GAS STORAGE

Dieter Helm¹
February 2013

¹ The author acknowledges the financial support of Halite (www.halite-energy.co.uk) in the preparation of this paper. All editorial control remains with the author and the views expressed are those of the author alone. The paper addresses the general issue of gas storage in Britain, and not any particular project or investment.
Gas Storage

Executive Summary

1. Gas already plays a significant role in Britain’s energy mix. It is a role that is likely to increase over the next two decades.

2. Britain’s fortunate position as a gas exporter has been transformed to one of import dependency. This new reality is unlikely to be changed by shale gas for a considerable time, if ever.

3. Gas storage has been provided by North Sea fields and facilities aimed at seasonal variation of demand. The depletion of North Sea fields has given rise to the need for new storage options.

4. Current import supplies rely on three pipelines (South Norway and the European continent) and LNG supplies largely from Qatar.

5. Increased renewables have rendered the energy market less secure, and in turn made gas CCGTs intermittent. Renewables are therefore increasing the volatility of the system.

6. There is a variety of ways of increasing energy security. The role of storage depends upon what other options are available.

7. There is no right answer to the optimal level of storage. However the gap between current provision and a range of possible optimal levels is very large – and that is what matters for policy. There is therefore little doubt that considerable investment in storage is required.

8. The optimal level of storage is a system property, and hence should be defined at the system level. It will not be achieved without intervention.
9. There are several mechanisms to ensure storage is increased. Given that Energy Market Reform (EMR) will introduce a capacity market, and the system operator will have to ensure security of supply, storage should be incorporated into the EMR reforms.

10. Storage contracts will require a counter-party, and it is likely that a supplier obligation will be required to ensure that this is achieved.

11. There is considerable urgency, given the time lag in bringing significant new storage facilities onto the system.
1. Introduction

Gas storage plays a vital role in ensuring security of supply. As gas has become increasingly important in Britain's energy mix, storage's role is moving from necessary to crucial. Yet the provision of gas storage in Britain ranks amongst the lowest in Europe. It is hard to avoid the conclusion that it is seriously inadequate, and increasingly so.

This failure to develop new gas storage facilities has been for very good historic reasons. Britain has for the past three decades had its own gas fields in the North Sea, which were, in effect, large gas storage facilities that were being depleted. In the early days, contracts provided for security of supply and flexibility in the event of interruptions to ensure that supplies could match fluctuations in demand, and in the case of supply side failures, supplies from one source could be made up from elsewhere.

The development of industrial and domestic markets was carefully planned by the state owned British Gas Corporation (BGC), with gas as a premium—and special—fuel initially reserved for industrial processes (especially petrochemicals) and domestic heating and cooking. It only became legal to burn gas in power stations after 1990 (and similarly in the US), and the subsequent building of the market share of gas in electricity supply started gradually. The supply of gas is now a major dimension of security of supply for electricity.

These early benign circumstances have now changed. The North Sea supplies are dwindling, imports are growing and gas may rise to 60% of electricity generation over the next decade. With the advent of more intermittent renewables, gas has an additional and critical back-up supply role for electricity. It is, and is likely to
remain, the marginal fuel. The development of shale gas and LNG facilities add further elements to this growing and changing gas market.

Whilst the need for more storage has grown, policy has not kept pace. To date, gas storage has largely been about seasonal fluctuations in demand — ranging between summer troughs and winter peaks. Now it plays a wider security role — acting as a cushion, an insurance against unanticipated shocks. This security role — rather than seasonal fluctuations — is the main focus of this paper. It requires the holding of stocks in excess of the mean expected demand. But no profit-seeking business would deliberately engineer circumstances of excess supply, since it will tend to drive down prices, notably by pushing the marginal price below the average cost. The optimal level of insurance will not arise spontaneously: it requires a policy intervention to create and sustain a storage market of sufficient scale. That is the policy challenge for the new and less benign circumstances Britain finds itself in.

A tempting solution might be to define that optimal level of storage and mandate it. But as will be explained below, the reality is much more complicated. Security of supply is multi-dimensional, and there are lots of ways of dealing with the insurance problem. Storage is just one of these, and it is very unlikely that DECC — or indeed any central planner — would be able to calculate the optimal level of security, or indeed of storage. Fortunately this calculation is not necessary. Instead DECC can calculate the overall insurance requirement for the energy system as a whole and allow market mechanisms to sort out the exact mix. This paper sets out how it might be done and, within this framework, makes the case for a substantial investment in storage and related security measures as a matter of urgency.
The structure of the paper is as follows. Section 2 sets out the energy challenge and context over the next two decades. Section 3 summarises the current (lack of) gas storage in Britain. Section 4 describes the dimensions of security of supply. Section 5 considers the economic value of gas storage, and looks at the benefits of increasing gas storage. Finally, section 6 sets out how the value of gas storage might be revealed within the energy policy framework, both generally and in respect to the proposed energy market reforms in the energy legislation now before Parliament.

2. The nature of the energy challenge over the next two decades: why Britain needs additional security of supply measures

At any time, the energy system is the product of decisions in the past—sometimes decades earlier—and inevitably the assets reflect past contexts, past assumptions and past forecasts. It is also often the case that current investments are driven by assumptions about given and known technologies, and these tend to view the future on the basis of the past—looking out of the back window. No energy system can therefore ever be optimal: we are prisoners of our past. Yet as long as the future can be expected to resemble the past, the problems of evolving the energy capital stock can run on reasonably smoothly. It is when there is structural change that problems arise, and energy crises result unless policy is changed.

The energy system in Britain is very much in this mould. Until the end of the 1970s, electricity demand grew at more than twice the growth rate of GDP and, under a centrally-planned energy system, the Central Electricity Generating Board (CEGB) together with the National Coal Board (NCB) planned the future on the basis of a largely coal-based electricity system, backed up with nuclear. Roughly,
the ratio of coal to nuclear was 80-20.

When the second oil shock hit at the end of the 1970s with the Iranian revolution, the major developed economies hit a growth brick wall. Britain suffered a very sharp recession, losing around 25% of manufacturing in just 18 months. From 1980 onwards, Britain embarked on a process of deindustrialization, which was to last for two decades. GDP growth no longer required more electricity: the energy-intensive industries left Britain for new economies like China.

A legacy of over-supply

This left an enormous oversupply of power stations built under the very different assumptions of the 1970s. These coal and nuclear stations still play a very large part in our electricity sector today—from DRAX and the coal fleet, to the Advanced Gas Cooled Reactors (AGRs). As a result, with the addition of the PWR at Sizewell and the gas CCGTs, Britain cruised through to the early 2000s with excess supplies. There was no security of supply problem.

These coal and nuclear power stations are now ageing and need replacing. The market is therefore shifting from excess supply to excess demand, and, as the capacity margin tightens, the security problem re-emerges. Subdued demand due to the deep economic recession may have provided a breathing space, but the structural changes have only been temporarily delayed by the general economic crisis.
The gradual emergence of gas in the energy mix

Gas only played a significant role in electricity supply after 1990. As noted, before 1990 it was illegal to burn gas in power stations, on the assumption that gas was a premium fuel, which ought to have been reserved for the petrochemical industry and domestic uses. The lifting of this European ban in 1990, and the coming on-stream of ever-larger supplies of North Sea gas, added yet another layer to the energy system's security. Gas after 1990 was not only an important fuel for industry and for heating, but could also be burnt on a large scale in power stations. The result was a gradual increase of gas as a share of electricity generation towards 40%. The ratios are now very roughly 40/45 for gas and coal, with nuclear at close to 20%. As yet renewables are a small proportion of the total, but growing. From a security perspective, renewables are also intermittent, so the share of capacity of electricity generated does not reflect their much lower security contribution (to which we return below).

Thus Britain has gradually moved from gas being a small niche player to its dominance in not only heating and industrial usage, but also electricity. Add in these other uses, especially heating, and its importance is obvious. Security of gas supply is increasingly synonymous with security of energy supply.
Long term contracts and enforced flexibility

The increase in the gas use in electricity generation coincided initially with greater North Sea production. The initial contracts which British Gas insisted upon (combined with the Continental Shelf legislation forcing gas in British waters to be landed in Britain) had two key characteristics: they were long term take-or-pay; and they provided for flexibility, so that British Gas could use the take up as a way of meeting the need for security of supply in the event of demand hikes or supply shocks. In other words, the gas fields were, in effect, giant stores, which could be depleted to meet the system needs. As a result, British Gas could get by with limited additional storage. It had local gas storage tanks, and it had line packing, and it had the ability to flex the fields' supplies. Together—with Morecambe and Rough—these proved sufficient.
Gas production starts to decline after 2000

For the 1980s and 1990s, British gas production kept on going up, beating initial expectations and facilitating large scale gas exports. But production peaked in around 2000 and it has been gradually falling ever since, as the graph below demonstrates. Now Britain relies increasingly on imports, and has had to join the queue for Norwegian and mainland European gas supplies, and for internationally traded LNG. Gone is the flexibility provided by North Sea gas fields, within Britain’s territorial waters. The British Gas monopoly was broken up, and long term contracts dropped away. In the place of British gas supplies and long term contracts is exposure to Norwegian fields and pipeline connections, and to the European market, which is still greatly dependent on Russia and Gazprom. Imports create a very different security context—and unsurprisingly countries that rely on imports of gas tend to take storage seriously.

Gas Storage

As the pie chart below indicates, the ratio of pipeline to LNG supplies for import is roughly 60-40. Britain is now vulnerable to failure in either supply conduit.

Gas Imports by origin 2011  Source: Digest of UK Energy Statistics 2012

Pipeline vulnerabilities

The Norwegian pipelines are the main source of imports, and for the rest, Britain has become part of the European gas system and also the LNG markets. The map below sets out the dense network of pipelines in the British North Sea, and the external reliance on three main pipelines—from Norway, Belgium and the Netherlands.
Gas Storage

The UK National gas transmission system 2011  Source: DUKES, 2012 p104

Source: International Energy Agency and DECC
Each of these sources of supply has its own problems. The Norwegian supplies rely on a small number of pipelines (notably Langeled) and hence are vulnerable to infrastructure problems and field issues in Norway, and potentially to terrorist attacks and accidents too. Put simply, if the Langeled pipeline were “taken out” Britain would be vulnerable. In Europe, there is an overwhelming reliance on Russia and Gazprom, backed up by Dutch gas, and although Nord Stream has ameliorated the pipeline position in Northern Europe, the contractual form in Europe (based on long-term take-or-pay contracts) may leave Britain vulnerable in the event of gas rationing from Russia.

**Gas import/export facilities in the UK at May 2012**

<table>
<thead>
<tr>
<th>Facilities</th>
<th>Owner</th>
<th>Between/Location</th>
<th>Max flow rate (million cubic meters per day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imports:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bacton-Zeebrugge Interconnector</td>
<td>Interconnector (UK) Ltd</td>
<td>Zeebrugge to Bacton</td>
<td>74</td>
</tr>
<tr>
<td>BBL Pipeline</td>
<td>BBL Co</td>
<td>Balgzand and Bacton</td>
<td>53</td>
</tr>
<tr>
<td>Versterled Pipeline</td>
<td>Gassco</td>
<td>Heimdal Raiser Platform and St Fergus</td>
<td>36</td>
</tr>
<tr>
<td>Tampen Link</td>
<td>Gassco</td>
<td>Statfjord to St Fergus</td>
<td>18</td>
</tr>
<tr>
<td>Gjea Pipeline</td>
<td>Gassco</td>
<td>Links Gjea to St Fergus</td>
<td>25</td>
</tr>
<tr>
<td>Langeled Pipeline</td>
<td>Gassco</td>
<td>Nyhamna and Easington</td>
<td>69</td>
</tr>
<tr>
<td>Exports:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bacton-Zeebrugge Interconnector</td>
<td>Interconnector (UK) Ltd</td>
<td>Bacton and Zeebrugge</td>
<td>55</td>
</tr>
<tr>
<td>UK Irish Interconnector</td>
<td>Bord Gais</td>
<td>Moffat and Ireland</td>
<td>30</td>
</tr>
</tbody>
</table>

*Source: Digest of UK energy statistics 2012 DECC*

This vulnerability via European pipelines is currently masked by the current dash-for-coal in Germany and other major European countries and by the very depressed state of demand—but it cannot be assumed that these conditions will last forever. Hoping for a continued economic crisis in Europe and for policy
makers to remain relaxed about the carbon implications of burning more coal is hardly a convincing energy policy.

**LNG risks**

LNG supply security depends upon both the LNG infrastructure and the supply of LNG cargoes. As with pipelines, the security threats are twofold—physical availability and price. On physical availability, Qatar is crucial and it is inside the Straits of Hormuz. In the event of a restriction or closure of these Straits, there might well be physical interruptions across the global market—or at least until the US shale gas revolution begins to bite into global gas trade. On price, as with pipelines, this depends on both contract forms and the global demand/supply situation. Long term contracts have priority over spot-traded LNG cargoes, and demand surges, such as in Japan after Fukushima, knock-on to import prices.

Britain has three main LNG facilities, as the table below shows (with Teesside a distant fourth). These play a security as well as supply role and new storage options need to be considered against the mix of LNG and pipeline options.

| **Liquefied Natural Gas imports by terminal (GWh)** |
|----------------|--------|--------|--------|--------|--------|
| **LNG Imports via** | **2007** | **2008** | **2009** | **2010** | **2011** |
| Milford Haven Dragon | - | - | 10,034 | 19,097 | 28,365 |
| Isle of Grain | 14,861 | 8,912 | 50,483 | 59,770 | 85,081 |
| Milford Haven South Hook | - | - | 49,249 | 124,922 | 157,287 |
| Teesside | 42 | - | 813 | - | - |

*Source: Digest of UK Energy Statistics 2012, DECC*
Managing intermittent wind generation

These external links are not just needed to replace domestic production: they are going to be needed in ever-greater quantities as the share of gas in electricity rises. This may reach perhaps 60% over the next decade. Britain will need more gas in aggregate, and more imports as the demand grows. But it is not just the aggregate demand for gas that is likely to rise. The composition of that demand is being altered by renewables and particularly wind. Intermittent wind renders everything else intermittent too. Gas power stations can no longer assume a baseload role: whenever the wind blows, its zero marginal costs push gas CCGTs off the system, and as a result the gas stations need much more flexible intermittent gas supply contracts. On very still winter days under high pressure weather systems, there is likely to be a surge in gas demand, followed by a collapse when south westerly low pressure systems arrive (provided the winds are not too strong). This intermittency in the demand for gas makes the optimal configuration of short term supplies critical, and so storage becomes much more valuable. Building OGC peaking plants is a further ratchet in this security problem. Thus, to seasonal demand fluctuations are added more immediate swings in demand, potentially across northern Europe. This in turn creates significant fluctuations in aggregate gas demand.

Coal and nuclear may be on the way out

The rest of the power sector also affects the role of gas. More intermittent wind is being complimented by less nuclear and less coal. Whilst Britain considers new nuclear, it is important to realize that for the next couple of decades, it is on a nuclear exit strategy roughly comparable to that of Germany. Though life
extensions may hold off the date of some closures, most of the nuclear power stations will close during the period to 2030. Though there may be some new stations in the 2020s, it would be rash to assume that these will make much difference until at least the second half of that decade.

For different reasons—the European directives on non-carbon emissions (LCPD and the IED)—much of the existing coal generation in Britain is due to come off the system over the rest of this decade, leaving only those stations with FGDs and related pollution-control technologies. Some of these stations may eke out their lives with biomass co-firing, though this energy source has its own sustainability issues. There are also security of supply concerns about the availability of what are necessarily very bulky cargoes of biomass material.

Mitigating factors

There are some offsetting features that may ameliorate these negative impacts on security of supply. In addition to plant extensions and biomass, the demand side may benefit from energy efficiency measures which reduce the total demand, and new technologies may make the demand side more resilient against shocks, increasing the ability of the system operator to absorb shocks on both the demand and supply sides. In time, smart technologies will aid the active participation of the demand side, and the Green Deal aims to reduce household demand. There may also be a prolonged period of weak demand in both Britain and northern Europe as the economic crisis drags on, buying some more time.
A new world

But ignoring a problem on the basis of the favourable backdrop of home supplies and the inheritance of over optimistic investment assumptions has led to a complacency which is being revealed as the underlying assumptions are being gradually turned on their heads. A series of largely unrelated developments are creating a much less benign situation in which the absence of storage measures is likely to prove costly over the coming decade. The current economic crisis—and the resulting much lower than expected demand—is possibly the last piece of “luck” the energy security context is likely to witness. Almost all the other factors are likely to be adverse.
3. The current gas storage position

The problem with measures to increase security of supply is that almost all require investment, and therefore time. Most energy sector investments take a minimum of 2 years, and more typically towards 5 years. Some take much longer, possibly including nuclear. It is hard to see that much will change before 2016 at the earliest, and more realistically 2018. Given too the current uncertainty about energy policy, the credit constraints and the state of the large utilities' balance sheets, the mismatch between what is needed and what may be provided is already alarmingly significant.

Hardly any storage

Faced with these major structural changes in the British energy market, how well prepared is it to withstand shocks? How much storage is available? Gas storage is notable by its absence. There just isn’t very much of it, and what there is, is concentrated in the Rough 1985 field and in the hands of one company, Centrica.

The table below sets out the current dismal state of Britain’s storage facilities.
## Gas Storage

### Gas storage sites in the UK as at May 2012

<table>
<thead>
<tr>
<th>Owner</th>
<th>Site</th>
<th>Location</th>
<th>Capacity (billion cubic meters)</th>
<th>Max flow (million cubic meters)</th>
<th>Type</th>
<th>Status (long, medium or short range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centrica</td>
<td>Rough</td>
<td>Southern North sea</td>
<td>3.30</td>
<td>45</td>
<td>Depleted field</td>
<td>Long</td>
</tr>
<tr>
<td>National Grid LNGS</td>
<td>Avonmouth</td>
<td>Bristol</td>
<td>0.08</td>
<td>13</td>
<td>LNG</td>
<td>Short</td>
</tr>
<tr>
<td>SSE</td>
<td>Hornsea</td>
<td>East Yorkshire</td>
<td>0.30</td>
<td>17</td>
<td>Salt Cavern</td>
<td>Medium</td>
</tr>
<tr>
<td>EDF Trading</td>
<td>Holehouse Farm</td>
<td>Cheshire</td>
<td>0.06</td>
<td>7</td>
<td>Salt Cavern</td>
<td>Medium</td>
</tr>
<tr>
<td>Scottish Power</td>
<td>Hatfield Moor</td>
<td>South Yorkshire</td>
<td>0.10</td>
<td>2</td>
<td>Depleted field</td>
<td>Medium</td>
</tr>
<tr>
<td>Star Energy</td>
<td>Humbly Grove</td>
<td>Hampshire</td>
<td>0.30</td>
<td>7</td>
<td>Depleted field</td>
<td>Medium</td>
</tr>
<tr>
<td>SSE &amp; Statoil</td>
<td>Aldbrough</td>
<td>East Yorkshire</td>
<td>0.20</td>
<td>12</td>
<td>Salt Cavern</td>
<td>Medium</td>
</tr>
</tbody>
</table>

*Source: Digest of UK energy statistics 2012 DECC (DUKES)*

### European comparisons are stark

The consequence is that Britain has less storage relative to consumption than any other major European economy, and less gas purchased under long term contracts. The table below illustrates how, as one of the largest economies in Europe, UK storage in aggregate is much lower than its peers. Taking population and GDP into account, Britain is at the very bottom of the list. As a result, “GB customers are more exposed to seasonal swings in gas prices and medium term volatility.” (Ofgem: Gas Security of Supply Report, November 2012 para 3.6, p.40). Ofgem omits to add and more exposed to interruptions of supply.
4. Security of supply and market failures

Section 2 demonstrated that Britain faces potentially serious security of supply problems on a different scale than it has confronted over the last two decades. Section 3 noted that Britain has little current gas storage. Whatever the optimal
level of security, Britain is likely to be well outside the comfort zone later in this
decade and into the next. This has been recognised by government—DECC
published its “Gas Security of Supply” statement in April 2012, Ofgem published its
“Gas Security of Supply Report” in November 2012, and DECC followed up with its
“Gas Generation Strategy” in December 2012, (published alongside the Treasury’s
Autumn Statement). All acknowledge the challenges ahead. There is no serious
dissent from this view. The problem isn’t one of recognition: it is one of action
and investment.

Lots of different types of security

The ways in which security can be provided are many and various. It is unlikely
that any one route will be sufficient, and it is more likely that a number of measures
and investments will be required. In order to identify the likely bundle of measures,
the first step is to be clear about what security actually means—to identify its
dimensions.

Though there is a physical dimension to security—the ability to provide energy to
customers—much of what passes for security is really about prices and market
functioning. There is almost always a price at which supply will equal demand—
and indeed for electricity (where there is no significant storage of electricity), they
must always be equal. As the price rises, fewer and fewer customers are able to
pay for the service, and they drop out of the market. But long before this
equilibrium is reached, there may be major adverse consequences, and security of
supply in practice means that supply must equal demand at reasonable prices.

To see what “reasonable” means, it is important to disaggregate what the
economic services provided by energy are. In electricity and gas, customers not
only buy the commodity, but also want to be sure that it will be available on demand. The trouble with this availability dimension is that it depends upon what everyone else wants at the same time—particularly if there is no storage. Thus the customer problem breaks into two parts: energy; and the insurance that the energy will be available.

Need for a margin of excess supply

It is the second bit that is now problematic given the erosion of the excess supply conditions of the 1980s onward when there was enough gas to export, and more power stations than needed. Security requires that there is an excess margin of capacity to absorb supply or demand side shocks. That means there must be an excess of supply over and above what a market would deliver: but no profit seeking company would ever want to engineer a situation in which there was an excess so that prices fell below average costs. So there needs to be an additional payment for the excess—some form of capacity payment—which must ultimately be paid for by customers. This excess—the insurance—is a system property, not one of individual investments. Hence, in the absence of policy intervention, the market will never provide the optimal level of excess capacity, especially when there is no storage. This is why there needs to be a policy intervention.

Until recently the gas market could be regarded separately from electricity, and since gas could be stored, the market could address the insurance problem in gas, but not electricity. As noted above, electricity could also be left to the market as long as there was excess capacity for other reasons—the overhang from the 1970s and the economic crisis cutting demand. That is not true now that electricity and gas are converging. Gas storage is now a problem for both electricity and gas.
Gas Storage

How then to provide the capacity margin in electricity and to ensure that the gas market provides sufficient capacity for gas customers? There are a number of options. These can be classified physically, but their optimal level is economic.

Lots of different ways of providing security

The physical ways of providing the insurance come from a diversification of sources of potential excess supply over and above the mean demand. These include:

- Pipelines with the capacity to increase supply
- LNG terminals
- Internal pipelines to reroute supplies
- Alternative forms of electricity generation with switching capabilities
- Storage on the supply side
- Demand management options, including the ability to vary the voltages
- Interruptible contracts

As each of these options is developed independently of the others, there is no reason to expect that the optimal portfolio of investments and contracts will be put in place. Building new pipelines impacts on the economics of storage, and vice versa. Contracts for back-up supplies are typically of varying durations, and the circumstances change. The number of power stations available is the outcome of multiple independent decisions made by companies and investors. Given security is a system property, someone or some institution or company needs to set the required level and ensure that the combination of measures adds up to the
required overall security. This is typically the system operator (SO), tasked with matching supply and demand on a continuous basis. Put another way, the SO cannot carry out its functions independently of storage.

Need for short, medium and long term security options

Until recently this was interpreted as a short-term requirement, on the assumption that the market would look after itself in the medium and longer term, responding to prices in wholesale markets. The short term in effect meant seasonal variations—matching winter demand with additional storage at peaks. More recently, the short-term security requirement has been greatly exacerbated by the advent of lots of intermittent renewables on the system—notably wind (solar has peaks in the daytime and hence is less problematic).

At its core, Energy Market Reform (EMR) recognizes that the assumption about the market looking after itself in the medium to longer term cannot be relied upon—only if the system were to “get lucky” by lower demand caused by recession and low growth, or energy efficiency measures were to make a big difference to energy demand, would this be a reasonable assumption to make (and these measures are in any event policy driven).

Ofgem’s options

The insurance can be provided either through planning and regulation, or through
market incentives. Ofgem (November 2012: Gas Security of Supply Report) identifies a number of options. These are:

- Information requirements
- Promoting standardization of interruptible contracts
- Demand side response tender
- Back-up fuel requirements
- Financial reliability option
- Non specific service obligation on suppliers
- Service obligation on the system operator
- Storage obligation
- Semi-regulated storage
- Strategic stocks

Market-based approaches

The starting point is the market, and market-based mechanisms. The market approach starts with setting the required capacity margin—this as a system property can only be set exogenously, unless customers are each offered different types of interruptible contracts, and these can be aggregated and enforced. Whilst this might work for very large electricity customers, it is implausible with current technology for individual retail customers, though suppliers may be able to aggregate some of these dimensions.

Once the system optimal is defined, a market system can operate by auctioning the requirement and hence a capacity market can be created alongside the energy market. The 2012 Energy Bill makes provision for an arrangement of this form, though the model it proposes is for the short term auctioning of all capacity requirements a year ahead, and a series of longer-term contracts for defined
projects. Some of these may be specifically for new gas power stations, and it is far from obvious why there should be energy-only contracts for renewables and nuclear and capacity-only contracts for gas power stations. A series of short-term measures, such as the so-called cash out arrangement, improve the short-term incentives—but make no impact on the longer-term investment horizon. It is vaguely indicated in the Bill that storage and the demand side might also bid into this capacity market, but no details are provided. What is apparent is that if there is a capacity market for electricity generation, then it will have to take storage into account—if only in deciding how many capacity contracts to offer. It is however remarkable how little thought appears to have been given to the role of storage.

Planning

An alternative to the market approach is simply to plan investment and hence ensure through planning that the capacity margin is met, together with the appropriate infrastructure and storage. The CEGB once fulfilled this function, and now that the Government has chosen to be a central buyer under the EMR proposals, it could take the further step towards individually contracting for all investments. It could then coordinate the infrastructure networks and interconnections to fit into its overall plan for the sector.

A number of intermediary models can be envisaged. Indeed, EMR is intermediate—some things are bilaterally contracted, others are auctioned and the network planning is, to an extent, in the hands of National Grid (which is also the System Operator). The central buyer model has many defects, and even under
EMR it is suggested that over time, the role of the market might be re-established. Whether it will or will not, central buying of storage appears unlikely in the (urgent) timescale within which it will be required.

Obligations

The responsibility to contract for sufficient storage could be placed with suppliers rather than the SO, though there would still need to be a system view of the required storage provision, and there would most likely be an effective parceling out of a national requirement. To the extent that a supplier obligation is required to contract for storage under all of the above options anyway, it will be required to ensure customer pay the costs of storage. So unless storage is paid for through the use of system network charges, supplier licences will have to be amended. The inescapable conclusion is that a supplier obligation of some kind is necessary.

5. The economic value of gas storage

Storage is but one amongst many ways of improving security. It comes in lots of different shapes and sizes, and therefore there is no generic model of its characteristics. Each storage facility has its own physical features and each has specific locations within the networks.

Costs of storage

Bearing these caveats in mind, storage has a series of costs which impact on its economics:

i. Initial sunk and fixed costs of preparing the store for holding gas, sufficient
for licensing purposes.

ii. Surrounding infrastructure costs in the gas networks.

iii. Variable costs associated with pumping the gas into and out of the store.

iv. The cost of gas.

Gas storage as a short-term supply management tool

In order to calculate the economics of a specific project, the two variable costs (iii) + (iv) need to be sufficiently below the value of the gas sold, such that the fixed costs (i) + (ii) are recovered, all subject to discounting by the cost of capital, in the absence of intervention to ensure sufficient capacity is available and suppliers are obligated to purchase it.

The gap between the gas purchase and gas sales costs is determined by the volatility of gas prices. Paradoxically, volatility increases the value of the project, but by providing storage volatility will be reduced, since in effect the store is arbitraging between these prices.

These costs—(i) to (iv)—are all features in the existing market and the revenues can be derived by estimating forward gas price volatility. Yet using current market prices means that the stores are not paid for the insurance value they bring to the system: they do not receive a capacity payment. Put another way, the optimal level of storage is above the actual level by the value of the insurance that the gas supply margin provides by storage. The value of that insurance—itsystem property—depends upon the costs of (unanticipated) interruptions in supply. In domestic gas, an interruption in supply has serious consequences for safety and reconnection is sufficiently costly as to be a situation of last resort. For gas power
stations, the price effect of security of supply is more important.

Storage v. alternative ways of providing supply security

That value in turn depends upon the costs of alternative ways of providing for that excess supply—through additional “peaking” contracts for supplies through interconnectors and so on. The benefits of storage versus the alternatives need to be recognized: in the case of storage the gas is physically there—like reservoirs on a water system. The gas required to provide back-up in the event of a demand or supply shock depends upon other features of the energy systems and other contracts. So, for example, Germany has a number of long-term take-or-pay contracts that take priority at points of stress in its supplies. As was witnessed in the Ukrainian interruption in 2009, where there is a European gas supply emergency, sourcing gas from other countries with their own contractual nexus is fraught with difficulties. If there had been a fully functioning internal energy market, and a liquid and transparent European wholesale market in gas, this contractual nexus would not have been such a problem. But the reality is that there is no well-functioning European gas market, and each country takes the lead in ensuring its own supply security first. These conditions are not likely to change in the near future, despite the efforts of the European Commission.

Looking at this European market, it is apparent that there are bottlenecks and dependencies on specific sources of supply. In Central and Eastern Europe, this source is overwhelmingly Gazprom, which is a state-driven political entity, capable of using its market power for political purposes—as in the case of Ukraine. Even with the Nord Stream pipeline—deliberately designed to link Germany and Russia directly by bypassing Poland and the Baltic counties—the security of supply is
ultimately political and fits within the special energy relationship between Russia and Germany. This creates a political premium to add to the value of gas storage identified above.

The different benefits of storage

How should the public benefits of storage be taken into account? Here we need to separate out a number of different dimensions:

i. The short term benefits in respect of seasonal and daily functions, and hence the value of addressing volatility of prices.

ii. The provision of supplies in the event of emergencies and associated supply side shocks.

Taking (i) the integral between the volatility with and without storage provides the first part of calculation, to which needs to be added the value to customers of the volatility avoided. It is a central rationale of current government policy that volatility is “a bad thing”. In numerous speeches, the current and previous Secretaries of State have explicitly used this as a justification for emphasizing renewables. But this justification ignores other ways of reducing volatility, such as storage. If the justification for offshore wind subsidies, for example, is avoidance of volatility, then the marginal cost of extra renewables should be compared with the cost of storage, which would have the same impact. Taking the Secretaries of States’ argument further, since wind is intermittent and reduces security and increases volatility, the relative economic attractiveness of storage compared to wind is likely to be very large.
Renewables and volatility

Renewables add to volatility in two ways: they tend to be intermittent and therefore administer positive and negative supply shocks; and because the marginal cost for many renewables is zero, they render everything else on the electricity system volatile too. This latter point is both very important, and typically ignored. As the share of renewables rises, volatility will rise too, increasing the economic value of the management of volatility via storage over time. Therefore the economic test in this example is: do storage options have higher costs than the marginal renewable technology, offshore wind?

No right answer

Taking (ii) it is hard to put any numbers on the value of storage in the face of emergencies and supply shocks. At the limit, continuous supplies of fuel are part of national defense and conventionally countries have kept physical stocks as part of defense. These have typically been for oil—and at various times coal has been important too. Now that gas is 40% of electricity generation, and gas is imported on an increasing scale, the case for a strategic stock of gas is more powerful. Europe conventionally relies upon the large-scale storage capacity in the Ukraine to hold Russian power at bay, and beyond that Germany holds large-scale stocks too. Traditionally a view has been taken about the number of days a country could withstand a major interruption in supply, and then translated this into a strategic security requirement.
Gas Storage

Over time new ways of managing security risks may come into play. Batteries and other forms of electricity storage are likely to play a bigger role, as are smart technologies. But these are some way off, and initially will compliment rather than substitute gas storage.

Paying for storage

Payment for storage services in excess of market returns can be organized in a number of ways. The most obvious is to set a generic security requirement, and then auction the capacity requirement. As noted above, this is proposed in respect of the EMR capacity contracts, with storage and demand side measures being options to be set against new power station investments. In theory, any and all ways of delivering security to the system could bid.

There could be a separate gas capacity requirement, and an auction of this margin, independent of the EMR electricity market auction. Yet another option could be for new gas power stations to be required to have back up contracts for supply that include storage release in the event of intermittency or substitute fuelling from distillates.

These considerations begin to break down the concept of a single market mechanism in the face of the multiple market failures—and market services—provided by storage. There is already a high degree of policy intervention in energy markets, and EMR effectively creates a separate policy support mechanism for each technology. Any auction in this context is going to be highly constrained, and for auctions to be effective, the EMR framework needs to shift towards a single integrated auction independent of technologies (but not of course of carbon).
The role of a gas storage regulated asset approach

If this market-based approach is not going to be pursued—and it appears that it is not—an alternative is to treat gas storage as a network function rather than in supply, and therefore to create a regulated service within a regulated asset base (RAB). This approach has lots of advantages: it enables the required level of storage to be defined and contracted for by the System Operator; it can be paid for in the same way as the network services through a charge similar to the use of system charge; and customers can be made to pay for it either by compelling suppliers to contract with the system operator (to be the counter-party) or by a direct cost pass through as with transmission and distribution costs.

The result is a planned one. The amount of storage is determined and investment commitments are made. It remains open to tender for the provision—and indeed that is likely to be more effective than bilateral negotiated contracts. The System Operator can retain powers over the use of the gas storage facility. For example, if there is to be a strategic gas storage reserve, then the contracts can provide for this with cost recovery in place through the above charging mechanisms.

The role of suppliers

We have already noted that a supplier obligation is a way of defining a contractual basis for paying for storage. Indeed, even with a RAB model, it could be supply rather than distribution that pays. It would of course remain to define what that
obligation actually is for, and from where that storage is supplied. Thus there is a range of options—from a supplier driven model in which it is suppliers who seek out storage and other security contracts to meet an overarching obligation placed upon them, to a more passive role in which suppliers are counterparties to a SO determined set of investments. In both cases, as noted, a supplier obligation is necessary. It can only be avoided in a network-driven model, and whatever the merits of this option, it is probably unlikely to materialize.

6. A strategy for storage in energy policy

It has been established that:

- The optimal level of storage will not be provided by the market without intervention;
- The value of storage to the energy system includes the value of volatility reductions,
- The system should provide insurance against shocks and national security.

In the absence of ways of incentivizing and paying for the additional value storage brings, it will be sub-optimally provided. That indeed is the case: the greater these system benefits, the greater the shortfall. Given that national resources are being depleted, imports are rising and the electricity system is increasingly dependent on gas as a fuel source, and the suboptimal provision is likely to be getting more serious.

The conclusion is obvious: Britain needs more gas storage. The question is how to
encourage rapid investment in new storage facilities. The first step is to define the required level of security exogenously, and then to contract to ensure it is delivered.

Since the need for extra security measures is considerable, and the lead time for many of the possible measures is several years, the need for action is urgent. In order to deliver a secure energy system, a number of measures have already been identified. In particular:

- The government accepts that the optimal level of power station investment is not likely to be met by the market—hence EMR.
- The government accepts that energy efficiency in the market will be suboptimal.
- The networks and pipelines are planned and operate under monopoly conditions.
- The carbon budgets require direct intervention, and the government is fixing the price of carbon, the contracts for particular technologies, and setting emissions performance standards.
- Nuclear is to be supported by special contracts.

These measures are intended to ensure that there are sufficient power stations and demand side measures. Yet they are incomplete without security of gas supply, and this is where storage comes in.

To ensure that there is sufficient capacity available in gas supply, the Government needs to consider jointly the various ways in which gas supplies are provided—by pipelines and supporting contracts, by LNG terminals, and by storage. In addition, dual fuel capacity at power stations provides the ability at the limit to switch to
Gas Storage

distillates and oil. This is, in effect, another storage requirement—in this case for alternative fuels at the power station.

It is practically impossible to define what is the optimal balance of these measures (and interruptible contracts too). But rather than be paralyzed by imperfection, all that is needed at this stage is to recognize that the gap between what exists now and a range of possible scenarios to achieve the optimal is large and likely to get larger. The main “givens” in these scenarios come from the Government’s own interventions. It is determining the amount of current intermittent renewables like wind, the contribution of inflexible nuclear, the coal closure rate (through Emissions Performance Standards (EPS)), and the network provisions (through Ofgem and the monopoly NG).

Rolling these assumptions forward, it is impossible to conclude that the current level of gas storage is anything other than significantly insufficient. Therefore however much storage is optimal, more is needed and needed in the next few years. It is implausible to imagine that Rough as a seasonal regulator is sufficient for a Britain in which gas may provide as much as 60% of electricity capacity and much of the rest will be intermittent wind. In other words, the current position is likely to be precisely wrong later in the decade, and more storage investments, if started now, are going to help close what may be a very large gap.

The current market-based approach, using short term incentive mechanisms, does not address the core system benefits that storage brings. Longer term capacity auctions are required in any event for a market-based approach to be effective. The regulated service model would also meet the requirements, and at a low cost of capital. Intermediate solutions, between the market mechanisms and the
Gas Storage

regulated approach are many and varied, but they are also complex, costly to introduce and reduce the certainty that the investment will be delivered.

All options require that customers pay, and hence that either suppliers or distributors would therefore have an obligation to contract. In practice, a supplier obligation is probably the most practical way of achieving this counter-party role.

The time has come to get on with gas storage, and to do so quickly. The test for any intervention is whether it will deliver at least some storage quickly and at reasonable cost.