Energy Market Insights

Gas Storage Valuation and Investment Incentives: The Example of Great Britain by Sean Gammons and Vakhtang Kvekvetsia

Introduction

Great Britain (GB) is becoming dependent on long-distance gas imports due to the rapid decline in North Sea production. As a result, many commentators have suggested the GB market requires major investment in new gas storage capacity to offset the loss in swing capacity currently provided by North Sea fields. The alternative of relying on spare capacity in long-distance pipelines combined with production swing in distant fields is expensive. So too is seasonal or occasional use of LNG import facilities.

However, as the recent financing travails of Portland Gas illustrate, it is not clear that the GB market is providing adequate incentives for new storage investment. In this EMI, we use our in-house Least Squares Monte Carlo (LSMC) energy storage model (E-StorM) to explore the returns currently available to storage investors in the GB market. Our analysis suggests returns are adequate to incentivise investment for the right kinds of projects.

Economics of Storage

Storage capacity gives the user an option to arbitrage gas prices over time, injecting gas when prices are low and withdrawing when prices are high. Future gas prices are uncertain and hence decisions over when to inject and when to withdraw depend on probabilistic assessments of future price evolution. This type of decision problem calls for the use of stochastic dynamic programming (SDP) techniques, which solve two problems simultaneously: (1) they give rules on what to do (inject, withdraw, or do nothing) as a function of observed variables, and (2) give the value of following those decision rules. SDPs take a variety of forms, including LSMC and trinomial trees, but the LSMC approach used by E-StorM has the advantage of being much more flexible than other techniques (e.g., it can handle jumps in prices unlike trinomial trees).

The SDP defines an optimal decision for the operation of the storage each day (inject, withdraw, do nothing) conditional on today’s opening storage level, today’s spot gas price, an assumed stochastic gas price process, and the capacities of the facility (working gas, injection, withdrawal). Hence, the SDP can be run for many simulations of realised spot price paths to obtain optimal operating plans for the storage facility conditional on each realised price path. The revenues earned from each of these simulations can be calculated as the sum of the daily cash flows, and the distribution of these revenues studied (average, variance, percentiles, etc.). Figure 1 shows an illustrative example of a net revenue probability distribution created by E-StorM.

About E-StorM

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From the Editor

This first EMI demonstrates the combination of expertise that NERA brings to its client assignments. Sean Gammons and Vakhtang Kvekvetsia require three very separate skills in analyzing gas storage valuation and investment incentives. First, they must choose an appropriate tool for valuing a gas storage facility. There are many such tools, of course, and the selection of the proper one must be grounded, among other things, in an understanding of the problem and a knowledge of a broad range of tools. Second, they must use empirical skills to calibrate the model to the particular client’s problem. Third, they must use an underlying understanding of the industry background to place the analysis in context. All three skills are necessary to persuasively address the client’s issue, so it is appropriate that this case study initiates our EMI series.

—Jonathan Falk, Editor
With GB’s entry-exit system for access to the gas pipeline network, all gas in GB is valued at the national balancing point (NBP), which is a virtual trading hub located within the network. As such, assumptions on price evolution at the NBP are the key driver of gas storage valuation in the GB market.

NBP Price Evolution

We model the evolution of NBP spot prices using a mean reverting GBM price process, with volatility and mean reversion parameters estimated using historical data and calibration to a forecast of the quarterly forward curve. Estimated seasonal average volatilities and mean reversion rates have varied significantly over the last 10 years, as illustrated in Figure 3.

For valuation, the revenue forecasts derived from the SDP must be compared with the capital and fixed costs of constructing and operating a storage facility, a large portion of which is normally in the form of cushion gas. A positive NPV given a fair market WACC, or alternatively on equity IRR above the hurdle rate for storage investment, would represent a positive signal to invest.

Table 1. Summary of Pricing Scenarios

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Volatility</th>
<th>Mean Reversion Rate (MR) Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Case</td>
<td>Average of estimates for summer 2007 and winter 2007-08</td>
<td>Average of estimates for summer 2007 and winter 2007-08</td>
</tr>
<tr>
<td>High Volatility</td>
<td>Average of volatility prior to the 2005-06 &quot;infrastructure crunch&quot;</td>
<td>Same as base case</td>
</tr>
<tr>
<td>High mean reversion rate</td>
<td>Same as base case</td>
<td>Average of MR rate prior to the 2005-06 &quot;infrastructure crunch&quot;</td>
</tr>
</tbody>
</table>

Source: NERA.
Recent trends might provide a boost to gas storage investment by reducing the cost of cushion gas without significantly impacting revenue expectations.

NBP spot and forward prices have crashed over the last couple of months due to the steep fall in world oil prices, which drive NBP gas prices through imports of oil-indexed continental European gas supplies. Forward summer-winter price spreads have been unaffected by the collapse in prices, however, as illustrated in Figure 3. These recent trends might therefore provide a boost to gas storage investment by reducing the cost of cushion gas without significantly impacting revenue expectations. We have used the two alternative forward curves illustrated in Figure 4 to examine the overall effects.³

Figure 4. Forward Curves for Two Alternative Information Dates

In addition to daily volatility, gas prices are prone to longer-term spikes due to the “boom-and-bust” of the investment cycle in what is a capital-intensive industry, and the risk of extreme events (e.g., extreme weather, supply interruptions). Hence, our GBM gas price process allows for the probability of a 1-in-50-year severe winter and a 1-in-20-year infrastructure crunch, like that seen in GB in the winter of 2005-06, as illustrated in Figure 5.

When to Inject and When to Withdraw
In general terms, storage owners need to inject gas when prices are low and withdraw gas when prices are high to maximise the value of their capacity. What qualifies as “low” and “high” depends on the setting, however, and there are no simple general rules available. E-StorM therefore provides decision surfaces that identify the optimal choice as a function of the current storage level and spot price, as illustrated in Figure 6 (the yellow hatched area signals where it is optimal to inject and the turquoise area signals where it is optimal to withdraw).

Figure 5. Severe Winter and Infrastructure Shocks: Seven Sample Paths, 29 July 2008 Information Date

Figure 6. Illustrative Example of a Decision Surface from E-StorM

Value of New Seasonal Storage
Against this background, we have used E-StorM to estimate the NPV of new seasonal storage capacity in the GB market based on the characteristics of the Rough facility owned by Centrica, which is currently the main seasonal storage facility in GB.¹⁰
If gas price volatility reverts to the levels seen prior to the recent “infrastructure crunch,” our high volatility scenario shows a new Rough would then be worthy of investment.

Hence, we have assessed a facility that takes 189 days to fill and 67 days to empty and has a cushion gas requirement of 4.0x its working gas capacity. We assume up-front construction costs and discounted lifetime fixed O&M costs of £15/MWh(working gas). With a 10% pre-tax nominal WACC and a 40-year asset life, we arrive at the NPV estimates shown in Table 2 for our two alternative information dates.

The “intrinsic value” of the facility shown in Table 1 indicates the value that can be derived from the facility by arbitraging quarterly forward prices (i.e., without factoring in spot price volatility). The comparison of the “intrinsic value” of the facility with the total values shown for the three spot price scenarios indicates the value of the “option premium” of the facility. As can be seen in Table 2, this “option premium” is significant even for a seasonal storage facility and hence needs to be correctly factored into any valuation or investment appraisal.

As shown in Table 2, the recent fall in the cost of cushion gas has substantially improved the economics of new seasonal storage in GB, but a new Rough is still not viable under our base case assumptions. If gas price volatility reverts to the levels seen prior to the recent “infrastructure crunch,” which was succeeded by a raft of new projects and potential over-supply, our high volatility scenario shows a new Rough would then be worthy of investment. However, that is a big “if” and should increased volatility be accompanied by an increase in the rate of mean reversion, the viability of a new Rough is again precarious, as illustrated by the comparison of our high MR rate scenario with the other scenarios.

| Table 2. NPVs for a New Depleted Field Storage Facility in GB |
|----------------------|----------------------|----------------------|
|                      | 29 July 2008 NPV, £/MWh (working gas) | 21 Nov 2008 NPV, £/MWh (working gas) |
| Base Case             | -69                  | -27                  |
| High Volatility       | -31                  | 6                    |
| High MR Rate          | -29                  | -32                  |
| Intrinsic value       | -106                 | -59                  |

Value of Additional Flexibility

We have also used E-StorM to look at the NPV of more flexible storage capacity in GB, like the new onshore salt cavity facility being developed by Portland Gas off the south coast of GB. Hence, we have assessed a facility that takes 50 days to fill and 50 days to empty and has a cushion gas requirement of 0.75x its working gas capacity. We assume up-front construction costs and discounted lifetime fixed O&M costs of £54/MWh(working gas), which are significantly higher than a new Rough because of the expensive leaching process required to create the salt cavity. With a 10% pre-tax nominal WACC and a 40-year asset life, we arrive at the NPV estimates shown in Table 3 for our two alternative information dates.

As can be seen from these results, we estimate that a flexible salt cavity facility in GB is NPV positive across all our scenarios once the “option premium,” which is much larger than for a new Rough, is factored in. The valuation bridge shown in Figure 7 illustrates the drivers of the extra value provided by a flexible storage compared to a new Rough. As Figure 7 illustrates, the biggest source of extra value is the extra flexibility, but the lower cushion gas requirement is also significant. The lower cushion gas requirement also means the capital costs of the flexible storage facility are less exposed to fluctuations in gas prices than a new Rough, as shown by the comparison of the two information dates in Table 3.

| Table 3. NPVs for a New Salt Cavity Storage Facility in GB |
|----------------------|----------------------|----------------------|
|                      | 29 July 2008 NPV, £/MWh (working gas) | 21 Nov 2008 NPV, £/MWh (working gas) |
| Base Case             | 42                   | 49                   |
| High Volatility       | 125                  | 124                  |
| High MR Rate          | 32                   | 40                   |
| Intrinsic value       | -47                  | -33                  |

Source: NERA estimates.

The valuation bridge is indicative of the benefits to investors of identifying flexible facilities and facilities with low cushion gas requirements. It is also illustrative of the way E-StorM can be used to value particular facilities, or value the payoff to specific attributes to help with site selection and project design as part of the investment decision-making process.
Conclusions

Overall, our analysis suggests the fundamentals of the GB market are providing strong investment signals for new flexible storage like the Portland Gas facility. The current financing travails of Portland Gas might therefore have more to do with the “credit crunch”, or project-specific technical issues, than the functioning of the GB gas market.

The case for investment in new seasonal storage facilities with characteristics similar to Rough is marginal, despite the recent fall in the cost of cushion gas. This result may suggest that these types of investment are indeed marginal in the “merit order” of available storage investment, thus requiring careful site selection, rather than indicating any fundamental problem with the GB gas market. On the other hand, it may be a signal of structural problems with the current setup of the market. For example, storage located close to a demand centre is partly a substitute for pipeline capacity, but because GB has an entry–exit system with a single wholesale gas price defined for a virtual NBP, this substitution value is not transparent. Similarly, the cash-out arrangements for imbalances do not currently allow the true marginal cost of gas on the day to be signalled to the market, thus reducing the value available to scarce capacity in peak periods. These issues deserve further investigation.

The approach to storage valuation we have applied in this paper is useful in markets with transparent and liquid spot and forward markets for gas, such as GB and the United States. The growing transparency and liquidity of continental European gas markets, led by the TTF in the Netherlands, suggests it is now necessary to apply the same techniques there in order to derive reliable valuations.

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EndNotes

Glossary: NPV = net present value; IRR = internal rate of return; WACC = weighted average cost of capital; GBM = geometric Brownian motion; O&M costs = operating and maintenance costs.

1 “Swing capacity” refers to the capability of gas fields to vary production to match variations in demand, e.g., between summer and winter. By analogy, gas contracts that allow off-takers to vary their off-takes between summer and winter and/or from day to day are known in the industry as swing contracts.

2 “Utility seeking strategic partner,” Financial Times, 8 November 2008. The article states: “Even as the UK is facing a shortage of natural gas, and is increasingly having to rely on imports, Aim-listed Portland Gas is finding it tough to obtain funds to complete the country’s largest gas storage facility. The group plans to set up a facility off the south-west coast by 2010 and is hoping to attract a larger utility company as a strategic partner for the project. Portland’s shares dropped from around 400p in May to 69p this week, in line with falling crude oil prices in this period.”

3 The recent report of the UK Parliamentary Business and Enterprise Committee (First Report of session 2009-09) expresses concerns about the ability of the UK gas market to provide storage investment incentives. Interestingly, the committee suggests that new storage capacity is needed to reduce gas price volatility. However, some volatility is required to incentivise storage investment in a market, which suggests there is some optimal mix of storage capacity and volatility in a well-functioning gas market. Unfortunately, the Committee does not recognise this difficult tradeoff and instead seems to prefer the guarantees offered by regulated solutions such as capacity obligations.

4 These techniques have been borrowed from financial markets, where they are used for valuing American options. The owner of an American option has a right to sell or purchase an asset at any time up until the contract expires, so the owner must decide the optimal date on which to exercise the option in the face of uncertainty over the evolution of the price of the asset, like the owner of a gas storage facility who has to decide when to withdraw their gas. A gas storage owner actually faces a more complex decision, because they have to decide when and how much to inject in the first instance, i.e., when to invest to create the option to withdraw.

5 “Cushion gas” is gas that must be kept in storage in order to maintain the pressure of the storage facility within the required operating limits.

6 In this respect, the NBP is similar to the TTF in the Netherlands, the GUD and E.ON GT hubs in Germany, and the PEG-Nord hub in France, for example.

7 Storage owners can realise some locational value through sales to the transmission system operator (TSO), National Grid Gas, which may provide an uplift over the revenue available from arbitrage of the NBP.

8 In the 2005–06 winter, the GB market saw exceptionally high gas prices in response to a shortage of supply capacity resulting from delays to a number of large infrastructure projects, which we refer to as the 2005–06 “infrastructure crunch.”

9 To extrapolate these forward curves into the long-term future we have applied annual inflation of 2.5%.

10 When these events occur, we assume average winter gas prices and spot price volatility both spike above their normal levels. We have calibrated the uplift in winter average gas prices to the observed uplift seen in winter 2005–06, which was roughly a 40% increase in the normal prices that we estimate would have prevailed without the “infrastructure crunch.” Similarly, we have set the volatility to 350% based on observed volatility in winter 2005–06, as compared to 105% in a normal winter in our base case.

11 The Rough offshore storage facility was created in the mid-1980s by converting the partially depleted Rough gas field.


13 Various industry sources. We assume the facility is commissioned at 1 April 2011.

14 Based on the rates used in Centrica’s standard storage contracts for Rough, we also assume variable injection costs of £0.21/MWh and variable withdrawal costs of £0.07/MWh, indexed to seasonal average gas prices.

15 The “option premium” is also known as the extrinsic or time value.

16 A full appraisal of the economics of a new storage facility must factor in a more detailed review of the upside and downside risks, as illustrated in part by the type of graph shown in Figure 1, which gives a range of net revenue forecasts with probabilities attached.

17 Various industry sources. We assume the facility is commissioned on 1 April 2011. We assume the same variable injection and withdrawal costs as for Rough.
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