Bogdan Kowalewicz
Office of Gas and Electricity Markets
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Dear Mr Kowalewicz

Costain believes that carbon capture and storage plays a major role in ensuring the UK meet their emission reduction targets. We support, in principle, National Grid's proposal to re-use existing NTS pipeline assets for the transport of carbon dioxide from large carbon dioxide producers in central Scotland, for sequestration in the North Sea. The project would be a significant step forward in the commercial deployment of CCS in the UK, with positive learning that can advance CCS worldwide.

Costain's response is focused around the potential of the proposed NG Carbon pipeline to generate the returns proposed for gas consumers (Question 5). The consultation does not provide evidence that the pipeline is capable of transporting carbon dioxide from the CCS demonstration plant, or more importantly for gas consumers, from multiple sources in a commercial transportation system. It is fundamental to the proposal that NG Carbon provide evidence that carbon dioxide transportation is feasible. Without this, there is no proof that NG Carbon are capable of providing value to gas consumers if the pipeline sections are disposed for re-use.

During the carbon capture demonstration at the power station it is possible that the pipeline will transport carbon dioxide in the gaseous phase, with pressures in the region of 20-50 bar. This pressure is within the maximum pipeline operating pressure stated in the consultation document.

It is widely accepted that mature carbon dioxide networks will transport carbon dioxide in the dense phase. A pure carbon dioxide stream will remain in the dense phase at the typical range ambient ground temperatures foreseen in Scotland, as long as the pipeline operates at a pressure of >75 bar, With impurities the pressure may need to be >85 bar. The consultation document states that the pipeline sections under consideration for conversion to carbon dioxide transportation have a maximum operating pressure of 70-85 bar. It is unclear if this is the upper design limit of the pipelines, or if they can be tested and re-rated for higher pressures. If the pipeline is not capable of transporting carbon dioxide at a pressure >85 bar, commercial operation of the pipeline with multiple carbon dioxide sources may not be possible. This indicates that the financial gains proposed for gas consumers through increased carbon dioxide throughput (2-6Mt/yr) may not be realised. Also this could impact on

the ability for NG Carbon to make the carbon dioxide pipeline a viable business, taking into account the costs NG Carbon could incur from the incremental buyback and increased NGG opex indicated in the proposal.

At present, accurate modelling of carbon dioxide flow in the dense phase may present a challenge to the pipeline industry. A recent report by the Health & Safety Laboratory on Comparison of Risks from Carbon Dioxide and Natural Gas Pipelines states that there is uncertainty when modelling dense phase carbon dioxide as the formation of solids cannot be measured accurately.

A full study on the condition of the NTS pipeline will need to be performed to assess corrosion within the pipelines, the suitability of the material for carbon dioxide use and the integrity of the pipeline.
Pure dry carbon dioxide is not corrosive, however if the stream contains impurities, this may not be the case, hence testing is required to determine the corrosive effects of the carbon dioxide stream on the pipeline.
In the event of a loss in pressure in the pipeline the carbon dioxide stream could enter multiphase flow and rapidly cool. The pipeline material needs to be capable of coping with the change in conditions.
The EIA states that the pipeline sections would need to be decommissioned by 2020 if they were not converted for carbon dioxide transportation, the sections will be roughly 45 years old at this time. If the pipeline is converted to carbon dioxide use in 2013 this only leaves 7 years of operation. Do NG Carbon believe that they can find other industrial carbon dioxide emitters who will have fitted carbon capture technology by 2020? If this is not likely, gas consumers will not make the returns that the consultation suggests.

There are numerous safety concerns regarding the transport of carbon dioxide in cross-country pipelines. Carbon dioxide is toxic and denser than air. This could presents a major safety hazard in the event of a pipeline fracture and leak, especially as the pipelines will undoubtedly pass near/through areas of population. There will need to be leak detection at regular intervals along the pipeline and additional sectioning valves to limit incidents. The gas may also require odourising. Early public engagement regarding transport of carbon dioxide over the proposed route will be vital in gaining public support for the proposal.
The recent Health & Safety Laboratory report mentioned previously concluded that carbon dioxide used for CCS has sufficient toxicity to be regulated as a dangerous fluid under the Pipeline Safety Regulations (PSR).

Currently in the UK there is no legislation for the transportation of carbon dioxide in pipelines. Each carbon capture technology produces a carbon dioxide stream with a different properties (due to the various impurities present), therefore a carbon dioxide specification that will be acceptable for all types of carbon capture technology requires developing and implementing. This will require investment from the carbon dioxide producers?

With the potential for other carbon dioxide emitters to inject into the pipeline, and carbon dioxide to be stored in several locations, the need for regulation should be addressed. If, or at what point should a UK regulator be appointed or should each pipeline be independently regulated?

Frequent pressure boosting will be needed along the pipeline to ensure the carbon dioxide remains in dense phase during commercial operation. This would also incur capex and opex costs for NG Carbon.

It is not clear from the consultation paper, whether National Grid is considering to re-use existing compressors at the compression stations for carbon dioxide duty. If this were to be completed the compressor station would require significant changes:

- Pipework modifications and additions in order to transport the carbon dioxide in the opposite direction and to separate from the existing natural gas compression system (May require lengthy outages for compressor stations)
- The power and compression ratios for compressing carbon dioxide gas would be different to compressing natural gas
- Some compressors may be aging and require re-lifing/replacement over the lifetime of the project
- Stations may need new after and coolers for carbon dioxide duty
- Compressor parts will need to be checked to ensure they are compatible with carbon dioxide, even down to o-rings and gaskets
- The carbon dioxide will not be pure, the effects of the other constituents need to be considered in the detailed design
- Gas detection systems will need modification at the stations and emergency procedures would change
- The location of compressor stations may also be an issue. They may be sited at incorrect locations along the pipeline for booster compression requirements.

To conclude, National Grid's proposal has the potential to advance the commercialisation of CCS technology, however in order to take this proposal further NG Carbon need to provide evidence that it is technically and economically feasible to re-use the pipeline sections for a carbon dioxide transportation business. Without this evidence the proposal for the asset disposal cannot be validated.

With best regards,

Dave Richardson

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