A New Approach to Assessing UK Gas Security

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Introduction

This briefing is based on two propositions. First, that gas security matters, because today in the UK gas plays a dominant role in the provision of energy services, accounting for almost 40% of total inland primary energy consumption in 2017 (Sharples 2018, 4-7). Thus, a short-run failure of gas security would undoubtedly have significant political and economic consequences (Vaughan 2018, Farmer 2018). Second, that the current measure is far too narrow to offer a comprehensive assessment of UK gas security, particularly in a post-Brexit context. The UK currently uses the EU's N-1 measure (EU 2017). This calculates whether or not a country can meet its 1-in-20 peak demand minus its largest piece of import infrastructure. This measure was designed following the first Russia-Ukraine crisis and is intended to prevent supply disruptions such as this from posing a risk to European gas security (EU 2010). It can also be ventured that because it had to be agreed by the member states it is relatively easy for many to meet and therefore lacks rigour. In addition, discussions at the Gas Security Forum[2] suggested that: it focuses only on infrastructure capacity and not supply (capacity does not equal flow); it fails to take account of the time-lag for gas delivery; it does not measure diversity or spare capacity; it ignores the impact of multiple asset failures; and, does not consider the costs associated with ensuring greater security.

It is in this context that this paper seeks to address the following questions:

- What are the constituent factors to consider in assessing gas security?
- What alternative measures exist?
- What potentially threatens gas security in the UK?
- What would a better approach to gas security look like?

The thinking behind this paper is that a more extensive approach to measuring UK gas security is needed to address the less dramatic challenges that face UK gas security, as well as the chance of managing a Black Swan (Taleb 2007) event.

Defining Gas Security

To consider what an appropriate measure might be, first we must define what is meant by gas security, as a particular form of energy security. The problem here is that 'energy security' is a difficult term to define. In a wide-ranging review, Sovacool (2011, 3-6) found 45 different and widely circulating definitions of energy security. He noted that the definition used depended upon the user and their particular motivations. Here we consider what constitutes gas security by adapting definitions from the existing literature, rather than devising yet another.

There are two approaches within the existing literature. One draws attention to the breadth of the issue, whilst the other considers its depth. Breadth looks at what has commonly been described as the 'energy trilemma' or 'quadrilemma' (Elkind 2010). This sees energy security as made up of four factors, each of these relating to further sub-factors:

- Availability
- Reliability
- Affordability
- Sustainability

By contrast, Bradshaw et al. (2014), while accepting the wider framing of the energy trilemma, considered whether it might be more practical to look at the supply chain for gas and assess where specific threats might emerge. This is in marked contrast to much of the existing analysis which tends to focus solely on security of supply. The supply chain can be summarised as:

- Upstream (Security of Supply)
- Midstream (Security of Transit/Transport)
- Downstream (Security of Demand)

The best way to judge the suitability of a new approach is to use the government's own definition of energy security from the 2012 Energy security review "ensuring that consumers have access to the energy services they need … at prices that avoid excessive volatility" (DECC 2012, 5). In the context of this paper 'gas' can be substituted for 'energy'. The definition can be seen as providing secure (physical security) and affordable (price security) access to the energy services supplied by natural gas. Thus defined, the task is developing an approach that can establish whether or not the UK has a secure and affordable system across the entire gas supply chain.

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2 This was a series of meeting with gas industry stakeholders held in the winter of 2017/18, as well as a day-long conference on Future UK Gas Security. A series of related briefings and a final position paper are available at: http://www.ukerc.ac.uk/publications.html

Assessing Current Measures of Energy Security

On the basis of an extensive review of the different measures of energy security, it is possible to divide existing measures into four groups: single indicators; combined indicators; stress-testing; and, modelling.

Single Indicators –These offer simplicity but sacrifice accuracy in return. Their strength lies in providing a simple snapshot as opposed to detailed analysis. When using such measures, it is important to understand exactly what is being assessed, so as to avoid reaching conclusions that are not supported by the indicator.

N-1: This measure was adopted by the EU in its 2010 gas legislation (EU Reg. No.994/2010) largely as a reaction to the Russia-Ukraine crisis of 2006 which if it had escalated could have seen gas shortages across much of Europe. The means for calculating the measure were then updated in the EU's 2017 gas legislation (EU Reg. No.2017/1938). It is designed to assess gas security by ascertaining whether or not a country can meet peak demand minus its largest single piece of importation infrastructure by capacity.

PF-1/2: This is a measure developed by BEIS (2016) and is designed to be more rigorous than N-1. It assesses whether a country can meet peak demand over a period of time minus its first and second largest pieces of infrastructure according to peak flow rather than capacity. The crucial difference is that this measure discounts the importance of high capacity pipelines that will exhaust their associated supplies over a short-period of time – e.g. by having emptied the LNG tanks that supply them.

HHI: The Herfindahl-Hirschman Index (see Månsson et al. 2014) is a measure of diversity and concentration in a population that is used in a number of fields including, biology, business and economics. It scores a population between 0 and 10,000, where the higher the score, the closer the population is to a monopoly. A score below 2,000 is generally considered a competitive market. The method creates the score by squaring the percentage market share of all participants. With relation to gas supply, diversity is seen as a proxy for security. Therefore, a country's sources of input or import are scored to establish how diverse and concentrated its supply sources are.

Shannon-Weiner – (see Månsson et al. 2014): This is another measure of diversity and concentration that uses a slightly more complex method of scoring the populations that it analyses.

Combined Indicators – These offer greater depth and breadth. They are at their most useful when a small number of well-considered indicators is presented in a tabular, traffic-light style format.

DECC: These were the 5 measures used in the DECC's (2012) Energy Security Strategy. They looked at capacity, diversity, availability and price in graphical form in addition to considering the availability of demand-side response (DSR) to gain a wider perspective on the resilience of the UK gas industry.

US Chamber of Commerce (USCoC 2016): The USCoC produces an annual report that assesses the energy security of the US and every year or so they analyse the 24 other nations that make up their large energy user group. They create a headline score for each nation that can be tracked back to 1980 and measures it relative to the OECD average. The measure produces a dashboard of scores for each nation under 7 categories of fuel import, energy expenditure, price and market volatility, energy use intensity, electric power sector, transportation and, environmental. These 7 scores are created using 29 weighted subcategories.

ACER: ACER's Target Model (ACER 2017) uses a combination of the N-1 score, HHI of importing firms and the number of distinct supplying countries to provide a graphical representation of a nation's gas security.

UKERC: Watson et al. (2018) The Security of UK Energy Futures looked specifically at the link between decarbonisation and energy security. The report looks at a number of indicators relating to the energy sector as a whole and presents them in a dashboard. The analysis offers new insight into the complex relationship between energy security and the low-carbon transition.

Stress-Testing – The core drawback of this method is that it measures a system's resilience against presently foreseen threats (CEPA 2017). In this sense it may fail to guard against a Black Swan event (Taleb 2007) as, by its very nature, this is an unforeseen crisis. Similarly, stress tests rarely deal with multiple low impact events.

EU Stress Tests (2014): In 2014 the European Commission carried out stress tests on a number of European countries considered to be most at risk in the case of a winter-long cessation of Russian gas supplies (broadly, the eastern half of Europe). The purpose of the exercise was to assess the capability of the European gas market to cope with the cessation of Russian gas supplies through Ukraine for a whole winter, following a number of disputes. The aim being to establish the best way for Europe to manage the situation in such an instance.

ENTSOG: ENTSOG (2017) carried out its first four-yearly Union-wide SoS Simulation Report as mandated by the EU's latest gas security of supply regulation (Reg No. 2017/1938). The exercise splits Europe and North-Africa into four broad areas consisting of the 13 risk groups identified in the 2017 regulation and looks at a total of 19 scenarios that might cause large-scale disruption. The report considers the disruptions over the most appropriate timeframes based around three baseline scenarios; peak mid-winter (1st January – 28th February); a peak two-week period, and; peak day demand.

Modelling – This approach combines shock analysis with an element of forecasting or scenario planning. This suffers from the same limitations as stress-testing, but with the added challenge of also trying to forecast how the supply chain and wider energy system will evolve in future. Most modelling exercises explore a range of possible future scenarios with multiple variables, rather than a single forecast. The following modelling reports were considered in the current review: Poyry (2010a, b, c & 2014), Redpoint (2012 & 2013) & CEPA (2017). These reports were treated as a distinct type because many of the assumptions that underpinned them were of a similar nature.

Potential Sources of UK Gas Insecurity: case studies from winter 2017/18

The winter of 2017/18 saw two gas emergency events (Tables 1 and 2) that provide important insights into the kinds of challenges that might threaten future UK gas security. First, was the event on 12th December 2017 (and thereafter), resulting from an explosion at the Baumgarten gas hub in Austria and problems with the Forties pipeline in Scotland (along with other more minor technical issues). Second, was the period from the 28th February to 2nd March 2018 encompassing the inclement weather pattern referred to in the media as "The Beast from the East" (Grimwood 2018) or less dramatically by National Grid as the "1st & 2nd March 2018 Cold Snap" (National Grid 2018c). The combination of very high demand and various technical problems on 1st March caused National Grid to release a gas deficit warning, which captured significant media attention. These two periods saw the type of multiple shocks that are often considered in stress-testing. Positive points to note from the following two case studies are that when the shocks occurred the price responded and the market delivered the necessary gas. However, there are at least five qualifying observations that can be made. First; both instances were short-lived in duration at 1 to 3 days (although the Forties outage lasted longer). Second, the supply losses themselves were relatively small in the context of the wider network. Third, during the 'Beast from the East' several supply sources were lost as a result of the weather itself, rather than due to external factors, adding an additional level of complexity. Fourth, these events do not qualify as Black Swans as they are not rare (harsh winters of this nature happen at least once a decade and aging equipment fails on a relatively regular basis) and they are not extreme (we have had much more severe winters in the last century and far more fundamental parts of the gas infrastructure could have failed). To put things into perspective there have been four similar events in the last 8 years (those of this winter plus January 2010 and March 2013) where cold weather or plant failure have caused concern regarding the UK's gas security. Fifth, the case studies highlight how all elements of the supply chain have an impact on the outcome of gas emergency events (Upstream – Baumgarten, Midstream – Forties, Downstream – Domestic Demand). Thus, when reading the following case studies, the focus should not be on how bad the events were, but on how much worse they could, quite feasibly, have been.

Table 1: Baumgarten/Forties/Troll Case Study

Who	What Happened, When, Where & Why
Baumgarten	The Baumgarten Facility in Austria suffers an explosion on 12th December 2017 halting imports from Russia to Central Europe for approximately 15 hours. The explosion resulted from a failure of aging equipment (Wabl et al. 2018).
UKCS	The Forties Pipeline in Aberdeenshire suffers a crack halting supply for just under three weeks starting from 11th December 2017. This resulted in the loss of 40 % of UKCS production (Ambrose 2018).
NCS	The Troll A platform suffers outage due to a power cut and associated gas leak lasting three days from 11th December 2017. The Kollsnes processing plant was also having maintenance carried out. As a result, Norwegian flows through the Langeled pipeline were reduced by 66 % (Moffat 2017).
NTS	Gas supplies were predominantly seeking entry in the south in a system that was designed to ship gas from North to South. The net result was a limit being put on to the amount of gas entering the system in the South, specifically through the interconnectors (National Grid 2018a).
IUK	Despite being fully operational IUK (Bacton) had to limit flows. This occurred because of congestion on the NTS described above (National Grid 2018a).
Utility Companies	Saw an on the day price spike due to the amount of gas entering the country having been reduced as a result of the above (National Grid 2018a).
Consumers	Unaffected.
LNG	Largely failed to respond to the price spike (National Grid 2018b).
Storage	Throughout late December storage facilities reduced stocks from approximately 70 % - 40 % over a three-week period (National Grid 2018b).

Table 2: 1st & 2nd March 2018 Cold Snap Case Study

Who	What Happened, When, Where & Why
NCS	The Kollsnes processing plant suffers an outage resulting in a supply loss of 16mcm/d due to cold weather from 28th Feb - 1st March (Grimwood 2018 & Platts 2018).
UKCS	North Morecambe – Rampside gas treatment plant suffers a technical fault. The supply equivalent to 7.7mcm/d was lost from 28th Feb at 04:36, limited flows return from 22:00. Full flow not recovered until 00:10 on 4th March (Centrica 2018). St Fergus – Lost supply equivalent to 18mcm/d through SEGAL on 1st March due to cold weather (Shell 2018). SEAL (Bacton) - Reduced from 12-10mcm/d from 06:00 28th Feb until 06:00 1st March due to compressor failure (National Grid 2018e). Perenco Bacton - Reduced from 12-10.5mcm/d from 17:00 28th Feb - 22:00 1st March due to gas production field unavailability (National Grid 2018e). Rough was out of action from 05:00 until 23:00 on 1st March due to the weather (Centrica 2018).
NTS/NBP	Gas Deficit Warning issued due to high demand resulting from cold weather and loss of several import facilities. The NTS itself suffered no malfunctions. The price of gas rises to 499p/therm from around 50p/therm the previous Saturday (National Grid 2018c).
IUK & BBL	BBL (Bacton) suffers outage due to technical problems on 28th Feb from 08:00-14:00 resulting in reduction of import capacity at 50 mcm/d (BBL 2018).
Utility Companies	Despite price jump Utility Companies seem largely unaffected.
Consumers	No formal use of demand response, but some voluntary reductions in the industrial sector, i.e. INEOS. Domestic consumers increased demand c.30 % over seasonal norms (National Grid 2018c).
LNG	South Hook – Lost full regasification capacity of 650 Gwh/d from 05:23 to 06:55 on 1st March due to weather-related technical problems, with a second loss of 575 Gwh/d from 20:22 2nd March - 05:00 3rd March (South Hook 2018). UK tanks were 35 % full thanks to deliveries from Russia & Qatar (National Grid 2018b).
Storage	The MRS emptied as price increased (National Grid 2018b).
Electricity Generators	Wind-generation met c.20 % of UK Demand, coal c.25 %. Gas scaled back its role to c.20 % due to price increases from a more usual 40 % (Staffell 2018).

Towards A New Approach

As we noted at the onset, the N-1 measure has a particular origin and purpose and only considers one factor relating to infrastructure capacity in the midstream of the UK's gas supply chain. Thus, at best, it is a very partial test of gas security as there are a number of other factors—across the supply chain—that also need to be considered. Fortunately, there are a variety of alternative measures available that measure other dimensions of gas security, several of which outperform the N-1 measure. With careful consideration of the supply chain of gas, an approach can be developed that provides a more rounded assessment of the likely threats to the UK's gas security. Considering the types of approaches available, a dashboard of combined indicators appears to be the best way forward, especially if it is expressed in a way that allows objective comparisons between indicators. Having also considered the case studies of the events of winter 17/18, it is clear that a wide-range of factors affect the severity of a gas 'event' and that they are both domestic and international in origin.

For a new approach to be effective it must consider and assess what constitutes security at each stage of the supply chain and find an indicator that appropriately reflects this. Table 3 addresses this in the 'measurements' column by listing the core roles of each stage of the supply chain and highlighting their unique contributions to gas security. The column then proceeds to highlight indicators that assess these core functions. The final step from this point is to collate the most appropriate measures into a dashboard that identifies potential areas of insecurity within the gas supply chain.

Table 3 brings together the aspects that have been considered so far by linking the issues currently faced by the UK to the appropriate stage in the supply chain. This analysis builds on a parallel assessment of the challenges facing future UK gas security and the potential impact of Brexit (Bradshaw 2018b). The Assessments column looks at bodies that collate data for and carry out assessments of each stage in the supply chain to help provide a broader picture of the information that is presently available.

Table 3: Summary of Supply Chain Measurements and Assessment

	Geopolitics	Issues	Measurements	Assessments
Upstream	Security of Supply	• Future UKCS production • Prospects for Unconventional gas • Future NCS exports to GB • Growing UK/EU import dependence • Trends in global LNG market • EU Energy Diplomacy	• Sources of current supply (ACER Target Model, USCoC 3 & 4) • Future supply prospects (BP Energy Outlook & DECC Indicator VI - Capacity) • Level of import dependence (Eurostat & USCoC 8 & 10) • Diversity of sources of supply (HHI, Shannon-Weiner, ACER Target Model, DECC Indicator VII – Gas Diversity)	• Global gas market assessments: IEA, EIA, IEEJ, IOCs, IGU, WEC, IHS-CERA, Wood Mac, McKinsey etc. • UK Oil & Gas Authority, Oil & Gas UK, European Commission, Eurostat. ENTSOG. • BEIS: DUKES, Energy Trends.
Midstream	Security of Transport (Transit)	• UKCS infrastructure • Utilisation of LNG Terminals • Status of Interconnectors to EU • Flexibility of the NTS • Status of Gas Distribution Networks • Availability of Domestic Storage • Status of NBP	• Infrastructure capacity (stock and flow) and resilience (N-1, PF-1/2, ACER Target Model, CEPA 2017, ENTSOG 2017) • Availability of domestic storage (Wicks, 2009) • LNG utilisation levels (BEIS: DUKES) • Network flexibility and resilience (DECC Indicator VIII – Reliability, DECC Indicator X – DSR, MOSES, USCoC 14) • Gas Market Performance (OFGEM Volatility Index & DECC Indicator IX – Price)	• National Grid: Outlooks & Statements • BEIS/Ofgem: Statutory Assessments • Energy Networks Association • Energy and Utilities Alliance • BEIS: Fossil Fuel Price Assumptions • NBP: Ofgem, ICIS, Argus, Platts etc.
Downstream	Security of Demand	• Role of gas in UK energy strategy • Intermittency and Capacity Markets • Carbon Floor Price & ETS • Carbon Capture & Storage	• Future demand forecasts/scenarios (BEIS 2018a & UKERC) • Sources of competition/constraint (NG FES & USCoC 12 & 13) • Key uncertainties (NG: FES (2018d & 2017a) & GTYS(2017b))	• BEIS: Energy & Emissions Projections • Climate Change Committee • National Grid: Future Energy Scenarios

In constructing the new assessment framework, a dashboard of existing measures is created that looks at the key indicators for each stage in the supply chain. Using this approach, an annual assessment can be carried out to evaluate the on-going security of the UK gas supply chain.

Table 4: Dashboard of Gas Security Measures

Geopolitics	Measurements	Method
Upstream	Sources of Current Supply	Number of Countries of Origin (ACER 2017b, 9)
	Future Supply Prospects	Future Supply Projections (BP 2017, 32)
	Level of Import Dependence	Energy Dependence by Product - Gas (Eurostat 2018)
	Diversity of Sources of Supply	HHI of Suppliers (ACER 2017b, 7)
Midstream	Infrastructure Capacity	PF-2 (BEIS 2016)
	Availability of Domestic Storage	Storage capacity as % of annual demand (Wicks 2009, 68)
	LNG Utilisation Levels	DUKES (BEIS, 2018b Chp. 4.4 & 4.6)
	Network Flexibility & Resilience	Indicator VIII – Gas Reliability (DECC 2012, 50)
	Gas Market Performance	Gas Price Volatility Index (OFGEM 2018)
Downstream	Future Demand Forecast Scenarios	Energy & Emissions Projections (BEIS 2018a, Annex E)
	Sources of Competition/Constraint	Gas versus Electricity - FES (National Grid 2017a, 91)
	Key Uncertainties	Range of Future Scenarios - FES (National Grid 2017a, 107)

Conclusions: A Gas Security Dashboard

The analysis presented in this report makes clear that gas security is a multi-faceted issue that is not easily reducible to a single measure. In their recent strategic assessment, BEIS (2017b, 3) conclude:

"We find that the diversity of supply and the available capacity underpin the strength of the GB system. The system must be supported by a market that continues to be price responsive, allowing the GB market to attract sources of gas when they are needed. In the longer term, a strong market incentivises investment in infrastructure to maintain the capacity and diversity which underpins our security."

Underlying this confidence is the fact that domestic sources still supply half the gas consumed in the UK and that the remaining imports come from a variety of sources (in fact two sources—Norway and Qatar—dominate). In addition, the fact that infrastructure capacity significantly exceeds annual demand and peak demand is grounds for further confidence (as measured by the N-1 test). However, we have argued that assessments based on measures of supply diversity and infrastructure capacity alone provide, at best, a partial understanding of the threats to UK gas security. Furthermore, as was made clear in the winter of 2017/18, the combination of an aging infrastructure and growing import dependence are likely to increasingly challenge the resilience and flexibility of the UK's gas supply chain.

We propose a dashboard approach (Table 4) that takes the measures from the supply chain approach and pairs them with the most appropriate presently available methods of assessing these criteria. By collating these 12 methods a simple dashboard assessing the performance of the whole UK gas supply chain can be produced on an annual basis. This approach should then form part of an annual assessment of UK Gas Security that also takes into account recent performance and potential short- to medium-term developments across the supply chain. In short, while passing the N-1 test currently satisfies the statuary requirements, it creates a sense of false security.

Acknowledgment

This research was funded by the University of Warwick's Industrial Strategy Fund and by Warwick Business School.

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