend gas graph illustrating St Fergus sub-terminals system entry volumes from May 2012 - May 2016 can be found below.



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It should be noted that there were only 3 unplanned days when both SAGE and SEGAL were unavailable simultaneously (a frequency of 0.2%). (Note the NSMP terminal was also shutdown at the same time). In these circumstances, SAGE and SEGAL do not mitigate the risk of there being CO_2 over 4mol% and the fields would need to be shut in.

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St Fergus CO_2 Blending Analysis

An example of operational flows at the St Fergus NSMP terminal can be found in Appendix 1. SAGE and SEGAL have separate entry points into the NTS and are downstream of the compression station; the blending happens within the NTS terminal. Frigg gas blends with Vesterled and then further with SAGE and SEGAL before entering the NTS terminal.

Four different scenarios were analysed (see Appendix [2]?) and all four assume Laggan Tormore trips for over 60 hours (highest of historical trips observed) on an ordinary summer's day. Actual average flow rates from SAGE and SEGAL are used but NSMP flows are adjusted in each scenario. The scenarios suggest that the gas flowing into the NTS does not go above 4mol% even when Laggan Tormore goes offline unplanned.

Comment [C5]: Do we want to include further information on the 4 scenarios in an appendix?

Comment [RH6R5]: Yes, MK to provide

A high CO_2 slug is produced but it is dependent on the actual flow rates when Laggan Tormore restarts. The actual size and duration is subject to the speed of the ramp rate. If this rate is slow, there is less pressure in the pipeline, the CO_2 content is lower, but the duration is longer. The BP scenarios assume Laggan Tormore ramps up to full production over a 6-hour period. This longer ramp up of Laggan Tormore reduces the rate at which offspec gas arrives at the NSMP terminal, thereby reducing peak CO_2 levels.

Deleted: Four different scenarios were analysed (see Appendix [2]?) and all four assume Laggan Tormore trips for over 60 hours (highest of historical trips observed) on an ordinary summer's day. Actual average flow rates from SAGE and SEGAL are used but NSMP flows are adjusted in each scenario. The scenarios suggest that the gas flowing into the NTS does not go above 4mol% even when Laggan Tormore goes offline unplanned.

For the BP Scenarios, the peak CO_2 slug duration ranges from 10 hours (scenario 1, peak CO_2 3.65%) to 15 hours (scenario 4, peak CO_2 3.87%). Therefore, the duration of 15 hours is considered the worst-case scenario.

The Workgroup asked National Grid NTS to provide a view on the analysis performed by BP and they used the inputs to the four BP scenarios and calculated the CO_2 content that would be expected on the pipelines leaving St Fergus terminal. The results below demonstrate that National Grid NTS' calculations align well with the analysis performed by BP. (Note the figure of 172 mscm/d relates to total national demand)

30th June 2016 (172mscm/d)							
Scenario 1		Scenario 2		Scenario 3		Scenario 4	
BP Results	NG Results	BP Results	NG Results	BP Results	NG Results	BP Results	NG Results
3.65	3.65	3.78	3.79	3.66	3.66	3.87	3.88

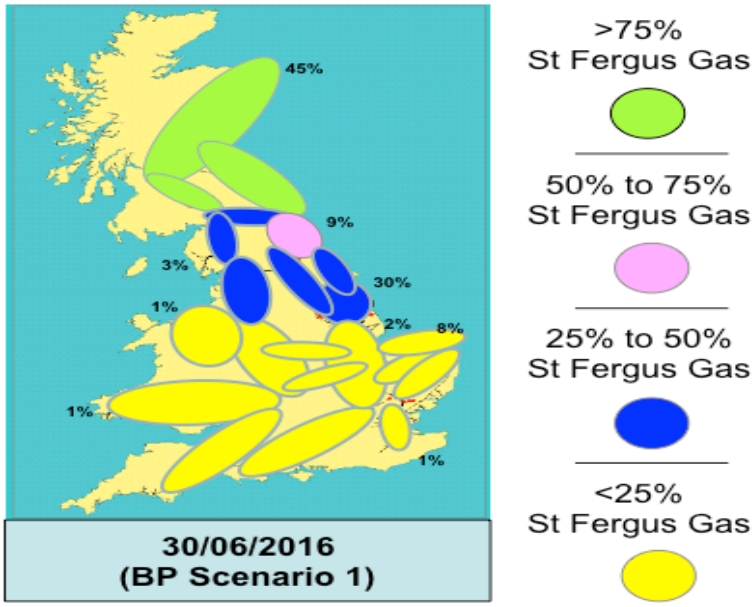
Penetration into the NTS

In respect of the BP scenarios National Grid NTS were also asked to provide a 'heat map' analysis; to determine the risk of high CO_2 gas entering the NTS and how far any out of specification flow might then be expected to reach. The Workgroup also requested that the analysis contained information about the assumed distribution of supplies, where the gas would blend on the NTS and the NTS flow patterns.

Two 'heat map' schematics were provided by NTS. The first shows the penetration of aggregate flows of St Fergus gas into the NTS, assuming entry flows are equal to those presented in BP's analysis, scenario 1 (selected because this contains the highest flows of all BP scenarios and is thus a 'worst case' from the BP scenarios):

- SAGE: 20 mcmd
- SEGAL: 18.3 mcmd
- Vesterled: 8.2 mcmd
- Frigg: 30 mcmd

Supplies from other NTS entry points are proportionate to the 2016 Future Energy Scenarios (FES) for that demand level. The percentages show the contribution to total demand from each supply source.



Comment [C8]: To be updated to include the weighted average CO_2 positions and the maximum daily CO_2 levels.

Comment [RH9R8]: Need to Update following 22/5/17 NTS presentation into appendix along with average daily cost from Feb 2017 WG meeting

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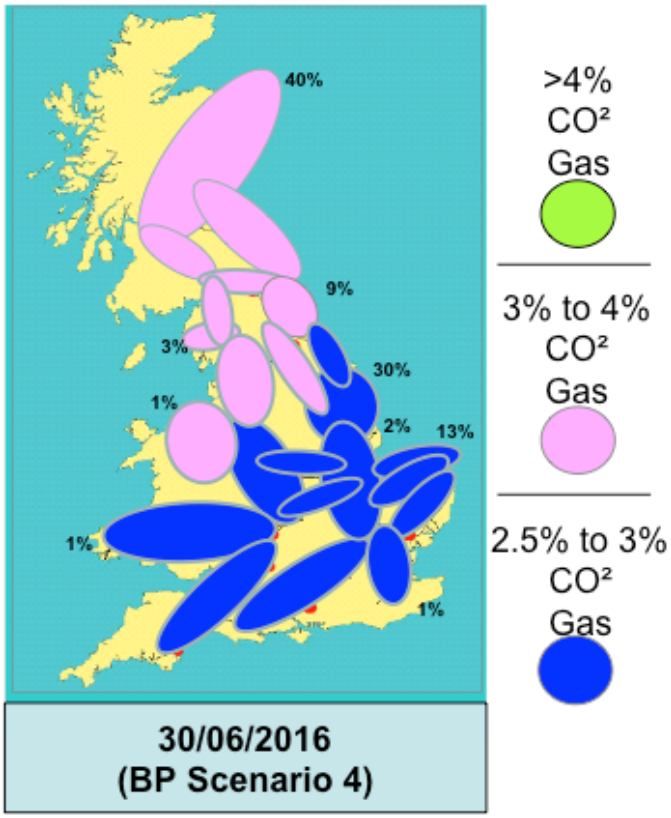
The second 'heat map' schematic shows the levels of CO_2 on the NTS, assuming St Fergus sub-terminal flows and CO_2 content are equal to BP's scenario 4 (giving a 'worst case' CO_2 entering the NTS from the four BP scenarios). This scenario shows a blend of 3.87% CO_2 entering the NTS, therefore no NTS direct connect receives any gas in excess of 4%.

Supplies from other NTS entry points are proportionate to the 2016 FES for that demand level and deliver gas at their CO_2 limits. The percentages show the contribution to total demand from each supply source.



In order to understand the impact on the St Fergus blending, the Workgroup also asked National Grid NTS to provide another 'worst case' scenario based on the Shell low flow period in June 2016 (using actual CO_2 data and NEA upper limits). To calculate the CO_2 blend at St Fergus terminal under each of BP's 4 scenarios, National Grid NTS altered:

- the Shell flow from 18.3 mscm/d to 10.4 mscm/d
- Shell CO_2 content from 1.6% to the maximum CO_2 limit of 2.0%

The results below show an increase above 4% CO_2 content entering the NTS under two of the scenarios.

30th June 2016 (172mscm/d National Demand)					
Scenario 1			Scenario 2		
BP Results	NG Previous Result	NG New Result	BP Results	NG Previous Result	NG New Result
3.65	3.65	3.94	3.78	3.79	4.13

30th June 2016 (172mscm/d National Demand)					
Scenario 3			Scenario 4		
BP Results	NG Previous Result	NG New Result	BP Results	NG Previous Result	NG New Result
3.66	3.66	4	3.87	3.88	4.24

Members of the Workgroup felt that this extreme scenario is unlikely to occur as the low flow from the Shell terminal was caused by a planned outage and the following steps would have been taken in advance to mitigate CO_2 >4% entering the NTS:

- Rhum owners would procure sufficient firm quantities of low CO_2 gas via the Norwegian Vesterled pipeline;
  or
- Rhum owners would cut back or shut in production to limit the volumes of high CO_2 gas

It should also be noted that the BP scenarios, on which this extreme scenario is based, already assume that a number of unlikely events would occur concurrently, namely:

- Conservative assumption in BP scenarios that there would be no low CO_2 blend gas flow via the Norwegian Vesterled pipeline. Vesterled < 3.7% CO_2 with average summer flow rates of 10.4 mcm in 2016.
- Conservative assumption of concurrent outages of all the fields delivering gas into the FUKA pipeline system e.g. BP scenario 4 assumes FUKA is operating at around 20% of normal throughput rates.

It should be further noted that a new Norwegian field is due to start-up shortly which will bring additional volumes of low CO_2 blend gas into the FUKA pipeline system which will further help mitigate any Laggan Tormore unplanned trip scenarios.

Insert text here for: **Action 0307:** SB to look at the low flow period (8 days in June 2016) to clarify the background to the event and how relevant it is to this analysis/development of further scenarios. **Carried Forward**

CO_2 content at Norwegian gas fields

The Workgroup asked if changing the CO_2 limit to 5.5% would introduce a risk of higher CO_2 gas entering through the Vesterled pipeline in the future. Information received from Gassco indicated that:

- The historical range in CO_2 levels had been 1.5% - 3.5%
- Production volumes are forecast to fall rapidly over the next few years
- Forecast CO_2 levels are expected to be 1.5% - 4%.

Anticipated Impact on Gas Quality

Action 0106: BP (MK) to clarify if other gas quality parameters are affected (CV, Wobbe and Dewpoint). – awaiting Dewpoint issue to be clarified. DOD to also confirm if there are any known issues with regards to introducing water through the application of this process at higher CO_2 level.

Comment [RH11]: Water or hydrocarbon

The Workgroup sought input from NSMP to improve their understanding of how the plant operates at the right Wobbe Index level and the effect on the CO_2 levels/liquids.

NSMP Response

The composition of export gas from St Fergus is monitored by the control room and procedures are in place to ensure the specification of export gas is maintained. NSMP is fully aware of the composition of commingled pipeline gas upstream of the terminal and therefore would be aware of higher CO_2 concentrations in FUKA pipeline gas well before such gas reaches the terminal (as they are today). If NSMP's pipeline operating model suggested that by processing such gas, the lower specification for Wobbe Index might be breached, NSMP would modify the operating conditions at the terminal (specifically levels of NGL extraction) to ensure that the specification for export gas is met. This can be done relatively quickly and well within the anticipated transit time of any high CO_2 gas present within the pipeline.

To answer the questions relating to CO_2 concentrations in liquids export and maintaining water dew point, NSMP has run a number of HYSYS simulations with gas compositions up to 6 mol% CO_2 and can confirm that at higher concentrations of CO_2 within the pipeline gas, the CO_2 content of the NGL does increase. However, in all modes of operation required to maintain the NTS gas specifications, the CO_2 content of the NGL remains less than 0.001 mol% which is well below the specification limits for NSMP's NGL export. In theory, there is some impact on the water dewpoint of export gas through increased CO_2 content however, this is taken care of by the gas dehydration system and in all cases modelled, the sales gas remains well within spec (by a margin of over 40°C).

Impact on other gas quality parameters

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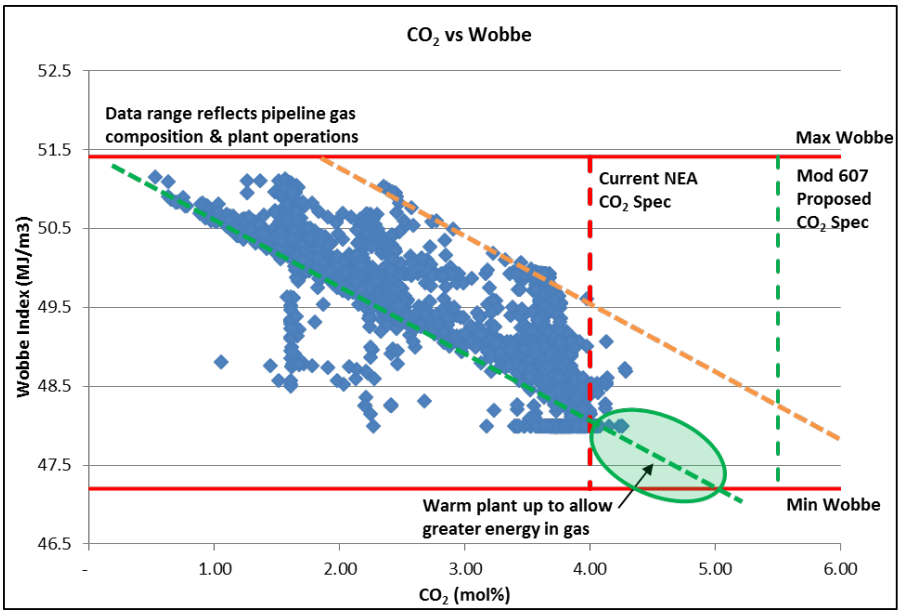
The Workgroup requested that analysis be performed on the consequential impacts of increased CO_2 on other gas quality parameters. The St Fergus terminal operator provided correlations of CO_2 content with other NEA Specifications in the gas delivered to the NTS from the FUKA pipeline. The CO_2 content of the processed gas from the FUKA pipeline has been correlated with several GS(M)R parameters measured at the same time (namely, WOBBE, Gross Calorific Value (GCV), Incomplete Combustion Factor (ICF) & Soot Index (SI)). The specification of processed gas from the FUKA pipeline is measured "stand- alone" before commingling with Vesterled gas and is upstream of the NTS compressor station. The data includes certain short-duration periods when blending with Vesterled gas was required due to higher CO_2 concentrations in FUKA pipeline (as per the current blending arrangements).



In summary, the historic data analysed reflects variations in pipeline gas composition and also plant operation. An increased CO_2 content of FUKA gas reduces Wobbe and (to some degree) GCV of redelivery gas. Higher CO_2 content gas may need to be managed by adjusting the processing plant operation (warmer plant) to reflect the pipeline gas composition and ensure the export gas meets the lower Wobbe specification.

European Standard on Gas Quality

The European Committee for Standardisation (CEN) published its gas quality standard EN16726 in December 2015. Agreement could not be reached on a harmonised range for Wobbe-Index but was for all other components including CO_2, for which the CEN standard states:

- "At network entry points and cross border points the maximum mole fraction of carbon dioxide shall be no more than 2.5%. However, where the gas can be demonstrated to not flow to installations sensitive to higher levels of carbon dioxide, e.g. underground storage systems, a higher limit of up to 4% may be applied."

The standard's application to Member States is voluntary, although the European Commission had already stated its aspiration to see the standard implemented across Europe. To that end, the Commission requested that ENTSOG conduct an impact analysis and propose an amendment to the EU Interoperability Network Code to make its implementation legally binding.

ENTSOG's project to examine the impacts was conducted during 2016 and this CO_2 wording raised a number of issues for GB at that time. For example, it was not clear how the flexibility between 2.5% and 4% would be applied and managed over time, and, as the GB network contains underground storage facilities, it appeared that all GB entry points would need to conform to a 2.5% limit. Analysis by National Grid NTS showed that this would be expected to have a material negative impact on GB security of

supply. This, together with a number of other concerns raised by EU market participants, resulted in the Commission announcing at the Madrid Forum in October 2016 that it did not propose to proceed with making the standard legally binding at this stage but would reconsider gas quality harmonisation again when further CEN work seeking to establish a harmonised Wobbe Index range reaches a conclusion, which is unlikely to be before 2020.

National Grid NTS' Assessment of its Operational Risks

National Grid NTS wishes to assess the possible NTS operational risks arising from higher CO_2 levels from an NTS integrity perspective. National Grid NTS is to assess the risks in terms of:

- Impact on pipeline corrosion rate of higher CO_2 gas if water was present in NTS pipelines.
- Confirm that the CO_2 levels on the NTS passing a salt cavity storage facility will not have a higher pipeline corrosion rate
- Assess any impact of higher CO_2 levels on compressor start-up
- Assess any impact on compressor running associated with a rapid change in CO_2 (such as might be expected with a trip)

In summary, the conclusions of these assessments are as follows:

- Transportation of gas with a CO_2 content of 5.5% would not increase corrosion risk if the network is dry or in the event that small amounts of water are present which result in thin aqueous films on the inner wall of a pipeline;
- If significant quantities of water were admitted into an NTS pipeline causing the formation of pools of 5mm depth accompanied by gas with a CO_2 content of 5.5%, significant corrosion damage would occur, particularly if multiple instances of such water ingress occurred over the operational life of the pipeline;
- A water dewpoint limit of -10 degrees celcius at transmission pressures means that corrosion would only occur if the pipeline wall temperature at the location of gas entering from a salt cavity storage facility were at this temperature or below, thus allowing the formation of liquid water in the pipeline. A sustained temperature of less than -10 degrees celcius has not occurred in the UK based on Met Office records, therefore there should be no impact if gas with a CO_2 content at 5.5% passes a salt cavity storage site.
- Gas with a 5.5% CO_2 content is not expected to impact the performance of National Grid's compressors at St Fergus provided that the total inerts content of the gas (i.e. CO_2 plus nitrogen) remains below 7mol%.

Impact on consumers

The analysis conducted suggests that Direct Connects (DCs) should not receive over 4mol% CO_2 as a result of an unplanned outage at Laggan Tormore but a slug of higher CO_2 (up to 3.87%) could enter the NTS and the duration could be up to 15 hours (worst case scenario).

The Heat Maps provided by National Grid NTS identify the flow routes, and areas which might potentially be affected if penetration reaches further zones.

The Workgroup has sought Views on the impacts on end consumers. For Modification 0498/502 information was provided by affected parties in relation to:

Combined Cycle Gas Turbines (CCGTs)

- Linking CCGT Trips to Changes in Gas Quality
- Direct Costs for CCGT Trips/Retuning
- Warranty Impacts
- Downstream Consumers – impact on CO_2 Removal Systems]

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Action 0301: Joint Office to contact various consumers/groups for views on the impacts on them from this proposal.

Impact on Storage Operators

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Richard Fairholme (Uniper) has offered to provide a view in relation to the Holford Storage site in Cheshire and discuss potential impacts with the Gas Storage Operators Group.

Action 0302: RF to provide a statement on the Storage impacts for the WGR at the next meeting.

Carbon Cost Assessment

Comment [C12]: Would this section benefit from including any further detail/conclusions from Mod 0498/502 FMR?

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At present, gas with high levels of CO_2 concentration flows from offshore fields and under normal circumstances is blended in the FUKA pipeline with gas of lower CO_2 concentration feeding into the pipeline from other fields such that the combined commingled flow of gas exiting the St Fergus terminal and entering the NTS meets the current NTS entry specification for CO_2 at 4 mol%. Therefore, the tonnage of CO_2 associated with gas with high levels of CO_2 concentration already flows into the NTS albeit in a diluted form.

The options for addressing the possible increases in CO_2 levels in export gas during periods when dilution in the FUKA pipeline is unavailable or reduced are to either:

- allow such gas to flow directly into the NTS up to an agreed level (5.5 mol%), or
- to remove the excess CO_2 above the current allowable specification (4.0 mol %) using CO_2 removal technology.

Modification 0498 and 0502[1] considered the following three scenarios, which are relevant to this modification request:

Comment [RH13]: Provide hyperlink to these FMRs?

1. Non-removal of CO_2
2. Removal Offshore
3. Removal Onshore

The removal technology in this scenario remains the same as that considered in Modification 0498/ 0502 and the significant cost (c. £200m) and long lead time (c. 3 years) associated with the brownfield engineering modifications required for options 2 and 3, all of which remain unchanged from 0498/0502, renders these options non-viable for use here on an ad-hoc basis. In addition, the key conclusion of the Teesside carbon cost assessment is that significantly more CO_2 is emitted by removing CO_2 from the gas due to the fact that CO_2 removal using amine units, the optimal technology for CO_2 extraction given the CO_2 concentration, requires process heat which generates additional CO_2. The magnitude of expected CO_2 emissions here is similar to the Teesside modification. When the fact that the CO_2 would already flow to the NTS is taken into account, the conclusion for this Modification 0607s, based on data from the Teesside report that the least impact in terms of overall CO_2 emissions is to allow the gas with high CO_2 to flow into the NTS, is also valid for the proposed St Fergus modification.

Wider Considerations

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Maximising Economic Recovery

1. Final Modification Report 0498: Amendment to Gas Quality NTS Entry Specification at BP Teesside System Entry Point and 0502: Amendment to Gas Quality NTS Entry Specification at the px Teesside System Entry Point

The Oil and Gas Authority (OGA) have provided the following statement with regards to their involvement to facilitate solutions for blending of high CO_2 gas from the Rhum field in pursuit of Maximising Economic Recovery (MER).

Following on from the Wood report and the establishment of the OGA as a new regulator for the UK upstream Oil and Gas industry there have been a number of legislative changes to establish the role of the new OGA and to clarify the obligations for all upstream industry participants. The Maximising Economic Recovery Strategy for the UK was published in 2015. The central obligation of this strategy is that 'Relevant persons must, in the exercise of their relevant functions, take the steps necessary to secure that the maximum value of economically recoverable petroleum is recovered from the strata beneath relevant UK waters'.

In its pursuit of fulfilling this obligation the OGA has actively intervened with the owners of the Rhum field and the operators of the Bruce field, the FUKA infrastructure and the SIRGE pipeline /Shetland Gas Plant (SGP).

These interventions have included: -

- *Facilitating completion of negotiations of an amended Rhum/FUKA Transportation Agreement which allowed ramp up of Rhum production from 1MCM/d to 5MCM/d albeit with additional payments required to secure arrival of sufficient Vesterled pipeline gas at the FUKA terminal as additional assurance against temporary % CO2 excursions exiting the terminal. This additional assurance represents significant UK value leakage.*
- *Encouraging follow on discussions between the Bruce/Rhum Operator and the FUKA operator to optimise pipeline and terminal operations which have reduced the requirement for guaranteed Vesterled blend gas at FUKA.*
- *Discussing potential upstream solutions with the owners /operator of SGP around plant trips and the timing of subsequent start ups*
- *Discussing with the prospective new owner operator of the SAGE terminal around the potential use of SAGE CO2 removal equipment to give further assurance around the % CO2 leaving the St Fergus National Grid plant (such service provision is potentially alleviated by the change in operatorship away from a US company).*

In addition, the OGA has engaged in discussion with National Grid to promote understanding of the OGA's role and in understanding the capacity for blending and risk reduction across the St Fergus terminals.

The driver for all these interventions is to reduce the economic impact of current blending approaches on the Rhum field and potentially on other high CO2 fields which could lead to premature cessation of production of the Bruce /Rhum offshore Hub (loss of significant UK gas to the downstream system) and/or deter further upstream investments to recover additional gas.

Impacts on Producers

Action 0303: AB to provide some text for the Workgroup Report on the wider impacts on producers.

The ability to accept a higher CO_2 at NSMP (from 4% to 5.5%) will depend the operating status of the various fields delivering gas into Shell St Fergus. Under normal operating conditions, the CO_2 content of this gas may permit a higher spec in the NEA at the NSMP sub-terminal, partly due to previous investment undertaken by field owners delivering gas into Shell St Fergus. However, in non-normal operating conditions, even the fields delivering gas into Shell St Fergus may themselves need a temporarily higher CO_2 content. Approval of the proposed UNC modification would remove National

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Grid's ability to accept such gas from other producers, with priority to any flexibility on the part of National Grid given to NSMP flows.

Risk of setting precedent

The Workgroup considered whether any decision taken for Modification 0607S might set a precedent for any other, future, requests at entry points. Ofgem's view as expressed in their UNC 0498 0502 Ofgem Decision Letter (25th September 2015) in response to concerns that the 0498/0502 modifications would create unnecessary barriers to future supplies entering the NTS stated "that it is open to UNC parties to raise any further gas quality modification proposals, and any such modification proposal will be assessed on a case by case basis on its merits and with respect to the UNC relevant objectives; therefore, this decision should not be seen as setting any precedent for the future". On the basis of this individual objective assessment, the proposal is not believed to be discriminatory.

Comment [C14]: From 0498/0502

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Conclusions

Comment [C15]: From modifications 0498/502. TBC

No clear conclusions have been achieved. Workgroup participants differed in their view of these changes, depending on the impacts they believed were most relevant to them. This report seeks only to document the arguments to inform further consideration within the UNC modification process (which assesses against the Relevant Objectives). Participants believed that there are other considerations, such as the wider UK interest and UK Government Policy, which are beyond the vires of a UNC modification.

7 Relevant Objectives

Impact of the modification on the Relevant Objectives:

Relevant Objective	Identified impact
a) Efficient and economic operation of the pipe-line system.	Positive
b) Coordinated, efficient and economic operation of (i) the combined pipe-line system, and/ or (ii) the pipe-line system of one or more other relevant gas transporters.	None
c) Efficient discharge of the licensee's obligations.	None
d) Securing of effective competition: (i) between relevant shippers; (ii) between relevant suppliers; and/or (iii) between DN operators (who have entered into transportation arrangements with other relevant gas transporters) and relevant shippers.	Positive
e) Provision of reasonable economic incentives for relevant suppliers to secure that the domestic customer supply security standards… are satisfied as respects the availability of gas to their domestic customers.	None
f) Promotion of efficiency in the implementation and administration of the Code.	None

g) Compliance with the Regulation and any relevant legally binding decisions of the European Commission and/or the Agency for the Co-operation of Energy Regulators.	None

Demonstration of how the Relevant Objectives are further inserted here:

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This modification to change the CO_2 limit at the NSMP Sub Terminal has been preceded by discussion between National Grid NTS and BP, aimed at assessing the feasibility of such change. Some of the following considerations therefore reflect both the results of National Grid NTS analysis and BP's own assessment of changes.

Positive impacts have been identified on the objectives of *a) efficient and economic operation of the pipeline system* and on *d) competition among shippers*.

The combined flows of Bruce and Rhum fields contribute around 5% of UK domestic gas supply into the NTS. These flows help towards a more efficient and economic operation of the pipeline system thanks to an increased utilisation of the existing infrastructure capacity and extending the useful life of existing assets. In addition, extending the production life of the Bruce and Rhum assets allows a wider range of gas into the network and mitigates instances of interruption in production flows, due to seasonal maintenance programs which affect the overall supply of gas to the UK market. In addition, the Workgroup has concluded that the lowest cost option would be to permit the entry of up to 5.5% CO_2 content from NSMP at St Fergus rather than install upstream removal of CO_2 or for the blending gas from Vesterled to continue to be procured.

Competition between shippers should be improved through maximization of available production by avoiding early cessation of production, maintaining diversity and reducing reliance on imported gas. In addition, the presence of domestic supplies could contribute to efficient price formation and help sustain the National Balancing Point (NBP) as a liquid hub.

Early cessation of production at Rhum is an assertion by the Proposer which the Workgroup was not able to test due to lack of evidence, for commercial reasons [this should probably be put elsewhere].

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8 Implementation

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As self-governance procedures are proposed, implementation could be sixteen business days after a Modification Panel decision to implement, subject to no Appeal being raised.

9 Legal Text

Text Commentary

As this is an enabling modification, no UNC legal text is required.

Suggested Text

Suggested text to modify the Network Entry Provisions contained within the relevant NEA has been provided by the Proposer.

"2.3 Gas tendered for delivery by System Users to the System at the System Entry Point shall not contain any solid, liquid or gaseous material which would interfere with the integrity or operation of the System or any pipeline connected to such System or any appliance which a consumer might reasonably be expected to have connected to the System. In addition, all gas delivered to the System at the System

Entry Point shall be in accordance with the following values: (k) Carbon Dioxide Not More than 5.5mol%."

The Workgroup has considered the legal text and is satisfied that it meets the intent of the Solution.

10 Recommendations

Workgroup's Recommendation to Panel

The Workgroup asks Panel to agree that:

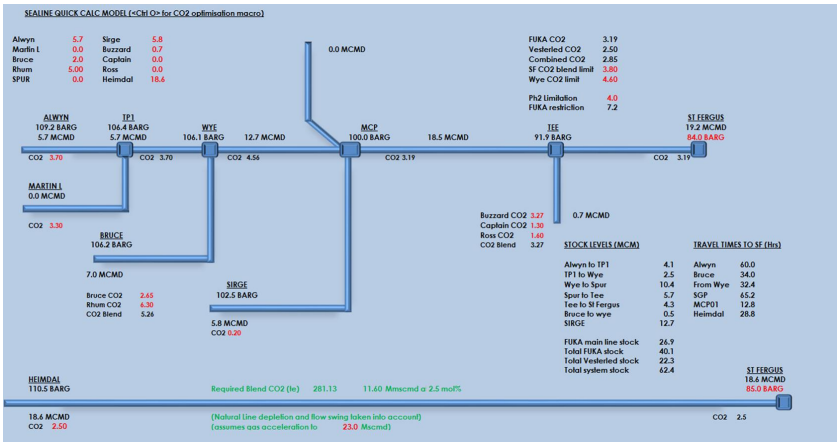
- This self-governance modification should proceed to consultation.
- This proposal requires further assessment and should be returned to Workgroup.

11 Appendices

1 St Fergus Flow Map

Appendix 1 - St Fergus Flow Map

Please find below an example of the operational flows at St Fergus NSMP terminal.



12 Glossary

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Implementing the change will remove the significant cost of securing additional firm blend gas from Norway and remove the probability of early Cessation of Production from the Rhum and associated Bruce and Keith fields. This will have a positive impact on the security of supply for the UK as a whole. Recovery of oil and gas from the specific fields will be maintained, while the continued flow of gas into the pipeline systems ensure a more efficient and economic operation of the pipeline system and the increased utilization of the existing infrastructure capacity will extend the useful life of existing assets and enable further new developments to access the pipeline infrastructure in the future.

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Domestic Consumers
Small non-domestic Consumers
Large non-domestic Consumers
Very Large Consumers

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please explain any deferred impact.

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