UK Gas Transmission System Benefits from Gas Storage

A report to the Gas Storage Operators Group

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Executive Summary

WWA has tested the hypothesis that Gas storage sites provide a benefit to the transmission system because on peak days they deliver to the system close to consumer demand, thereby reducing the need for pipe and compression capacity between alternative sources of gas and the demand offtakes.

Using the Transportation Model[1] ("the Model") recently published by National Grid, WWA set about developing a number of supply scenarios to attempt to quantify any benefit which maybe attributable to the storage facilities.

The Model contains a database of all pipes that form the NTS. It calculates the Long Run Marginal Cost (LRMC) at each existing and known proposed entry and exit point on the NTS by optimising peak day flows of gas through the system based on this pipe database. The LRMC at each entry or exit point represents the capital investment cost in additional pipe and/or compression which would be incurred (or saved) by an incremental change in supply or demand respectively at that point.

Using an unconstrained variant of the Model, WWA was able to develop a Base case valuation of the total capital investment in the NTS. The Base Case value was determined my multiplying the peak flows recorded in the Model by the relevant LRMC's and the Expansion Factor. Again the LRMCs and the Expansion Factor of £2223GWh/km are provided in the Model.

This Base case was tested against a number of scenarios which were all based on the provision that if storage did not exist then flows into the system would have to be provided at alternative sources i.e. flow substitution. The scenarios tested were as follows:

i. storage gas is sourced in equal volume at each of the terminals
ii. storage gas is sourced in equal volume from the top three terminals only, on the basis that the LNG entry points are not sized to provide swing and St Fergus provides only associated gas which cannot provide swing
iii. storage gas is sourced in equal volumes only via Bacton and Teesside, assuming the Langeled line is delivering flat gas and has no spare capacity to provide swing.

The results are provided in the form of annual savings, using the Model annuitisation factor, and measured against the Base case. The results show a range of annual savings of £24m to over £200m with most concentration around the £30m to £40m range.

The results suggest that that the original hypothesis is correct and that the industry should consider the impact storage facilities have on the transmission system at greater length. WWA suggests that the industry may want to

[1] Transportation Model produced by National Grid on 29 November in relation to Charging Consultation NTS GCM01

consider the potential for reducing capacity costs to storage users, providing for more cost reflective charges consistent with National Grid's Licence obligations. In its analysis WWA did not evaluate OPEX savings, principally realised through compressor fuel, which maybe considered to a reasonable basis to formulate future SO related, and potentially negative, charges.

UK Gas Transmission System Benefits from Gas Storage

1. Introduction

1.1 In April 2007 the Gas Storage Operators Group ("GSOG") commissioned Waters Wye Associates ("WWA") to produce a report examining the potential benefits UK Storage Facilities provide to the UK Gas Transmission System.

1.2. GSOG believes that due to the location and operational characteristics of the Storage Facilities that investment by National Grid in the transmission system to meet peak day demand is reduced.

1.3 It is well established that UK will become increasingly reliant on gas imports sourced from locations more remote than recently experienced. As a consequence it is commonly understood that the UK must encourage investment into local storage facilities to reinforce overall Security of Supply.

1.4 At the present time, National Grid via changes to the UNC and proposed changes to its charging methodology is increasing the costs associated with the shipping to and from storage facilities. Examples of these changes include the radical overhaul of the exit capacity regime and the imposition of a storage SO commodity charge.

1.5 It is not the intention of this report to develop arguments against the imposition of additional costs on storage users, rather to identify the benefits which storage facilities provide to National Grid, as the owner and operator of the UK transmission system. It is hoped that this report will form the basis for further debate into the legitimacy of imposing costs onto storage utilisation and/or the development of proposals into rewarding storage facilities for providing significant benefits through intrinsic network support.

2. Hypothesis

2.1 Gas storage sites[2] provide a benefit to the transmission system because on peak days they deliver to the system close to consumer demand, thereby reducing the need for pipe and compression capacity between alternative sources of gas and the demand.

[2] We consider both underground storage and the four LNG storage sites owned by National Grid to be gas storage for the purposes of this exercise.

3. Quantification of Benefit

3.1 We can calculate the benefit of storage using National Grid's Transportation Model (which is proposed to be used for calculating UK gas system capacity charges).

3.2 The Model contains a database of all pipes that form the NTS. It calculates the Long Run Marginal Cost (LRMC) at each existing and known proposed entry and exit point on the NTS by optimising peak day flows of gas through the system based on this pipe database. The LRMC at each entry or exit point represents the capital investment cost in additional pipe and/or compression which would be incurred (or saved) by an incremental change in supply or demand respectively at that point.

3.3 The Model as supplied to users has a constraint which ensures that both entry and exit charges must be greater than zero (plus a de minimus charge) – and it also contains algorithms which equalise the capital cost of the system between entry and exit. For the purpose of this exercise the constraint on negative exit or entry charges has been removed, so that the true benefit or cost of entry or exit at a particular node can be ascertained. It is also not necessary to use any of the algorithms within the Model other than that to calculate the LRMC at each entry or exit point.

3.4 Using the unconstrained Model we can calculate a Base Case Value, which is the total capital investment in the NTS, through adding together the results of multiplying the peak day flows in the Model at each entry or exit point by the LRMC at that point and also by the Expansion Constant within the Model.

3.5 The Expansion Constant, expressed in £/GWhkm, represents National Grid's estimate of the capital cost of the transmission infrastructure investment required to transport 1 GWh over 1 km in order to increase the peak day flow at an entry or exit point. Its magnitude is derived from the projected cost of an 85bar pipeline and compression for a 100km NTS network section. The 100km distance was selected as this represents the typical compressor spacing on the NTS. The default value of £2223/GWh km is that used in the published indicative charges for the charging consultation GCM01 and discussion GCD01, available at http://www.nationalgrid.com/uk/Gas/Charges.

3.6 Using this approach we have derived a Base Case Value of the NTS system of £2.958bn. It is comforting to note that this is the same order of magnitude as the Regulated Asset Value (RAV) of the NTS[3]. Achieving an absolute match in value between the RAV and the Base

[3] Within Ofgem's Final Proposals (206/06 - December 2006), the average RAV is quoted as £2.786bn for 2006/7 (in 2004/5 price base)

Case Value is not important as we consider only changes to the Base Case Value in subsequent analysis.

(Note that in the unconstrained Model, the Base Case Value is independent of the choice of Reference Node in the Model.)

3.7 The Base Case Value can be converted to an annual cost of capital recovery through multiplying by the Annuitisation Factor supplied by National Grid within the Model (which is set at 0.10772, quoted as being specified within National Grid's NTS licence). As noted above, our interest is only in changes to the annual cost of running the system, not in the absolute value. Hence we can derive increases or decreases in annual system costs by multiplying the difference between the Base Case Value and a Scenario Value (described below) by this Annuitisation Factor.

3.8 If storage were not to exist, additional gas from outside the UK NTS would need to be delivered through existing terminal entry points in order to meet peak demand. We can therefore calculate the benefit which storage brings to the system by moving the entry of gas from storage sites on the peak day to existing terminal entry points under a number of scenarios. We run the Model and calculate the Scenario Value of the System under each of these scenarios and compare this with the Base Case Value. If the Scenario Value is higher, then it demonstrates that the NTS would need further investment to accommodate the revised flows of gas and quantifies this investment: this is the saving which storage brings to the system. If lower, then it demonstrates that the existence of storage is a net cost to the system and again quantifies this cost.

3.9 The analysis excludes the operating costs of compression required to move gas through the system, as the Model considers purely the capital investment required in and subsequent non-fuel operating costs and maintenance of the system for a change in network flows. Where a capital investment need is identified, it follows that additional annual costs will be required to supply the fuel gas for operating additional compression and as such the analysis underestimates the value of storage to the NTS.

4. Base Case

4.1 As supplied the Model contains the peak day entry flows to the NTS as follows:

Source	GWh	%
Bacton	1492.5	26%
Easington (less Rough)	629.8	11%
Isle of Grain LNG	140.8	2%
Milford Haven	0	0%
St Fergus	1232.7	21%
Teesside	341.1	6%
Other Terminals	579.3	10%
LNG Storage	526.1	9%
Underground Storage	844.8	15%
TOTAL	**5787.1**	**100%**

4.2 This shows that LNG and Underground Storage together make up almost as big a flow into the NTS on a peak day as the forecast from Bacton (the largest terminal flow), and more than is forecast through St Fergus (the second largest terminal flow).

5. Alternative Scenarios

5.1 We have first considered likely entry points for additional gas if storage were unable to deliver gas to the system on peak days.

5.2 In view of the decline in the southern UKCS and Morecambe Bay, we believe it is appropriate to neglect entry points that connect solely to these areas.

5.3 We consider additional entry of gas may therefore be at:

- Bacton, via the Interconnector or the BBL
- Easington, via Langeled
- Teesside, via Excelerate LNG
- St Fergus
- Grain LNG
- Milford Haven LNG

5.4 As baseline scenarios, we can consider all storage gas to enter at only one of the above six sites. This provides an upper bound to the benefit brought by storage to the system.

5.5 We then consider three more probable scenarios, which assume the storage gas is sourced partially through each, or a combination of, the above six terminals:

i. storage gas is sourced in equal volume at each of the terminals
ii. storage gas is sourced in equal volume from the top three terminals only, on the basis that the LNG entry points are not sized to provide

swing and St Fergus provides only associated gas which cannot provide swing

iii. storage gas is sourced in equal volumes only via Bacton and Teesside, assuming the Langeled line is delivering flat gas and has no spare capacity to provide swing.

6. Results

6.1 The following table shows the savings in investment cost for the NTS through the existence of storage providing peak day flows from the NTS compared with replacing those aggregate flows in the percentage shown under the six terminal columns for each terminal. The Total column shows what additional capital investment would be needed, calculated from the Model as described above by subtracting the Base Case Value from the Scenario Value for the revised flow pattern shown.

All values shown in £million capital	Bacton	Easington	Isle of Grain	Milford Haven	St Fergus	Teesside		Total
Single Source Replacement of Storage Gas	100%						**£**	**218m**
		100%					**£**	**339m**
			100%				**£**	**314m**
				100%			**£**	**234m**
					100%		**£**	**1,929m**
						100%	**£**	**697m**
Replacement Gas Sourced in proportions:	16.7%	16.7%	16.7%	16.7%	16.7%	16.7%	**£**	**288m**
	33.3%	33.3%	0.0%	0.0%	0.0%	33.3%	**£**	**368m**
	50%	0.0%	0.0%	0.0%	0.0%	50%	**£**	**420m**

6.2 The table below shows the same scenarios with the capital cost saving converted to an annual cost saving through multiplying by the Annuitisation Factor, again as described above.

All values shown in £million annual cost	Bacton	Easington	Isle of Grain	Milford Haven	St Fergus	Teesside		Total
Single Source Replacement of Storage Gas	100%						**£**	**24m**
		100%					**£**	**37m**
			100%				**£**	**34m**
				100%			**£**	**25m**
					100%		**£**	**208m**
						100%	**£**	**75m**
Replacement Gas Sourced in proportions:	16.7%	16.7%	16.7%	16.7%	16.7%	16.7%	**£**	**31m**
	33.3%	33.3%	0.0%	0.0%	0.0%	33.3%	**£**	**40m**
	50%	0.0%	0.0%	0.0%	0.0%	50%	**£**	**45m**

7. Conclusions

7.1 Even in the most advantageous cases - that all replacement gas for storage gas could be sourced either through Bacton or Milford Haven – there would be an additional investment cost required in the system of over £200m, equivalent to an additional system cost of £24-25m per annum.

7.2 A more likely scenario would see some of the replacement storage gas coming from northern terminals, and delivering this to demand would require an investment of the order of £300m-£400m, equivalent to an additional annual system cost of £30-45m.

7.3 The worst case – that all additional gas would be shipped from St Fergus – would require nearly £2bn of additional system investment, leading to capacity charges for users rising by over £200m per annum.

7.4 In performing its analysis, WWA believes that the hypothesis is correct; *Gas storage sites* ***do*** *provide a benefit to the transmission system because on peak days they deliver to the system close to consumer demand, thereby reducing the need for pipe and compression capacity between alternative sources of gas and the demand.*

7.5 As stated previously additional OPEX savings generated through, for example a reduced demand for compressor fuel, have not been considered. WWA is not privy to the use and interaction of the various compressors situated in the System and any attempts to quantify savings would be based on conjecture. WWA believes that National Grid is best placed to provide input into the use of compression and would welcome any analysis and/or data it may provide to assist the industry in quantifying OPEX savings which could be attributed to the operation of storage.

8. Next Steps

8.1 GSOG has argued in responses to previous National Grid pricing consultations that the benefit provided by storage to the UK gas transmission system has not been recognised and should be taken into consideration before National Grid proposes charges specific to storage utilisation. WWA believes that GSOG is justified in promoting this approach as this report confirms that the benefits are substantial.

8.2 It may be argued that storage is no different to competing providers of flexibility e.g. customers providing demand side response. On this point WWA suggests that the flow patterns exhibited by storage facilities are unique and cannot be easily compared with other offtakes.

8.3 Storage facilities are more predictable than other system points as they tend to flow directly in response to price signals and therefore demand changes. Other system points will react to any number of variables, most obviously being prices of substitutes, alternative non-UK gas markets and/or complimentary fuels/outputs. Clearly, and again unique to storage flows may occur into, or out of the facilities.

8.4 WWA proposes that storage facilities are given individual attention and further work is done to establish the full benefit provided by storage facilities to the UK gas transmission system e.g. OPEX savings from operating compression. As stated in 7.5 above we would welcome input from National Grid in this regard.

8.5 WWA suggests there are two options worthy of further consideration with regards Transmission charges:

i) A proportion of this benefit is already being captured by storage users through current entry capacity charges which, under the terms of National Grid's licence, are required to be cost reflective. In accordance with National Grid's transportation charging methodology, the Model is used to derive reserve prices at each ASEP for the entry capacity auctions. However, the charging methodology does not allow all the benefit identified by WWA in this report to find its way back to storage users. On this basis WWA argues that the charges are not truly cost reflective.

   WWA suggests that the industry may want to consider the potential for changes to the charging/market arrangements such that storage captures the balance of the benefits that it is providing to the transmission system.

ii) The analysis performed by WWA focuses purely on TO designated costs. Further analysis of SO costs should be carried out to ensure that the total benefit attributable to the operation of storage facilities is calculated. The benefits identified in this analysis should be recognised in future charges e.g. through the application of potential negative SO commodity charges. Once again this would ensure that National Grid's charges are consistent with the relevant Licence obligations.

Additional Notes

Diversified Entry Advantage

Whilst the above analysis necessarily simplifies the possibilities for entry gas location, it demonstrates the benefits of multi-location delivery of gas to the NTS on a peak day. In general the more localised the delivery of gas at a single point in the network, the more the network is put under strain and so requires additional investment to alleviate the potential constraint.

Thus the diversification of storage delivery locations within the network invariably has a benefit in aggregate to the system regardless of scenario.

Hence, although more detailed analysis shows that a single storage site by itself may, under certain entry flow scenarios, appear to be a cost to the system, such an approach underestimates the benefit brought by that site's contribution to the whole in terms of distributing flows throughout the system on a peak day.

Appendix

Results (excluding LNG sites)

The following table shows the savings in investment cost for the NTS through the existence of storage **(EXCLUDING LNG SITES)** providing peak day flows from the NTS compared with replacing those aggregate flows in the percentage shown under the six terminal columns for each terminal. The Total column shows what additional capital investment would be needed, calculated from the Model as described above by subtracting the Base Case Value from the Scenario Value for the revised flow pattern shown.

All values shown in £million capital	Bacton	Easington	Isle of Grain	Milford Haven	St Fergus	Teesside	Total
Single Source Replacement of Storage Gas	100%						**£ 26m**
		100%					**£ 106m**
			100%				**(£ 133m)**
				100%			**(£ 23m)**
					100%		**£ 1,131m**
						100%	**£ 329m**
Replacement Gas Sourced in proportions:	16.7%	16.7%	16.7%	16.7%	16.7%	16.7%	**£ 98m**
	33.3%	33.3%	0.0%	0.0%	0.0%	33.3%	**£ 125m**
	50%	0.0%	0.0%	0.0%	0.0%	50%	**£ 154m**

The table below shows the same scenarios with the capital cost saving converted to an annual cost saving through multiplying by the Annuitisation Factor, again as described above.

All values shown in £million annual cost	Bacton	Easington	Isle of Grain	Milford Haven	St Fergus	Teesside	**Total**
Single Source Replacement of Storage Gas	100%						**£ 3m**
		100%					**£ 11m**
			100%				**(£ 14m)**
				100%			**(£ 2m)**
					100%		**£ 122m**
						100%	**£ 35m**
Replacement Gas Sourced in proportions:	16.7%	16.7%	16.7%	16.7%	16.7%	16.7%	**£ 11m**
	33.3%	33.3%	0.0%	0.0%	0.0%	33.3%	**£ 13m**
	50%	0.0%	0.0%	0.0%	0.0%	50%	**£ 17m**

Conclusion for Underground Storage Sites

Excluding LNG sites from the previous analysis shows that underground storage brings a significant benefit to the system compared with entry of replacement at St Fergus. Underground storage appears to be a slight net cost to the system compared with Isle of Grain or Milford Haven entry points, and a slight net benefit to the system compared with Easington, Bacton or (to a greater extent) Teesside.

However the three lower scenarios have been selected on the basis of the most likely entry points for replacement gas. Where flows are assumed to be equally distributed among entry terminals, underground storage in aggregate brings a small net benefit to the system. Although the last two neglect the most advantageous southern-based LNG import terminals, they also neglect the most disadvantageous northern terminal at St Fergus, and both these scenarios also show a clear net benefit brought to the system by underground gas storage sites in aggregate.

Although the location of the LNG site at Avonmouth brings an obvious benefit to the system, it is consistent to include the LNG site at Glenmavis which is in general a cost to the system on peak days compared with alternative terminal entry of gas. Hence the benefit of LNG storage in aggregate is not as significant a component of overall storage benefit as might be first presumed.