Strategic storage and security of gas supply in the UK

A paper by Poyry Energy Consulting[1]

Introduction

The delivery of significant quantities of reliable, new gas supplies is required to meet future demand for gas, and there are a number of large infrastructure projects currently under development that will bring new commercial supplies of gas to the UK. There is some debate, however, as to whether the level of security of supply that will be delivered by the market, under its current regulatory structure, is as high as may be economically, socially or politically desirable.

In addition there are a number of factors that have led to calls to examine the question of the long-term security of supply:

- The increasing use of gas in electricity generation;
- The declining 'swing' capability of UKCS production;
- Concerns about the reliability of existing gas industry infrastructure; and
- The UK's increasing reliance on imports. Imports will arrive by pipeline through Europe and as LNG in tankers delivering gas production from countries outside Europe.

There is the possibility of an emerging 'gap' between supply and demand. We define a gap as emerging when commercial gas supply fails to meet commercial demand. The only option left for supply to balance demand is for involuntary firm demand load shedding to occur, with the consequent interruption to industry and industrial production. Forced interruption of firm gas demand would cause industry to incur unexpected costs through loss of production. There may be a basis for government intervention if the costs of the market failure are sufficiently high. In this study, we analyse the costs and benefits of such intervention, and alternative options for addressing long term gas supply security in the UK.

Calculating the potential gap

We calculate the future gap between demand and supply by assuming that the government takes *no action* to develop solutions to address the gap. In this 'do nothing' world, the commercial market is left to operate without any interference. The expected gap between supply and demand is our mean estimate of the extent to which the market, left to its own devices, will <u>not</u> meet firm customer demand in the future, resulting in involuntary firm load

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1 This study was undertaken by ILEX for the DTI in the first half of 2006. Since the completion of the work, ILEX has changed its name to Poyry Energy Consulting. Throughout this article, we refer to ILEX rather than Poyry in order to maintain consistency with the original study.

shedding. We calculate a probability distribution for the gap between supply and demand; the 'expected gap' is the mean of this probability distribution.

We attempt to quantify the gap in gas supply in the UK, for each year in the timeframe 2006 to 2020. We attempt to assess both the annual volume shortfall (in billion cubic metres, or bcm) and the number of days in the year during which the shortfall occurs.

Supply-demand

We have developed three scenarios – Constrained, Balanced and Abundant – for supply-demand conditions over the next 15 years. The scenarios include projections for demand, UKCS production, import capacity and storage capacity. These projections include known projects as well as generic new build. In these scenarios, our demand and capacity projections are combined in 'opposition' (e.g. high demand growth with low capacity) in order to create *high*, *central* and *low gas price* scenarios.

The Constrained, Balanced and Abundant scenarios correspond to P10, P50 and P90 cases, respectively, in the probability modelling. This means that, in any given year, we estimate there is a 10% chance of the supply-demand balance being tighter than in the Constrained world; and a 90% chance of it being tighter than in the Abundant world.

Table 1 – Supply-demand scenarios

	Demand	Domestic UK supply	Available import capacity	Storage capacity
Constrained (high price)	High	Low	Low	Low
Balanced (central price)	Central	Central	Central	Central
Abundant (low price)	Low	High	High	High

Source: ILEX

The three scenarios – Constrained, Balanced and Abundant – represent the range of possible future scenarios for the UK gas industry plus a central scenario Together the three scenarios represent an envelope of outcomes and we would expect that the future UK supply-demand balance is likely (with 80% likelihood) to be contained within this envelope. The position in any year will depend on future demand and supply, and we would expect the path taken to go through periods of constraint and periods of abundance as part of the normal commercial investment cycle. The winter of 2005/06 is an example of a period of constraint.

Furthermore, these scenarios are based on 'normal' conditions (for example, normal weather patterns and long term supply reliability) and do not take account of random or unpredictable effects. These are simulated separately, as discussed in the following section.

Simulation approach

In order to estimate interruption likelihood, we need a probabilistic framework for our supply demand scenarios[2]. We also need to quantify *atypical* effects – comprising short-term losses in supply, and variations in demand due to weather – both of which are outside the scope of our initial scenarios. In order to combine our scenarios and capture these various short-term effects, ILEX has developed a simulation model of future gas supply and demand, using our GB Gas Model as a basis.

It has proved to be very difficult to reach consensus on the probabilities of supply interruption, and on the proportions of supply from each given source that could be interrupted. ILEX's approach has been empirical: we have based our probability estimates (the "ILEX probabilities") on observed historical events that have affected the UK's gas supply. We have based our "outage proportions" on the relative sizes of individual fields in the UKCS – assuming for the analysis that any given interruption would occur at a single large field – while we have assumed that any individual LNG source or pipeline could be completely curtailed. We have run the analysis with an alternative set of probabilities (and outage proportions) based on greater supply reliability, determined by the DTI.

We model the risk of losses of supply and variation in demand in the three scenarios. The likelihood of a given shortfall is then determined from the number of iterations which give at least that level of shortfall, out of a total number of 1000 iterations.

The supply-demand gap

The following key messages emerge from the analysis of the potential gap between supply and demand:

- regardless of one's views on the probabilities that outages will occur at individual sources, there is always a minimum level of supply gap risk, which is associated with demand variation and the underlying balance of demand and supply;
- at the 1 in 20 chance level, the gap is close to zero, but there is a 1 in 50 chance that the gap could be comparable with 1 Rough Equivalent[3];
- aside from the next two winters – which are too imminent for the advent of a major new storage facility – this gap only becomes manifest in the years from 2014 onwards in the commercial market;
- the profile of modelled outages tends to suggest that a solution which covers 60-90 days of shortfall is more suitable than one which covers a few days or weeks;

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2 The probabilities here are not for the scenarios themselves (whose probability is zero as they are point estimates) but for the world being 'better' or 'worse' than any particular scenario.

3 A Rough Equivalent is a measure of storage capacity based on the largest storage facility in the UK. Rough can supply around 44mcm/day for a period of 75 days i.e. a total volume of 3.3bcm.

- even a strategic storage facility equivalent to Rough would not completely eliminate the risk of a shortfall, and the cost-benefit analysis needs to consider the magnitude of the residual risk; and
- 1-day supply interruptions cannot be ignored, though longer duration outage risks in aggregate make a greater contribution to the expected materiality of a supply shortfall.

Alternative Options

We look at alternative options that could close a shortfall between gas supply and gas demand in the UK (the 'gap') equivalent to one Rough storage facility (one RE), or 44 mcm/day for 75 days. We do not imply that 75 days is necessarily optimal for a new facility (though the simulation results suggest it may be a reasonable duration) but by specifying the storage requirements in detail, we can compare alternatives numerically.

To be considered, any option must deliver incremental physical gas to the UK, or bring about an actual reduction in the UK gas demand. The options must be separate from, and additional to, the commercial arrangements that are called upon for balancing supply and demand under normal conditions.

We group the options that could fill a shortfall between supply and demand under a) increase in the supply of gas, and b) reduction in gas demand; and describe each of the options in turn. DTI requested that the three most promising alternative options should be developed in more detail. After some discussion about the feasibility of each option to fill the gap it was decided that the short-listed options were:

- storage in the UK using any of depleted field storage, salt cavern storage and LNG storage tanks. The higher deliverability of salt cavern and LNG storage would mean that only part of the deliverability would be used to provide a 75-day service;
- supply from Europe, probably sourced from new-build storage. This would require additional transit and interconnector capacity to transport the gas to the UK; and
- oil storage at CCGT sites.

Economic impact of interruption

By examining the cost of a gas supply interruption in a 'do nothing' scenario we have estimated the avoided cost, or benefit, of developing different amounts of strategic storage. This stage of our analysis builds on work previously undertaken by ILEX and Global Insight (GI) on the effects of a UK gas shortage.

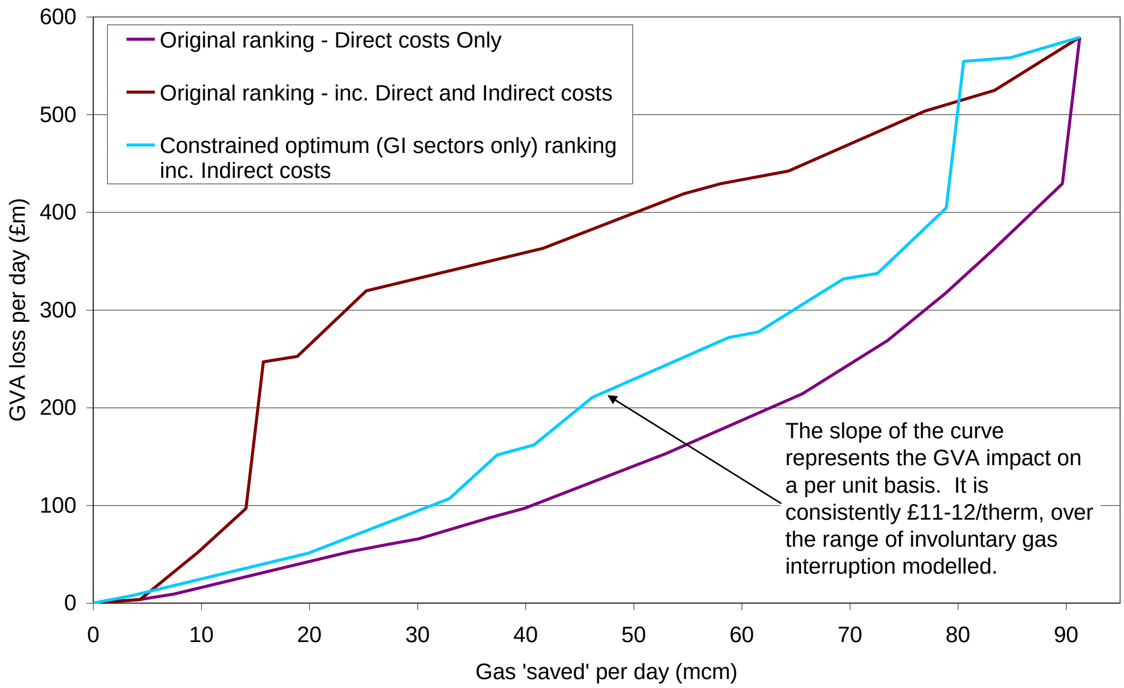
Data published by the Office of National Statistics, in particular the Annual Business Inquiry, has been used to measure the impact on the UK economy. Gross value added (GVA) at basic prices has been used in order to quantify these economic impacts, where GVA is defined as the value of goods and services less the value of the products used to make them[4].

Given its high degree of complexity and the short duration of our study, our approach to modelling the economic costs of interruption has been based on a number of assumptions:

- we have assumed the impact is limited to the industrial sector of the economy only (the commercial sector is not included). In total we have identified up to 90mcm/day of gas interruption from the industrial sector, which is greater than the potential gap in the simulation;
- we have assumed the impact of switching-off demand for one day will result in costs from one day's lost production from the sector interrupted and from the sectors directly upstream and directly downstream of the gas interruption. We do not include costs of restarting, cost of damage to stock and/or plant, or long-term loss of market share to offshore companies. These – and the assumption that only the industrial sector is affected – are optimistic assumptions. On the other hand, we do not take account of possibilities for shifting maintenance to coincide with the interruption, we assume lost production is not recoverable, and we assume (although this assumption is largely supported by our research) that industrial stocks are insufficient to avoid production losses;
- we take account of the reduction in electricity demand associated with lost production, and assume that the electricity demand reduction leads to lower gas consumption at gas-fired CCGT power stations; and
- the order of interruption is important. We assume that the order is optimised taking account of the total GVA cost (direct + upstream + downstream) with the lowest cost sectors (GVA per mcm) interrupted first. This is the constrained optimum (blue) line shown in Figure 1. Without this optimisation the GVA costs could be significantly higher, as shown by the brown line. The purple line shows the direct costs only and is the impact that would occur if there were no upstream or downstream effects.

4 ONS definition: GVA + taxes on products – subsidies on products = GDP

Figure 1 – GVA loss per day (£m) compared to gas saved per day (mcm) – ranked by energy-intensive sector, taking account of both direct and indirect costs



Source: DUKES, ONS and ILEX analysis

Whenever, in the simulation, there is a gap between demand and supply (after the demand response to price has been netted off), then the simulation model looks up the level of the gap (in mcm) to determine the resulting economic cost (in £m). The losses are summed for each year to give a total annual economic loss from gas supply interruptions. The model reports these annual losses, for each year, in each iteration of the simulation.

Costs

Storage in the UK

We have forecast storage costs based on the costs of new storage recently developed or presently under development in the UK. The projects represent a range of different size facilities and have different characteristics in terms of the amount of cushion gas required and the capital expenditure. The shorter duration salt cavern and LNG storage facilities generally have higher capex costs per volume of storage.

The average figures quoted give an indication of cost. In the implementation section of this report we allow the cost to be set by the market, and cheaper alternatives where they exist would be expected to come through.

Supply from Europe

Since there is no evidence of spare storage capacity in NW Europe, the costs of supply from Europe would be the cost of new build storage plus the cost of transportation across Europe and through the gas interconnector. If it were possible to access gas production from Groningen in the Netherlands, we would expect the service to be priced competitively against the alternative markets in NW Europe.

The costs of transit from Europe are likely to add between £0.5 and £1.0 billion pounds (for one Rough Equivalent) in addition to the cost of new build storage, making a supply from Europe uneconomic compared with storage in the UK.

Reduced gas demand at CCGTs

The costs of providing 75 days of backup fuel capability for 400MW are scaled up to cover 10 GW of generation capacity (a Rough Equivalent) and would require 26 tanks at each of twenty-five 400MW CCGTs, giving a total of 650 tanks.

With oil storage there is a risk that, in a high gas price and constrained world in which strategic reserve is required, the amount of gas used and therefore the amount that can be interrupted at CCGTs would be limited, providing at maximum 1 to 1.5 RE (the total installed CCGT capacity is around 2.5 RE).

We looked at the option of holding reserve capability at mothballed coal plant and found that the option may be able to offer a limited amount of capacity.

Benefits

By combining our analysis of GVA loss per day within the simulation, we have obtained a probability distribution, on an annual basis, for the economic impact due to a gas shortfall. Using the ILEX probabilities (and outage proportions), the impact is significant at the 95th percentile, from 2014 onwards; and it rises to around £20bn per annum at the 99th percentile. In other words, there is a 5% chance of a significant impact from 2014 onwards; and a 1% chance that the impact could be at least £20bn per annum.

If instead of the ILEX probabilities (and outage proportions) we use the alternative set supplied by the DTI, the impact is no longer significant at the 95th percentile, although it is substantial (£5bn-£10bn per annum) at the 99th percentile, from 2015 onwards.

The expected impact is simply the average of all 1000 iterations. This is the green line in Figure 2. The expected impact over the timeframe is the sum of the expected impact in each year. Note that this statement does <u>not</u> depend on an assumption that the Constrained scenario, or the Abundant scenario, is sustainable for the entire timeframe. Even if the supply-demand balances for consecutive years are deemed to be independent of each other, the mean of the sum is equal to the sum of the means[5].

We can now obtain the benefit of a Rough Equivalent by inserting an extra RE into the simulation model and re-running the simulation. The result is the

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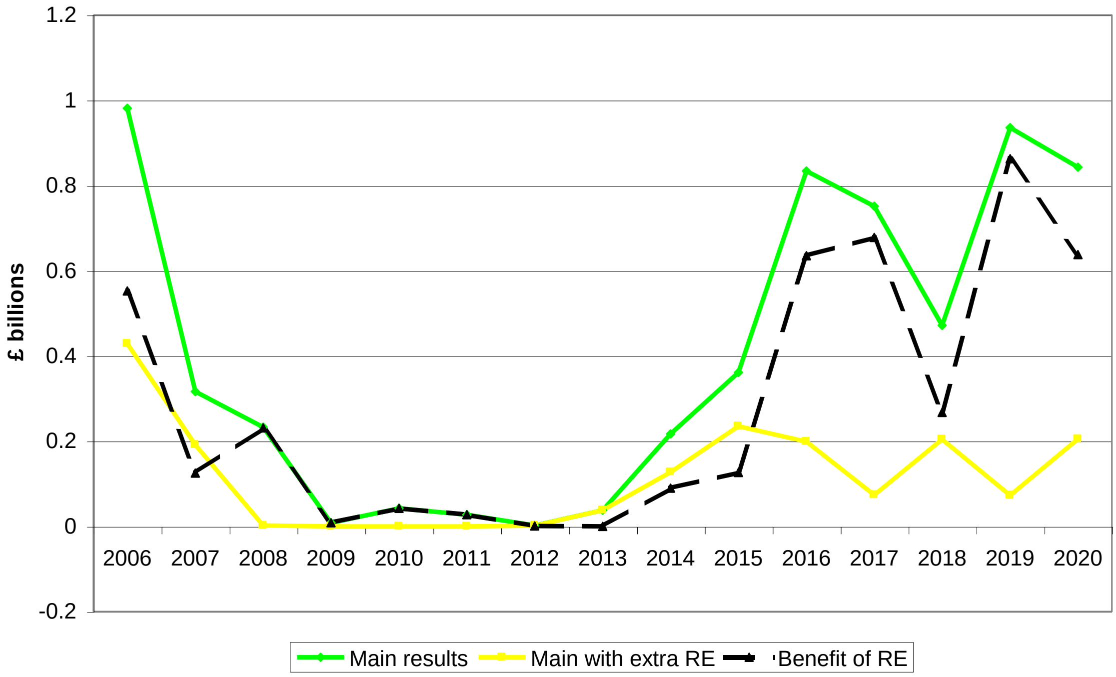
5 If the supply-demand balances in consecutive years were treated as independent, then the standard deviation of the economic impact over the timeframe would be drastically reduced. In our analysis, we have concentrated on the expected result for the timeframe as a whole, and only consider the shape of the distribution (e.g. standard deviation and percentiles) in individual years in isolation.

yellow line in Figure 2 and is the residual GVA impact per annum, even if an extra Rough is developed. The difference between the green and yellow lines is the black line, which is therefore the (mean) economic benefit of the extra RE.

Figure 2 – Benefit of Rough Equivalent, using ILEX probabilities (mean outcome)



Using the ILEX probability assumptions, the benefit is expected to be around £0.5 billion per annum after 2020, based on the average benefit over the timeframe 2015 to 2020. Using the alternative probability assumptions, the mean benefit is around £0.2 billion per annum after 2020.

We estimate that a solution which addresses a shortfall is likely to be needed by 2014. In addition, we make the following assumptions in relation to a storage facility (oil or gas):

- the storage facility will take 3 years to develop, and the costs of it will be incurred 2 years prior to operation;
- the storage facility has a 30 year asset life; and
- the relevant public sector discount rate is 3.5% real.

With these assumptions, the NPV at the end of 2012[6] (the year in which the costs are incurred) is £8.6 billion using the ILEX probabilities, and £3.4 billion using the alternative probabilities.

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6 We assume the benefits are realised at the end of each year from 2014 onwards, and the cost is incurred at the end of 2012.

Summary of costs and benefits

Table 2 summarises the net present value based on an investment in one Rough Equivalent operational in the year 2014 and available for a period of 30 years (the assumed asset life).

Table 2 shows the range of costs and covers the full range of fuel price assumptions for depleted field storage (£1.2 to £2.4 billion) and for distillate storage at CCGTs (£0.9 to £1.4 billion).

The benefits are based on the two cases we have used for source outage events and probabilities: the ILEX case and the alternative case. Note that the ILEX figure of £8.6 billion is our best estimate, not the top of a range.

Table 2 – Summary of costs and benefits

	Investment in one Rough Equivalent (3.3bcm) operational in 2014
Benefit	£8.6 billion (ILEX case) £3.4 billion (alternative case)
Cost	£0.9 to £2.4 billion
Net benefit	£6.2 to £7.7 billion (ILEX case) £1.0 to £2.5 billion (alternative case)

Benefits are discounted at 3.5%

We conclude that under the range of assumptions analysed the net benefit of providing one Rough Equivalent of strategic reserve is positive and at least of the order of £1-2 billion. Our best estimate of the net benefit is £6-8 billion. If we discount this back to 1st January 2006, then our best estimate of the net benefit is £5-6 billion.

Comments on the results

The results of our analysis shown above suggest that the NPV of building a Rough Equivalent is likely to be substantially in excess of its cost. At first sight, this seems odd given that the probability of a gas supply shortfall is small, even post 2015. However, our research indicates that the economic impact, if a shortfall does occur, could be many times as great as the cost of the RE. The economic costs to the economy of running short of gas are not commensurate with the narrow commercial costs to the gas industry itself.

In calculating the economic impact, we have assumed loss of output in not only the directly affected sectors, but also the sectors immediately upstream and downstream (the so-called "second-order effects"[7]). Although we have not analysed the economic impact "without second-order effects" in detail, it is apparent from Figure 1 above that the results for the benefit analysis would

[7] This is economists' jargon, and certainly does not mean second-order in the scientific sense of a negligible quantity!

fall by approximately one third. Even with this assumption, the net benefit of an RE appears to be positive.

Of course, the choice of discount rate is important and using a higher discount rate would make the investment less attractive. However, sensitivity analysis shows that even doubling the rate (to 7% real) gives a benefit of £5.5 billion (ILEX) and £2.2 billion (alternative); and hence the net benefit, after subtracting the cost, is still likely to be positive.

It is noteworthy that our analysis assumes the government is risk neutral. We have assumed in our work that an uncertain financial impact of £X occurring with probability Y is equivalent to a certain financial impact of £XY. This is risk neutral by definition, because mathematically it focuses on the expectation or mean outcome. In practice, government might consider that the former is more undesirable than the latter, i.e. government might be risk averse in the same way that most people are risk averse with their finances. Any attempt to introduce a measure of risk averseness would make the conclusions that we have reached even more stark.

Implementation

We envisage a three part process:

- Determine quantity of strategic storage required and the timetable;
- Determine the process by which the required quantity is provided; and
- Determine the trigger or mechanism for the use of the strategic storage.

We recommend that the DTI, in conjunction with Ofgem, conduct a similar evaluation to determine the quantity of strategic storage required using analytical techniques similar to those used above and based on transparent modelling of the gas/supply outlook. We recommend a detailed evaluation at least every three years with annual updates of a less rigorous nature in between.

We suggest two possible options which could be examined in more detail if a decision is made to implement a form of strategic storage. In the first option, National Grid (NG) would take on a new licence obligation to run a process, details to be agreed with Ofgem, requiring NG to pay for the options bid into a form of competitive tender. In the second option, gas suppliers take on a new enhanced form of licence obligation for security of supply. This could be called a Security of Supply Obligation (SOSO) similar in nature to the Renewable Obligation. We also evaluate – but do not recommend – a third option, setting a very high emergency cash out price (£12/therm to reflect the estimated damage to the economy) and compensating consumers who have been interrupted at this price.

In our view, any form of strategic gas option must be clearly ring fenced from the commercial market and not be used in other than clearly defined circumstances. This would allow normal winter/summer gas price differentials to continue to drive commercial investment in both storage and additional gas importation infrastructure and other forms of gas flexibility, such as alternative fuels at CCGTs and industrial sites.

The existence of a strategic reserve will have a psychological impact on the market and this is likely to reduce the volatility of prices on the forward curve. We cannot see that this impact can be avoided. However, in our view having a clear set of rules for the triggering the use of strategic reserve will largely mitigate the impact on the spot price.

The trigger for the use of strategic reserve should be a significant loss of supply for a long duration (weeks rather than days). A tightening of the supply-demand balance should not in itself trigger the strategic reserve. If demand is higher than normal, due for example to severe weather, this should not in our view immediately trigger the strategic reserve. Instead the normal commercial market should be allowed to continue to operate at least for the time being. If the high demand levels persist and, in consequence, storage stocks fall to the level at which a Gas Supply Emergency is triggered, then at this point the strategic reserve could also be triggered.

Risks and unintended consequences

The main risk we identify is that an intervention to provide a strategic reserve might have an adverse impact on commercial storage projects. As a consequence the amount of new storage developed by the market is less than it would have been, increasing the amount of strategic reserve required. Unless this risk can be mitigated, the cost of providing strategic storage could be considerably increased. In addition, the risks associated with option 3, the high emergency cash out price, are potentially very high and could lead to market failure.

To mitigate the risks the following steps should be considered:

- The Government should signal to the market well in advance the need to have a strategic reserve, allow a number of years for it to be developed, and allow it to be met from a number of different facilities, including standby fuel at CCGTs.
- The strategic reserve would be used to replace a known loss of supply. However, this should not be triggered immediately; instead the commercial market would be left to operate for a period (e.g. a week) before any action is taken. During this week the prices in the commercial market would be expected to rise. Once the strategic reserve is triggered, the gas released would be sold by National Grid to shippers through the cash-out mechanism at the prevailing cash-out price.
- There should be a predefined set of rules for triggering the release of the strategic reserve. The triggers would not include the price of gas. The sharp rise in gas prices seen in November 2005 (when the spot price rose sharply to around 120p/th) would not trigger the use of strategic reserve.
- The strategic booking would be ring fenced and the quantities of reserve reported.
- Another mitigation could be to make Ofgem, the agency closest to the UK gas market, the agent that makes the decision on any release of strategic reserve gas, in order to diminish the potential for the strategic reserve to be used (or seen to be used) as a political tool.

Summary and recommendations

Security of supply in gas has become a topic of concern amongst consumers, gas industry players and government. There are a number of factors that have led us to examine the question of the long-term security of supply:

- increasing use of gas in electricity generation;
- declining 'swing' capability of UKCS production;
- concerns about the reliability of existing gas industry infrastructure; and
- increasing reliance on imported gas.

ILEX concluded in its report for UKOOA in October 2005 that the UK market, as currently structured, may deliver a number of relatively small gas storage projects but will not provide sufficient volumes to insure against high risk but low probability events.

Our conclusions based on more detailed analysis remain the same. In our view, the UK gas market will bring forward some new facilities, particularly if planning procedures are eased; but the total quantity of gas storage is likely to fall short of providing the level of security against high impact-low probability events which is economically desirable, without some form of intervention. We do not consider planning difficulties as the primary reason for the UK having less gas storage than Germany or France, notwithstanding the fact that easing planning procedures is necessary to allow the commercial storage market to work efficiently. Rather, the key issue is that current commercial incentives to provide storage are not commensurate with the *expected* economic value of these high impact-low probability events.

Our analysis, using probabilities of supply interruptions, indicates that the UK faces a small but not insignificant risk of shortfall in the next two years, after which there is likely to be a period of abundance due to the commissioning of several planned gas importation projects. The risk of shortfall and associated economic consequences reappears from 2014 when the UKCS production has declined further and demand has increased.

Of course, we cannot be certain of the timing or magnitude of risk:

- the size of the gap is based on views of the supply-demand position 20 years into the future;
- the size of the gap is based on views of probabilities which cannot be considered precise; and
- the new importation projects may be delayed or, even if built, may import less gas than is assumed in our scenario modelling to date.

Whilst the supply-demand gap could be better or worse than forecast, the risk may not be symmetrical in that the potential damage to the UK of a worse outturn than the one we have predicted is very costly to the economy.

We suggest that two approaches be considered by the DTI as possible alternative courses of action. These are set out below and both assume that after full consideration of this study, and all the other Energy Review related analysis and further consultation, the Government decides that a form of strategic reserve should be provided.

Fast Track timetable

If the outcome of the Energy Review is a move to a more risk averse future, the DTI should fast track further studies and consultation to develop strategic reserve. The aim would be to complete the development and full consultation by mid 2007. Licence changes may take a bit longer but the objective would be to launch the strategic reserve initiative by the end of 2007 to stimulate provision of reserve by 2011.

Post 2013 timetable

There may not be much that can be done on the supply side to help with the potential problem in the next two years. The apparent breathing space until 2014 should be used to develop the detailed implementation arrangements.

We recommend that the DTI, in the aftermath of the Energy Review, publish a timetable leading to putting strategic reserve in place by 2014. This would include a detailed evaluation study in 2008 of the supply-demand position, in the light of recent gas importation projects and the quantities of gas delivered.

We recommend that the DTI with Ofgem instigate an industry group tasked with developing detailed implementation rules and licence modifications with a delivery date of the end of 2007.

Following on from the 2008 evaluation study, the DTI should instigate the start of the strategic reserve scheme by the end of 2009. This would allow sufficient time to bring forward some reserve by 2014.