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UK Dependence on Imported Hydrocarbons: How Important is Russia?

Introduction

The dramatic deterioration in UK-Russian diplomatic relations in early 2018 coincided with the arrival in the UK of several cargoes of liquefied natural gas (LNG), which had originated from the recently-launched Yamal LNG project in northern Russia. This triggered debates over the extent to which the UK depends on Russian energy supplies, with the question even being raised in the UK parliament.[1] Such debates play out against a background of Russia's status as the largest supplier of coal, crude oil, and natural gas to the EU[2], and the UK's long-term declining domestic production of these fuels.

Much of the debate over UK hydrocarbon imports has focused narrowly on the share of particular countries in supplying energy (particularly natural gas) to the UK. This reflects concerns that energy supplies may be used as a 'tool of foreign policy', particularly by hydrocarbon-exporting countries that channel those exports through a single, state-owned company. However, to gain a deeper understanding of the role of imports in general, and Russian imports in particular, in the UK consumption of coal, oil, and gas, it is necessary to examine not only the share of different countries in UK imports of these fuels, but the extent of UK dependence on each of these fuels *per se*.

In order to address this point, and to place considerations of UK dependence on imported hydrocarbons (including those of Russian origin) into a broader context, this paper begins by highlighting the point that imported hydrocarbons are not only competing with growing renewable energy sources in UK power generation, but they are doing so in a context of declining UK power demand. Secondly, the paper emphasises the role of natural gas in UK heat generation and final energy consumption, in addition to its prominent role in UK power generation, thus making natural gas the most important fuel in the UK's non-transportation sectors. The third section of this paper examines how trends in domestic hydrocarbon production and consumption leave the UK facing a long-term increase in oil and gas import dependency. The fourth section examines the UK hydrocarbon import portfolio to identify the major suppliers, before the final section specifically analyses the role played by Russia in that import portfolio, and the challenges faced by the UK gas sector in addressing security of supply concerns.

The main conclusions of the paper highlight the crucial role played by natural gas in the UK's non-transportation sector, with the major challenge to security of gas supplies coming, not from dependence on imports from Russia (which remains at a low level), but from increasing exposure to price volatility in line with the ongoing increase in UK gas import dependency and decline in gas storage capacity.

[1] BBC News, 18 March 2018, 'Salisbury attack: How much of the UK's gas comes from Russia?'

[2] Eurostat, 2018. *Imports-Solid Fuels-Annual Data [nrg_122a]; Imports-Oil-Annual Data [nrg_123a]; Imports-Natural Gas-Annual Data [nrg_124a]*. http://ec.europa.eu/eurostat/web/energy/data/database. Sourced on 20 March 2018.

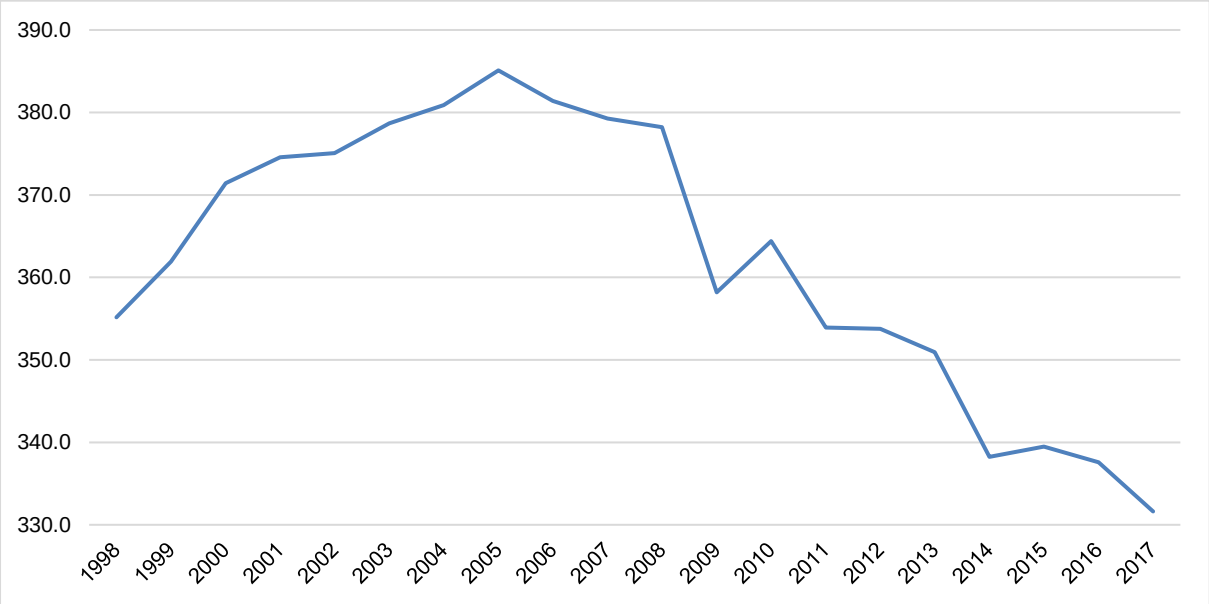
Jack Sharples

UK energy consumption

Energy demand for power and heat generation

The UK exhibited an almost continuous decline in power demand between 2005 and 2014, before several years of relatively stability in 2014-2016, and renewed decline in 2017 (see Fig.1, below). This reduced overall energy demand for power generation and, by extension, UK dependency on imported hydrocarbons for use as fuel inputs. National Grid has modelled future UK power demand under several scenarios (to 2035), and the divergence in forecast power demand under these scenarios (particularly after 2022) highlights the difficulty in planning for future energy demand (see Fig.5, below).

Figure 1: UK power supplies (including imports) (TWh), 1998-2017

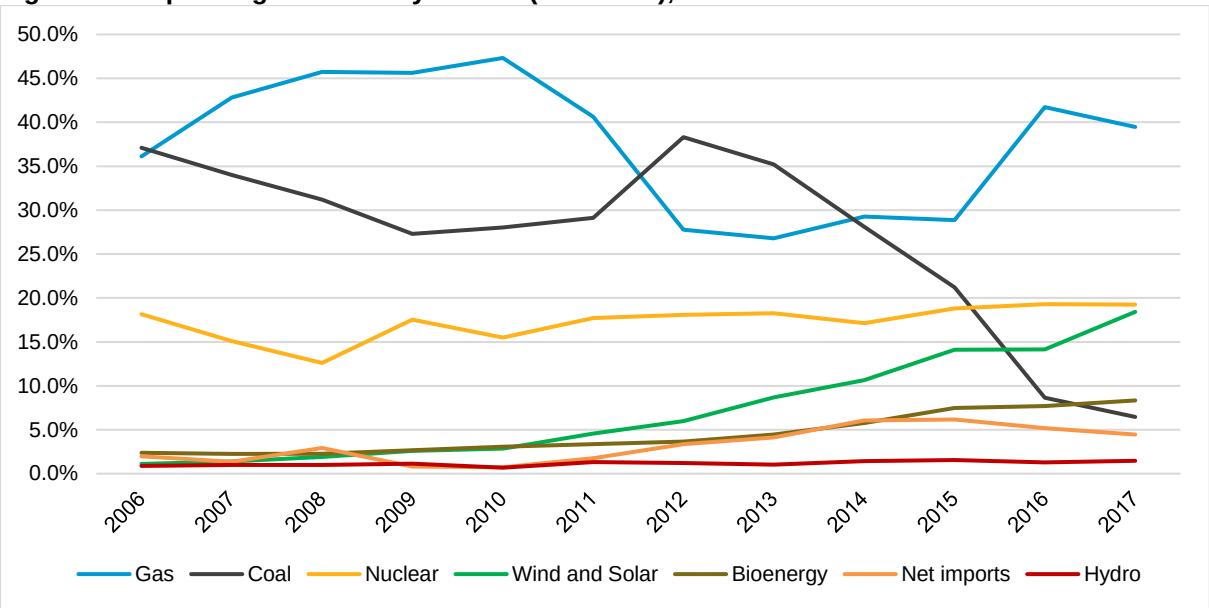


Source: Data from UK government statistics[3]

In terms of how that power is generated, the use of coal has declined sharply since 2012, while the shares of wind, solar, and bioenergy have shown strong growth (Fig.2). The decline in coal for power generation in the UK was substantially influenced by the introduction of the UK carbon floor price in 2013, which raised the cost of generating power from coal. It did so by adding a supplementary UK Carbon Support Price (CSP) of £18/ton of CO_2 (2015-2021) to the existing cost of carbon credits under the EU-wide Emissions Trading Scheme (ETS).[4] This reduced the profitability of generating power from coal, as expressed in terms of *clean dark spreads*, which measure the differential between the wholesale power price and the cost of generating power from coal inclusive of the cost of carbon. This change in regulatory conditions opened up a window of opportunity for natural gas, given the price-competitiveness of gas-fired power generation relative to coal-fired power generation, as illustrated in Fig.3, below. Indeed, in April 2017, the UK passed its first (24 hour) working day without electricity generation from coal.[5]

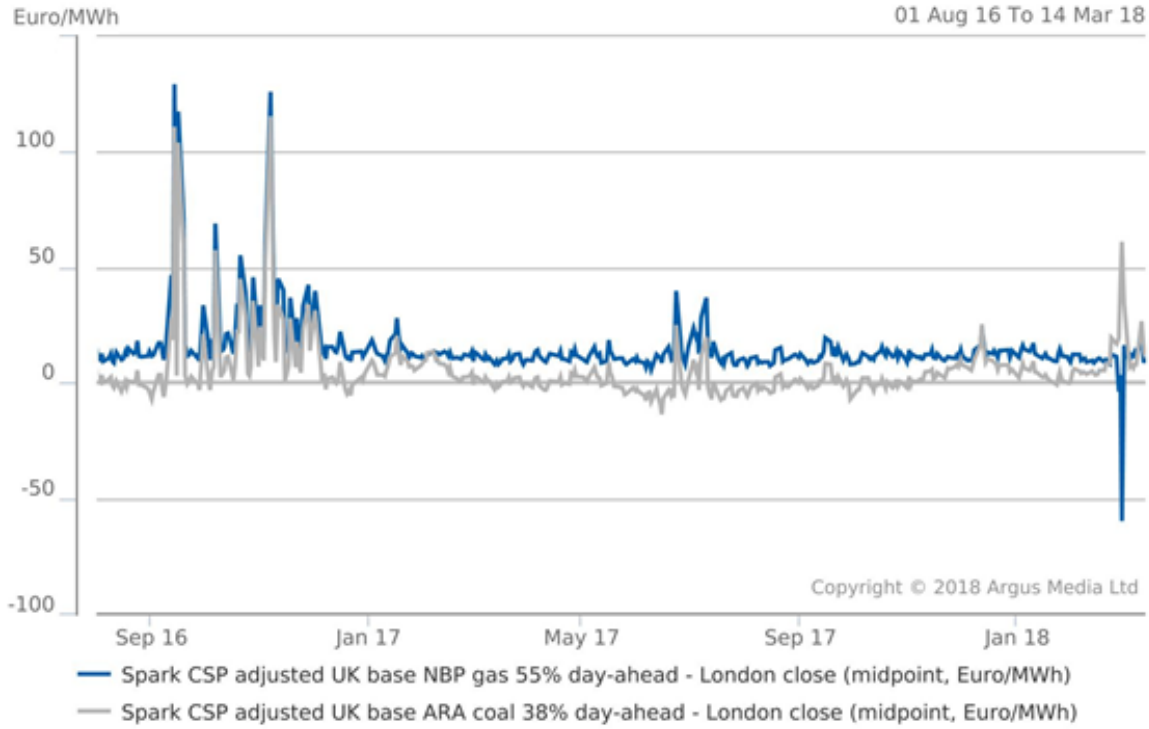
[3] UK Government, 2018. *Energy trends: Electricity. Fuel used in electricity generation and electricity supplied (ET 5.1)*. https://www.gov.uk/government/statistics/electricity-section-5-energy-trends. Sourced on 3 April 2018.
[4] HMRC, 2014. *Carbon price floor: reform and other technical amendments*. https://www.gov.uk/government/publications/carbon-price-floor-reform. Sourced on 19 March 2018.
[5] Financial Times, 22 April 2017, 'UK generates a day's electricity without coal'.

Figure 2: UK power generation by source (% of total), 2006-2017



Source: Data from UK government statistics[6]

Figure 3: Clean dark and spark spreads for coal and natural gas in the UK 2016-2018

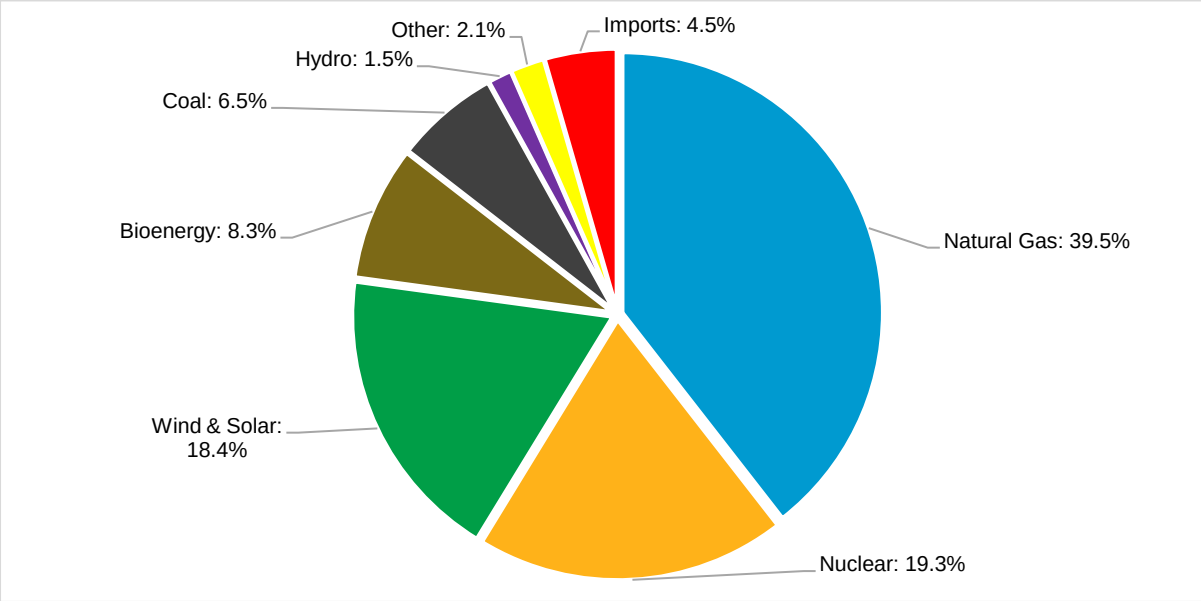


Source: Argus Media[7]

[6] UK Government, 2018. *Energy trends: Electricity. Fuel used in electricity generation and electricity supplied (ET 5.1)*. https://www.gov.uk/government/statistics/electricity-section-5-energy-trends. Sourced on 3 April 2018.

[7] Argus Media, 2018. *Prices and data: Spark CSP adjusted UK base NBP gas 55% and ARA coal 38% day-ahead – London close.* Sourced on 15 March 2018.

Figure 4: UK power supplies by source, 2017



Source: Data from UK government statistics[8]

The decline in coal burn and the growth in the use of renewable sources for power generation are expected to continue, and the present position of natural gas as the most important source of UK power generation is expected to continue in the short term. In 2017, natural gas provided 39.5% of UK power generation, down slightly from 41.7% in 2016, as illustrated in Fig. 4, above.

In contrast to the power generation sector, which draws upon multiple fuels, heat generation in the UK is overwhelmingly based on natural gas. In terms of heat generation on an industrial scale (in dedicated heat plants or in combined heat and power plants), natural gas provided 87.7% of the source fuel in 2016, ahead of coal (5.2%), bioenergy and waste (2.7%), and oil (2.4%) in 2016. Once generated, that heat was consumed by industry (53.7%), public services (41.4%), and the residential sector (4.6%). However, the heat sector plays a far smaller role in UK final energy consumption than electricity. In 2016, heat accounted for 0.8% of total final UK energy consumption, with notable shares in final energy consumption only in the industrial (2.6%) and public services (8.1%) sectors.[9]

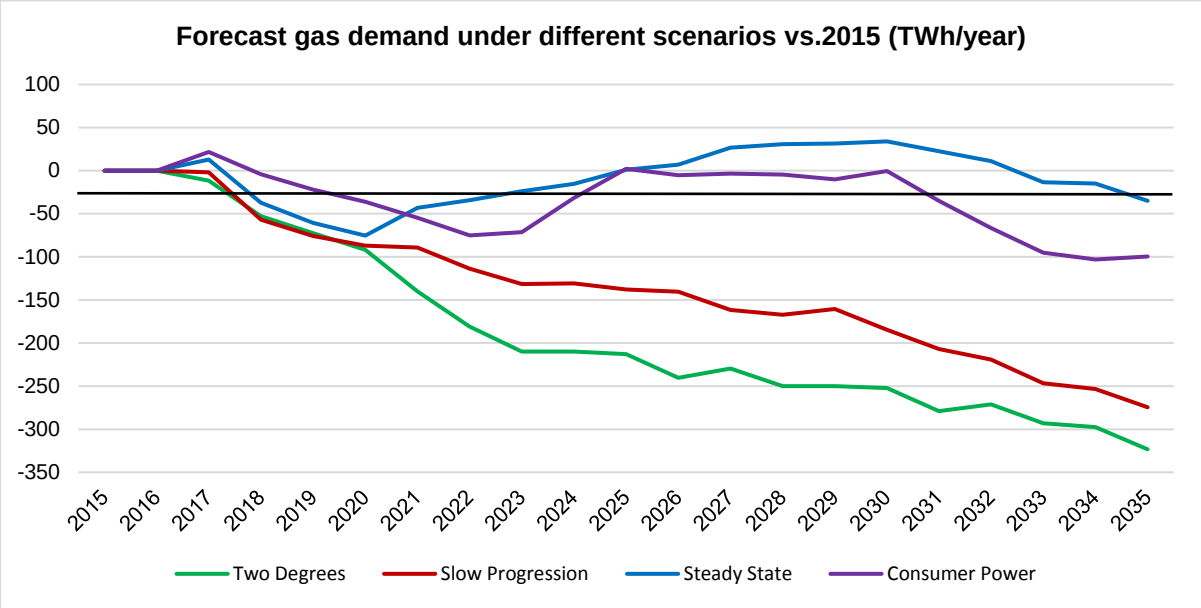
The longer-term (2030 and beyond) future of natural gas in the UK power and heat generation mix is uncertain, and dependent upon both UK government policy in relation to decarbonisation, and the ability of the gas sector itself to 'decarbonise' through the use of carbon capture and storage (CCS), which could facilitate the continued use of natural gas for hydrogen production and consumption, as a low-carbon substitute for the consumption of natural gas itself.[10] This uncertainty is reflected in National Grid forecasts for gas and power demand under different scenarios (see Fig.5). However, in the medium-term future (to 2022), natural gas is set to remain dominant in UK heat and power generation.

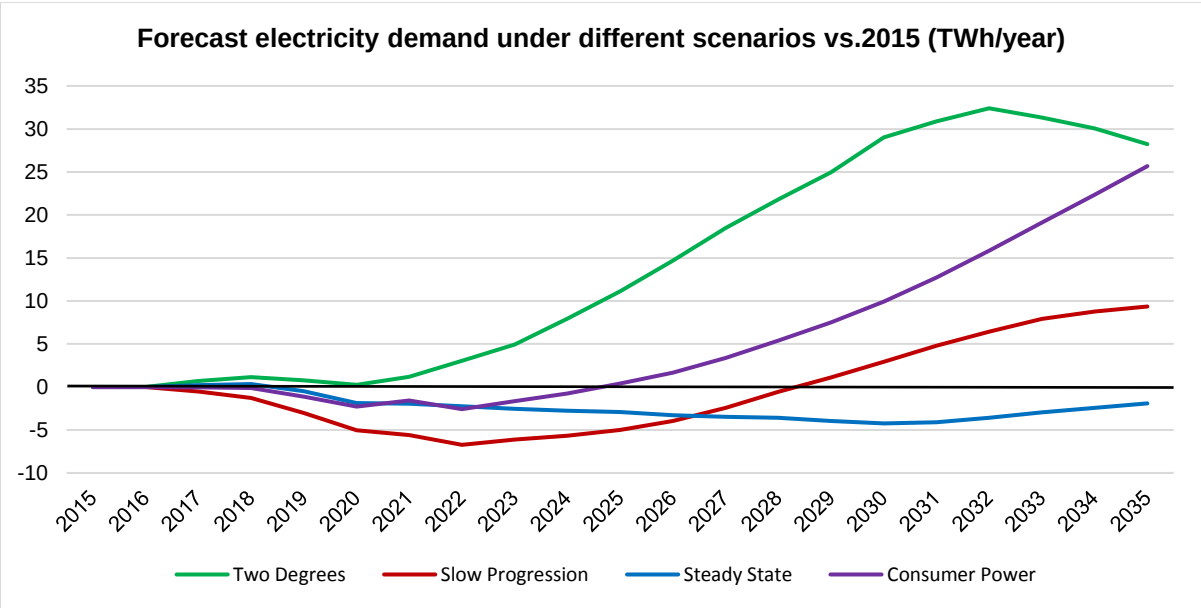
[8] UK Government, 2018. *Energy trends: Electricity. Fuel used in electricity generation and electricity supplied (ET 5.1)*. https://www.gov.uk/government/statistics/electricity-section-5-energy-trends. Sourced on 3 April 2018.

[9] UK Government, 2017. *Digest of UK Energy Statistics (DUKES) Chapters 1.1-1.3: Aggregate energy balances.* https://www.gov.uk/government/statistics/energy-chapter-1-digest-of-united-kingdom-energy-statistics-dukes. Sourced on 16 March 2018. [Note: The next DUKES statistical update is due in July 2018, with full-year statistics for 2017]

[10] Bradshaw, M., 2018. *Future UK gas security: the future role of gas*. UK Energy Research Council. http://www.ukerc.ac.uk/publications/the-future-role-of-gas.html. Sourced on 22 March 2018.

Figure 5: National Grid forecasts for GB gas and electricity demand under different scenarios





Source: Data from National Grid[11,12].

Note: Starting point for demand in 2015: Gas (817 TWh) and Electricity (306 TWh). Statistics from National Grid refer to Great Britain (i.e. the 'mainland' part of the UK, excluding Northern Ireland and the Isle of Man), rather than the United Kingdom (which includes Northern Ireland).

[11] National Grid, 2017. *Future Energy Scenarios 2017 (Charts workbook)*. http://fes.nationalgrid.com/fes-document/. Sourced on 22 March 2018.

[12] For more information on the assumptions and sensitivities underpinning these scenarios, see: National Grid, 2017. *Future Energy Scenarios 2017 (FES 2017 PDF)*. http://fes.nationalgrid.com/fes-document/. Sourced on 22 March 2018. See pages 14-18, and 90-108.

Final energy consumption in the UK by sector

In the residential sector, natural gas (64.8%) and electricity (22.5%) together accounted for 87.3% of UK residential sector energy consumption in 2016.[13] Specifically, natural gas is the most prevalent fuel for the generation of heat within individual households in the UK, through the use of gas boilers that provide hot water for central heating systems. According to Ofgem, in 2012-14, of the 26.25 million homes in the UK, 22.09 (84.2%) used gas central heating as their source of heat, while 2.23 million homes (8.5%) used electricity.[14] Natural gas and electricity also provide hot water and cooking fuel for UK homes, while electricity provides an energy source for lighting and household appliances.

In the commercial and public services sector in 2016, electricity (46.8%) and natural gas (41.3%) provided 88.1% of final energy consumption, again for space heating, lighting, and the operation of electrical appliances.[15] In the industrial sector, natural gas (35.5%) was the largest source of energy consumption, ahead of electricity (33.3%), oil products (17.2%), coal (4.5%), and heat (2.6%).[16]

Finally, as expected, oil products accounted for 97.5% of energy consumption in the UK transportation sector in 2016. Conversely, the transportation sector accounted for 76.8% of UK consumption of refined oil products, ahead of the non-energy consumption (11.0%), industry (5.8%), and the residential sector (3.6%).[17] The implication here is that a substantial reduction in the use of oil products in the UK transportation sector would have a significant impact on total UK demand for refined oil products and, by extension, reduce the UK's oil import dependency. In July 2017, the UK government announced that it "will end the sale of all new conventional petrol and diesel cars and vans" by 2040.[18] However, in 2016, battery and plug-in hybrid electric vehicles accounted for just 1.4% of the UK car fleet[19], and in 2017, alternative fuel vehicles (i.e. non-petrol or diesel) accounted for 4.7% of new car registrations, up from 3.3% in 2016.[20] Even if new registrations of alternative fuel vehicles rises sharply in the next five years, this will leave a large number of petroleum-fuelled vehicles on UK roads, which will continue to be the basis for UK oil demand for the coming decade.

Direct and indirect consumption of natural gas in the industrial, residential, and commercial/public service sectors

Given that natural gas currently acts as the source fuel for approximately 40% of UK power generation and 88% of UK heat generation, with substantial shares of final energy consumption in the residential sector (65%), commercial/public services sector (41%), and industrial sector (36%), UK dependence on natural gas can hardly be overstated. Its importance is starkly illustrated if the final consumption of natural gas is combined with the consumption of electricity and heat generated from natural gas, as a share of total final energy consumption in each sector.

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[13] UK Government, 2017. *Digest of UK Energy Statistics (DUKES) Chapters 1.1-1.3: Aggregate energy balances.* https://www.gov.uk/government/statistics/energy-chapter-1-digest-of-united-kingdom-energy-statistics-dukes. Sourced on 16 March 2018.

[14] Ofgem, 2015. *Insights paper on households with electric and other non-gas heating*. https://www.ofgem.gov.uk/ofgem-publications/98027/insightspaperonhouseholdswithelectricandothernon-gasheating-pdf. Sourced on 15 March 2018. See page 10.

[15] UK Government, 2017. *Digest of UK Energy Statistics (DUKES) Chapters 1.1-1.3: Aggregate energy balances.* https://www.gov.uk/government/statistics/energy-chapter-1-digest-of-united-kingdom-energy-statistics-dukes. Sourced on 16 March 2018.

[16] Ibid.

[17] Ibid.

[18] UK Government, 2017. *UK plan for tackling roadside nitrogen dioxide concentrations: an overview.* Dept. for Environment, Food, and Rural Affairs and Dept. for Transport. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/633269/air-quality-plan-overview.pdf. Sourced on 21 March 2018.

[19] IEA, 2017. *Global EV outlook 2017*. https://www.iea.org/publications/freepublications/publication/GlobalEVOutlook2017.pdf. Sourced on 21 March 2018. See page 51.

[20] Society of Motor Manufacturers and Traders (SMMT), 2018. UK new car market declines in 2017 but demand still third highest in 10 years. *SMMT News*, 5 January. https://www.smmt.co.uk/2018/01/uk-new-car-market-declines-2017-demand-still-third-highest-10-years/. Sourced on 21 March 2018. See page 51.

In the industrial sector, total energy consumption in 2016 was 23.7 million tonnes of oil equivalent (mtoe). Of this, 8.4 mtoe (35.5%) was natural gas, 7.9 mtoe (33.3%) was electricity, and 0.6 mtoe (2.6%) was heat. If the 40% share of gas in UK power generation is applied to the 7.9 mtoe of electricity consumed in the industrial sector, this implies that 3.2 mtoe of electricity consumed in the industrial sector was generated using natural gas. Similarly, 0.5 mtoe of heat consumed in the industrial sector was generated from natural gas. When the direct consumption of natural gas (8.4 mtoe) is combined with the consumption of electricity (3.2 mtoe) and heat (0.5 mtoe) generated from natural gas, the result is that 12.1 mtoe (51.1%) of UK industrial energy consumption depended on natural gas in 2016.[21]

Using the same methodology, it is possible to calculate that in the commercial sector, natural gas directly and indirectly (as a source of electricity and heat) provided 56.6% of total final energy consumption. The shares are even higher in the residential (73.9%) and public service (74.0%) sectors. Natural gas is not only the UK's single most important source of heat and power generation, it is also the most important source of final energy consumption outside the transportation sector. When these three modes of consumption are combined, the potential impact of any interruption to UK gas supplies becomes apparent: In 2016, natural gas, electricity generated from natural gas, and heat generated from natural gas accounted for a combined 59.1% of total final UK energy consumption.

The almost complete dependence of the transportation sector on refined oil products, and the highly significant role played by natural gas in the non-transportation sectors, mean that an analysis of UK energy supply security should pay particular attention to the extent to which the UK can meet its own demand for these fuels, and the imports that bridge the gap between demand and domestic production.

Trends in UK energy production

Coal

The consumption, production, and imports of coal have been following the same pattern of steep decline since 2013 (Fig.6, below). This phase-out of coal in the UK has been starkly illustrated by the closure of the UK's last deep coal mine in December 2015[22], and the closure of nine coal-fired power stations across the UK between 2011 and 2016, with a further two coal-fired power stations set to close in 2018.[23] The remaining six plants will most likely close by October 1 2025 (if not before), when the government intends to implement new CO_2 emissions limits for UK power plants. These new limits will make unabated coal-fired generation impossible, and could be 'the final nail in the coffin' for coal-fired power generation in the UK.[24] Given the already small (and continually-shrinking) share of coal in UK power generation, the UK's dependence on imports for 59% of its coal consumption in 2017 is not especially concerning from a security of supply perspective. Indeed, at the end of Q4 2017, coal stocks held by major power producers in the UK were slightly higher than the volume of coal consumed for power generation in Q2-Q4 2017.[25] The ongoing closure of UK coal mines and coal-fired power plants makes a future upturn in UK coal production and coal-fired power generation virtually impossible, given that the re-opening of these facilities is highly unlikely under current commercial and regulatory conditions.

[21] UK Government, 2017. *Digest of UK Energy Statistics (DUKES) Chapters 1.1-1.3: Aggregate energy balances.* https://www.gov.uk/government/statistics/energy-chapter-1-digest-of-united-kingdom-energy-statistics-dukes. Sourced on 16 March 2018.

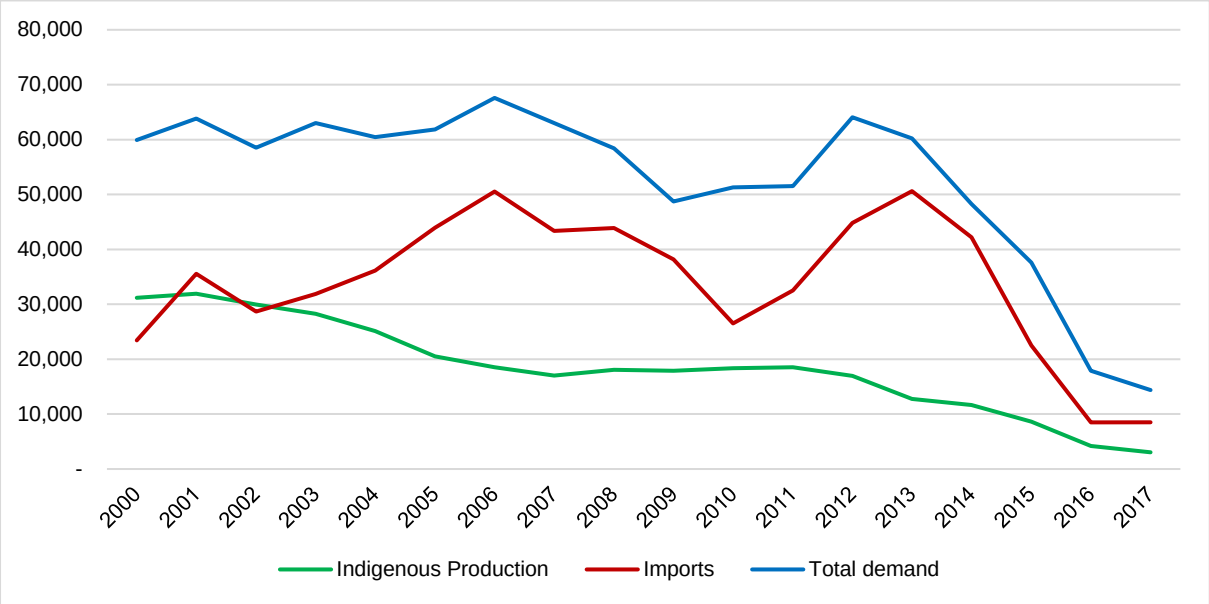
[22] BBC News, 14 March 2016, 'UK's last deep coal mine Kellingley Colliery capped off'.

[23] The Guardian, 5 Jan 2018, 'UK government spells out plan to shut down coal plants'.

[24] UK Government, 2018. *Implementing the end of unabated coal by 2025: Response to unabated coal closure consultation*. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/672137/Government_Response_to_unabated_coal_consultation_and_statement_of_policy.pdf. Sourced on 16 March 2018.

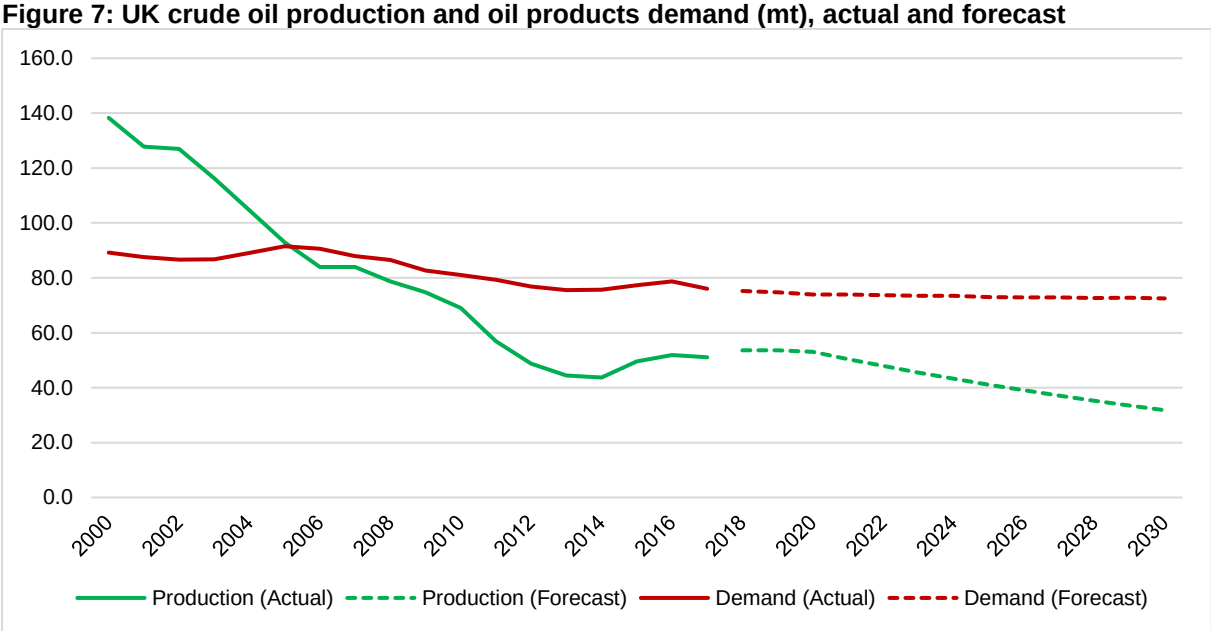
[25] UK Government, 2018. *Energy trends: Solid fuels and derived gases*. *Supply and consumption of coal (ET 2.1).* https://www.gov.uk/government/statistics/solid-fuels-and-derived-gases-section-2-energy-trends. Sourced on 3 April 2018.

Figure 6: UK coal production, demand, and imports (kt), 2000-2017



Source: Data from UK government statistics[26]

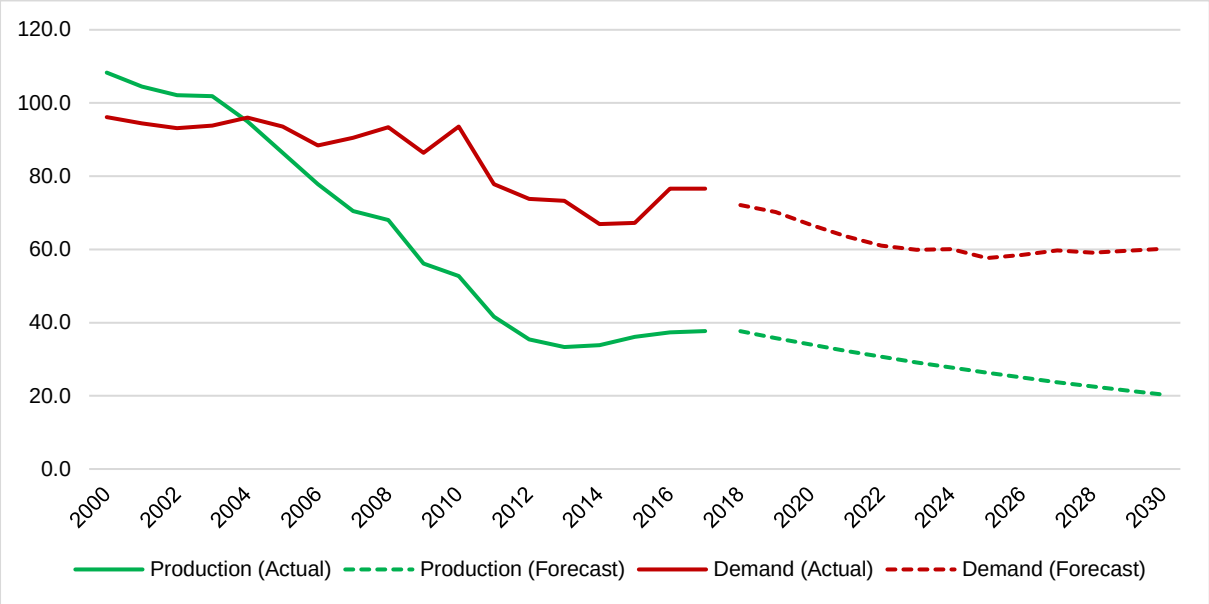
Figure 7: UK crude oil production and oil products demand (mt), actual and forecast



Source: Data from UK Oil and Gas Authority[27]
Note: actual, 2000-2017, forecast 2018-2035

[26] Ibid.
[27] UK Oil and Gas Authority, 2018. *Production and expenditure projections (Feb 2018)*. https://www.ogauthority.co.uk/data-centre/data-downloads-and-publications/production-projections/. Sourced on 15 March 2018.

Figure 8: UK natural gas production and demand (bcm), actual and forecast



Source: Data from UK Oil and Gas Authority[28]
Note: actual, 2000-2017, forecast 2018-2035

Oil and gas production on the UK Continental Shelf (UKCS)

Looking to the future, the UK faces a long-term decline in crude oil production levels from the peak reached in 1999. Even if the transportation sector does curtail its consumption of refined oil products, particularly in light of UK government plans to ban the sale of new petrol and diesel vehicles from 2040[29], the widening gap between domestic production and domestic demand forecast by the UK Oil and Gas Authority for the period to 2030 could result in an increase in the UK's import dependency in relation to crude oil and refined oil products, particularly from 2022 onwards (see Fig.7, above).

It is a similar story in relation to UK natural gas production (see Fig.8, above). Since its peak in 2000, UK natural gas production showed an almost continuous decline through to 2013, with a slight recovery between 2013 and 2017. However, as with UK crude oil production, UK natural gas production is forecast to resume its long-term decline after 2018, resulting in an increase in import dependency. It is this long-term trend of increasing import dependency in relation to oil and natural gas that contextualises the question of where the UK sources its imports of these commodities, and the extent to which Russia in particular is the source of those imports.

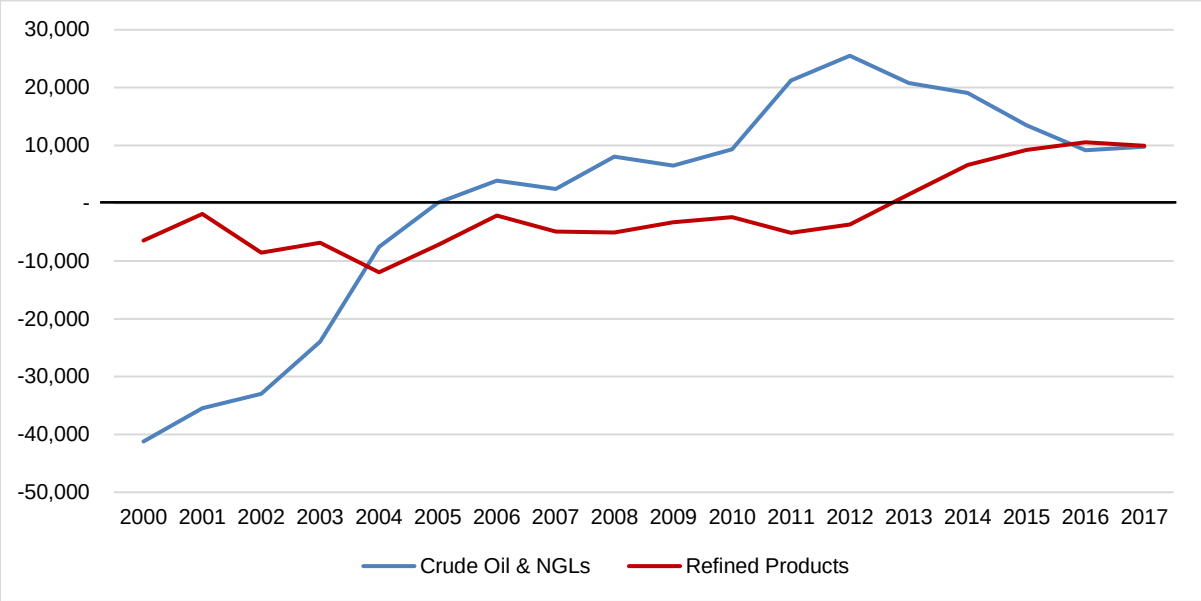
UK coal, oil and gas imports

Growing import dependency

The period 2000-2013 saw demand for natural gas and refined oil products fall more slowly than the production of natural gas and crude oil, resulting in the UK becoming a net importer of both of these commodities (see Figs.9 and 10, below). Despite a short-term recovery in oil and gas production in 2014-2017, there is a strong probability that the long-term widening of the gap between production and consumption will lead to increased UK import dependency in relation to these crucial fuels.

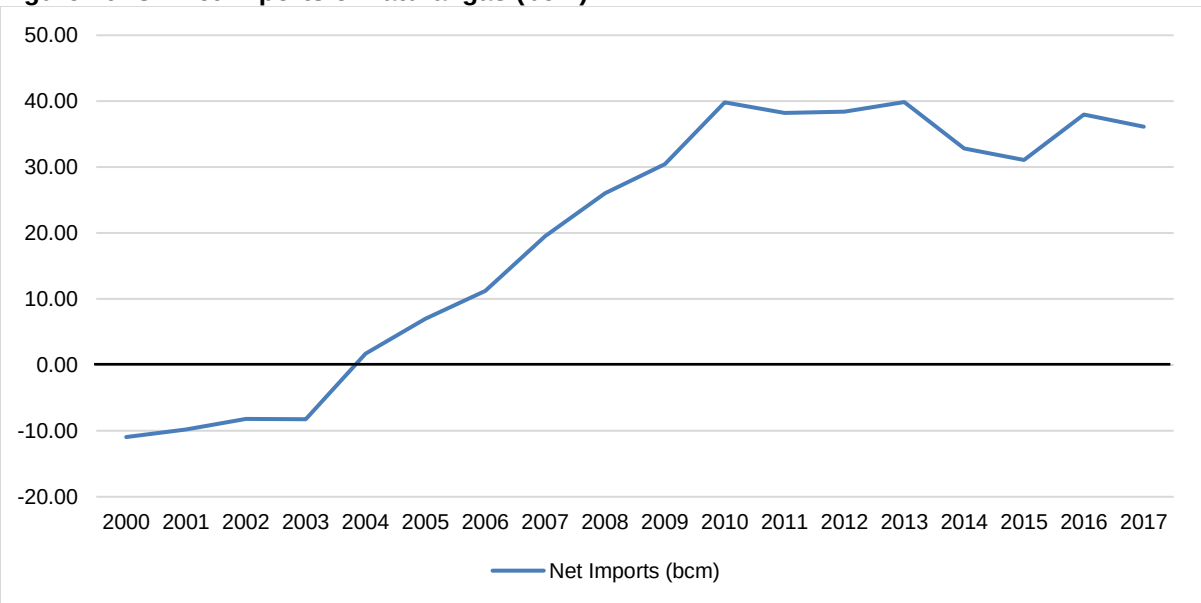
[28] Ibid.
[29] Financial Times, 29 July 2017, 'Plan to ban new petrol and diesel cars'.

Figure 9: UK net imports of crude oil and refined oil products (kt)



Source: Data from UK government statistics[30]

Figure 10: UK net imports of natural gas (bcm)

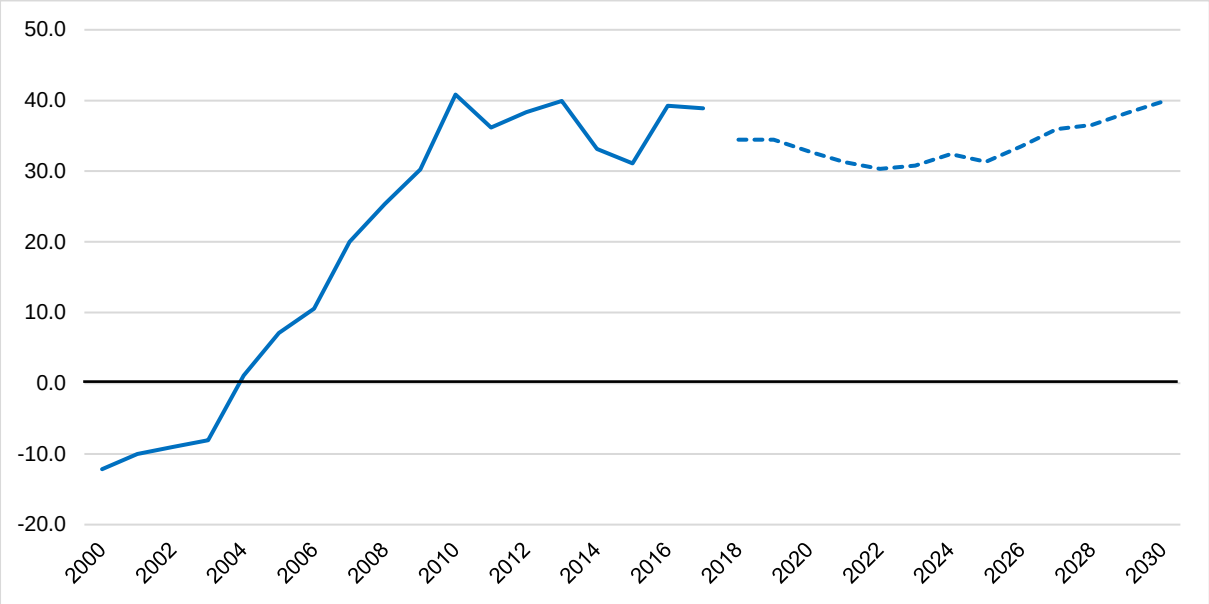


Source: Data from UK government statistics[31]

[30] UK Government, 2018. *Energy trends: Oil and oil products. Indigenous production, refinery receipts, imports and exports (ET 3.10)*. https://www.gov.uk/government/statistics/oil-and-oil-products-section-3-energy-trends. Sourced on 15 March 2018.

[31] UK Government, 2018. *Energy trends: Gas. Natural gas supply and consumption (ET 4.1)*. https://www.gov.uk/government/statistics/gas-section-4-energy-trends. Sourced on 15 March 2018.

Figure 11: UK actual and forecast net imports of natural gas (bcm)



Source: Data from UK Oil and Gas Authority[32]

Note: actual, 2005-2017, forecast 2018-2035

UK coal imports by source

The dramatic decline in UK coal imports is illustrated in Fig.6 (above), with total imports falling from 50.6 million tonnes (mt) in 2013 to just 8.5 mt in 2016 and 2017. Given the substantial year-on-year (2016-17) declines in UK coal production (-27.2%) and demand (-19.6%), these imports appear to have been directed towards coal stocks, which, in Q2 and Q3 2017, grew for the first time since Q3 2014. However, total coal stocks at the end of 2017 were 40% lower than at the end of 2016, and reached their lowest level for 19 years, "due to generators reducing stocks held due to closures and lower coal-fired demand".[33] This would suggest that coal stocks are being sustained at levels just high enough to ensure security of supply during the final years of the coal 'phase out' from the UK energy mix.

UK government statistics identify three types of coal imported into the UK: Steam coal (for power generation), coking coal (for use in blast furnaces), and anthracite (for domestic heating). Given that anthracite accounts for just 1.4% of UK coal consumption, the focus here is on steam coal and coking coal. In terms of headline figures, imports of steam coal declined dramatically between 2013 and 2017, from 44.2 mt to just 5.7 mt, while total imports of coking coal fell from 6.2 mt to 2.7 mt in the same period.[34] This suggests a decline in UK demand for coal in both power generation and industry.

The graphs below illustrate the major suppliers of steam and coking coal to the UK. Of particular note is the decline in steam coal imports from Columbia and their replacement by imports from Russia and the USA in 2017, which grew strongly after several years of relative decline. Between them, Russia (51.3%) and the USA (25.5%) provided 76.8% of UK steam coal imports in 2017, while Russia (34.0%), the USA (33.5%), and Australia (27.9%) provided 95.4% of UK coking coal imports in 2017.[35]

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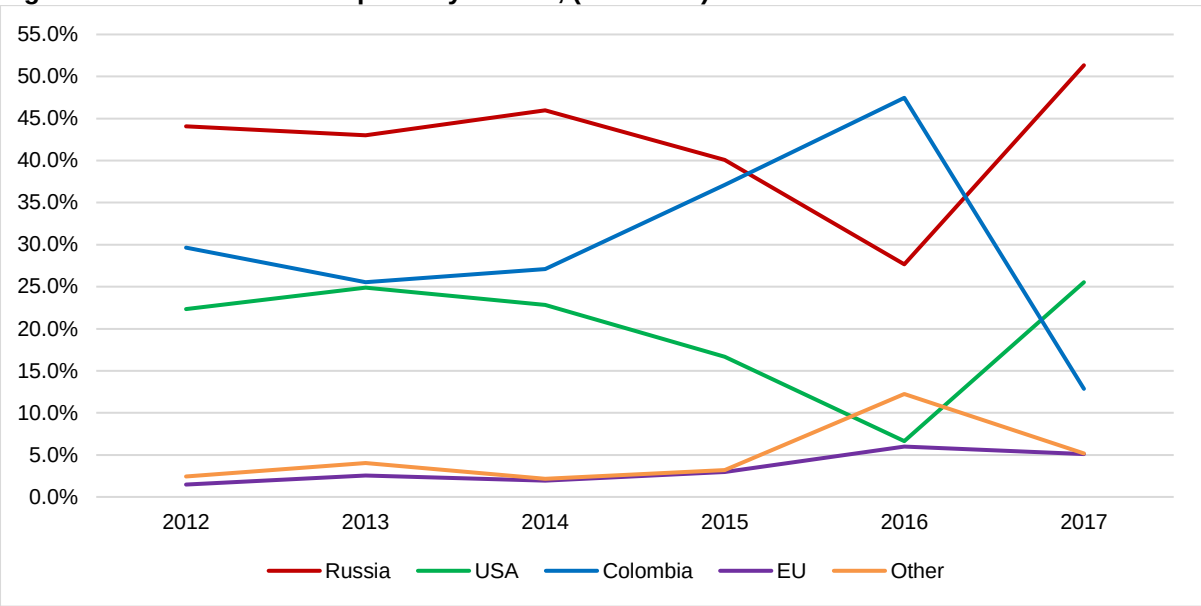
[32] UK Oil and Gas Authority, 2018. *Production and expenditure projections (Feb 2018)*. https://www.ogauthority.co.uk/data-centre/data-downloads-and-publications/production-projections/. Sourced on 15 March 2018.

[33] UK Government, 2018. *Energy trends: Solid fuel and derived gases. Supply and Consumption of Coal (ET 2.1)*. https://www.gov.uk/government/statistics/solid-fuels-and-derived-gases-section-2-energy-trends. Sourced on 3 April 2018.

[34] UK Government, 2018. *Energy trends: Solid fuel and derived gases. Coal imports (ET 2.4)*. https://www.gov.uk/government/statistics/solid-fuels-and-derived-gases-section-2-energy-trends. Sourced on 3 April 2018.

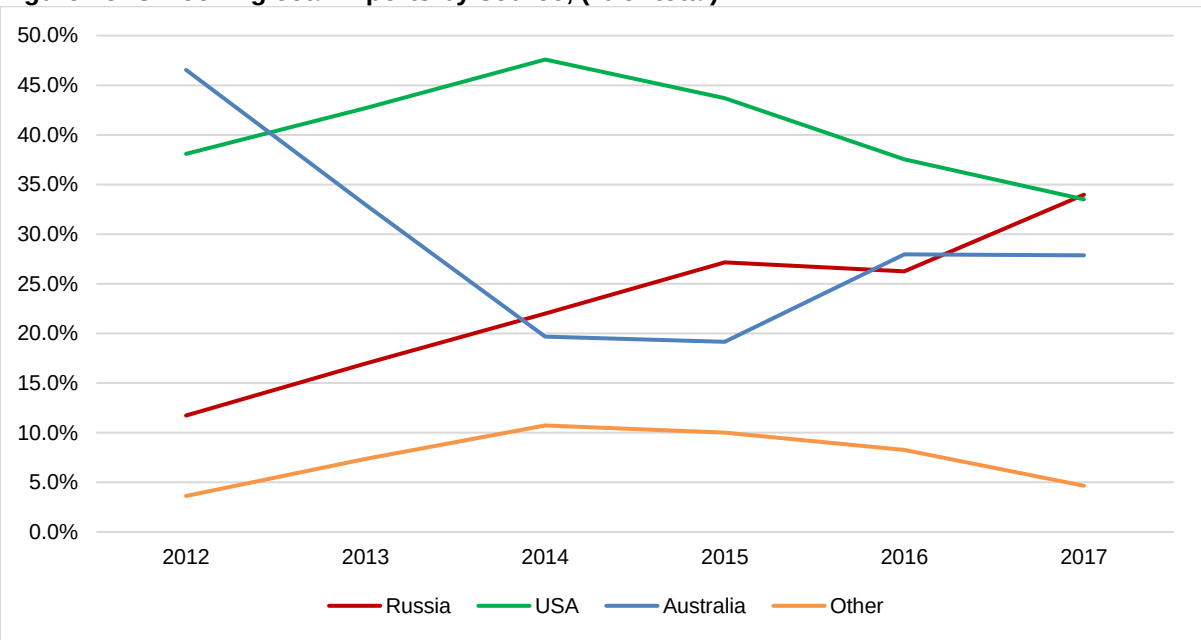
[35] Ibid.

Figure 12: UK steam coal imports by source, (% of total)



Source: Data from UK government statistics[36]

Figure 13: UK coking coal imports by source, (% of total)



Source: Data from UK government statistics[37]

[36] Ibid.
[37] Ibid.

Despite the current UK dependence on a limited number of suppliers (Russia, the United States, and Australia), the situation with regard to coal has never been a cause for concern in terms of security of supply. This is primarily because of the liquidity of the global coal market, and access to multiple suppliers. Coal stocks also protect against short-term supply disruptions. For example, as mentioned earlier, UK power producers held distributed stocks of steam coal sufficient for nine months of power generation at 2017 levels, at the end of Q4 2017. Furthermore, distributed stocks held at coke ovens at the end of Q4 2017 were sufficient for three months of coke production, ensuring short-term supplies to UK industry.

In the longer term, the dramatic decline in UK demand for steam coal for power generation since 2013 will continue between now and 2025, when the last of the UK's coal-fired power stations are expected to close. This will further reduce UK dependence on steam coal imports for power generation. UK consumption of coking coal for coke manufacture declined from 5.3 mt in 2013 to 1.8 mt in 2016, before stabilising year-on-year in 2017, at 1.9 mt. The longer-term demand for this fuel (and, by extension, UK dependence on coking coal imports) will be shaped by trends in UK industry. The potential outcome over the next 5-10 years - of steam coal all but removed from UK energy consumption and continued low levels of coking coal imports for industry - does not present a particular cause for concern in terms of UK energy security.

UK oil imports by source

As Fig.9 (above) illustrates, UK net imports of crude oil fell by more than half between 2012 and 2016, from 25.5 million tonnes (mt) to 9.2 mt, before stabilising in 2017. During the same period, the UK shifted from being a net exporter of refined oil products (3.7 mt in 2012) to being a net importer (10.5 mt in 2016 and 10.0 mt in 2017). Therefore, an examination of imports of crude oil and refined oil products by source should be considered within this context of relative stability in 2016-17, preceded by several years of declining UK crude oil imports and rising imports of refined products.

The UK imports most of its crude oil and refined oil products from a relatively small number of suppliers. In 2016, the six largest suppliers provided just over 80% of UK crude oil imports, of which only Norway (56.3%) provided more than 7%. In the same year, the nine largest suppliers provided 76% of UK imports of refined oil products. The most significant suppliers were the Netherlands (19.0%), the United States (14.3%), and Russia (13.0%).

As the tables below illustrate, the UK exhibits substantial dependency on crude oil imports from neighbouring Norway, which both shields the UK from the need to source oil from the rest of the international market and leaves the UK dependent on trends in Norwegian oil production. In January 2018, the Norwegian Petroleum Directorate updated its forecast for oil and gas production to 2022. That forecast predicted annual 2% declines in oil production in 2018 and 2019, before an upswing in production linked to the launch of new production at the Johan Sverdrup field.[38] Given the ongoing trends in UK crude oil demand and imports, this is likely to leave Norway as the UK's largest crude oil supplier, and UK dependence on alternative suppliers relatively limited, at least in the coming five years.

By contrast, the medium-term rise in UK imports of refined oil products has increased the importance of the UK's major suppliers: The Netherlands, Russia, and the United States. However, given the relatively stable forecasts for UK demand for refined oil products in the coming fifteen years, and the expected decline in UK crude oil production (as a source of domestic refinery throughput) after 2020, UK dependence on these suppliers is set to increase substantially over the coming decade, unless demand for refined oil products is reduced.

[38] Norwegian Petroleum Directorate, 2018. Increasing oil and gas production for the next five-year period. *Press release*, 11 January. http://www.npd.no/en/news/News/2018/The-Shelf-2017/1-Increasing-oil-and-gas-production-for-the-next-fiveyear-period/. Sourced on 20 March 2018.

Figure 14: UK crude oil imports by source

	Share in UK Crude Oil Imports				
	2012	2013	2014	2015	2016
Algeria	5.7%	10.8%	13.8%	14.4%	5.5%
Angola	2.6%	2.5%	1.1%	5.5%	2.5%
Nigeria	11.2%	10.3%	10.6%	9.8%	6.9%
Norway	43.1%	38.0%	43.9%	47.2%	56.3%
Russia	12.4%	9.1%	4.9%	3.9%	6.8%
Saudi Arabia	0.9%	3.2%	3.1%	2.9%	2.7%
Total	75.9%	73.9%	77.5%	83.7%	80.8%

Source: Data from UK government statistics[39]

Figure 15: UK refined oil product imports by source

	Share in UK Oil Product Imports				
	2012	2013	2014	2015	2016
Belgium	3.8%	4.2%	8.7%	8.9%	8.2%
Kuwait	8.9%	8.8%	8.7%	4.8%	3.2%
Netherlands	15.7%	19.5%	12.5%	14.4%	19.0%
Norway	4.3%	3.4%	3.3%	3.6%	2.9%
Russia	10.1%	13.9%	15.8%	15.3%	13.0%
Saudi Arabia	2.7%	3.2%	4.3%	3.2%	4.7%
Sweden	17.4%	9.2%	11.5%	13.9%	5.8%
United Arab Emirates	3.9%	1.5%	2.0%	2.8%	5.0%
United States	8.4%	8.1%	8.2%	9.8%	14.3%
Total	75.2%	71.6%	75.0%	76.5%	76.1%

Source: Data from UK government statistics[40]

UK natural gas imports by route

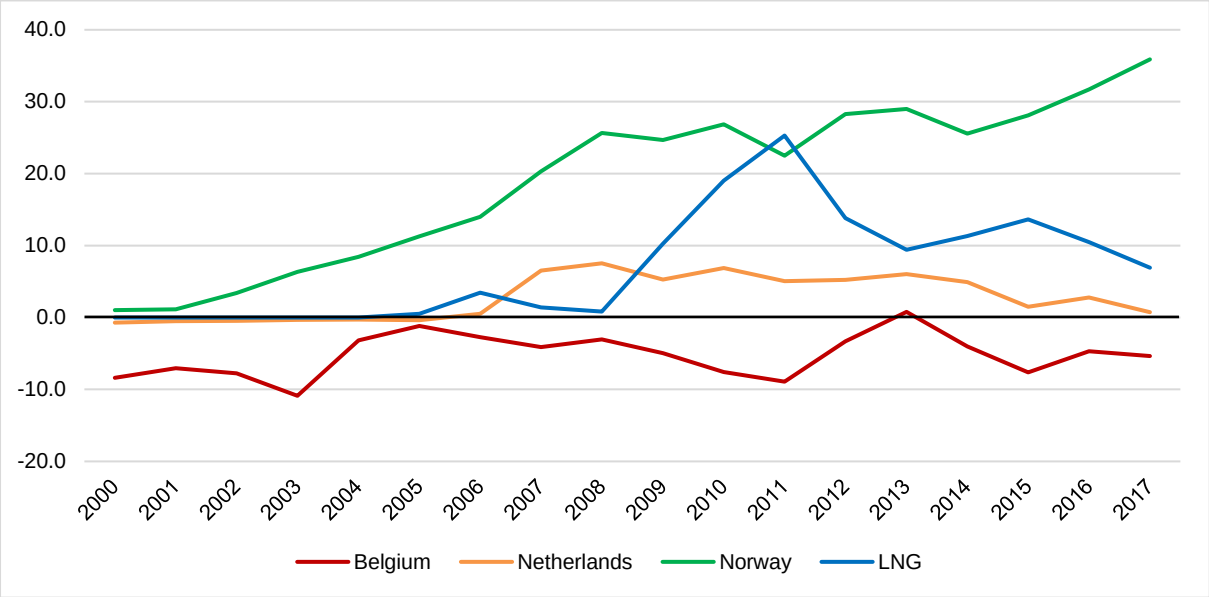
In 2017, the UK relied on imports to meet 47.0% of its natural gas demand. This is consistent with the trend since 2011, when the share of imports in domestic demand has fluctuated within a corridor of 43.7% to 53.7%.[41] The UK imports natural gas via four channels: Pipeline imports from Norway, the Netherlands, and Belgium, and LNG imports via its three terminals. The balance between these channels is illustrated in Fig.16, while a map of this infrastructure is provided in Fig.18. The volumes imported via these channels have been shaped by the growth in the UK's gas import dependency over the past 15 years. As Fig.16 illustrates, this began with net exports to Belgium, when the UK was still a significant gas exporter. The UK's growing need for imports was later met through the growth in imports from Norway (2001-2008), supplemented by imports from the Netherlands (2006-2008), and finally a dramatic growth in LNG imports (2008-2011). Since 2011, imports from Norway have continued to grow, while imports via the Netherlands and in the form of LNG have declined.

[39] UK Government, 2017. *Digest of UK Energy Statistics (DUKES) Chapter 3.9: Imports of crude oil and petroleum products by country of origin.* https://www.gov.uk/government/statistics/petroleum-chapter-3-digest-of-united-kingdom-energy-statistics-dukes Sourced on 20 March 2018.

[40] Ibid.

[41] UK Government, 2018. *Energy trends: Gas. Natural gas supply and consumption (ET 4.1).* https://www.gov.uk/government/statistics/gas-section-4-energy-trends. Sourced on 3 April 2018.

Figure 16: UK net imports of natural gas by route (bcm)



Source: Data from UK government statistics[42]

The Interconnector pipeline between the UK and Belgium was launched in 1998. As a result of several expansions, the Interconnector now has 20 bcm/year of capacity for the UK to export gas to continental Europe, and 25.5 bcm/year capacity for the UK to import gas from continental Europe.[43] The pipeline was initially conceived as a means to export UK and Norwegian natural gas to continental Europe, in line with the UK's status as a net exporter of natural gas. Since then, the pipeline has also been used to balance UK supplies with small imports from continental Europe, including volumes purchased on the virtual Zeebrugge Trading Point (ZTP). Over the past decade (2008-2017), UK exports to Belgium via the Interconnector have averaged 6.2 bcm/year, while imports have averaged 1.3 bcm/year.[44]

By contrast, the Balgzand-Bacton Line (BBL) between the Netherlands and the UK has functioned exclusively to bring Dutch gas to the UK since its launch with a 15 bcm capacity in December 2006, although physical deliveries from the UK to the Netherlands via the BBL are planned from autumn 2019.[45] [46] Over the past decade, the UK has imported an average of 6.1 bcm/year from the Netherlands via the BBL. The UK has also exported 1.5 bcm/year back to the Netherlands, directly from UK fields in the North Sea. However, the decline in Dutch gas production and exports has precipitated a gradual decline in UK imports from the Netherlands, from 7.6 bcm in 2013 to 1.9 bcm in 2017, despite the increasing liquidity of the Dutch gas trading hub, the Title Transfer Facility (TTF). During the same period, UK net imports from the Netherlands fell from 6.0 bcm to 0.7 bcm.[47]

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[42] UK Government, 2018. *Energy trends: Gas. Natural gas imports and exports (ET 4.3)*. https://www.gov.uk/government/statistics/gas-section-4-energy-trends. Sourced on 19 March 2018.

[43] Interconnector, 2018. *How we got here*. http://www.interconnector.com/about-us/how-we-got-here/. Sourced on 16 March 2018.

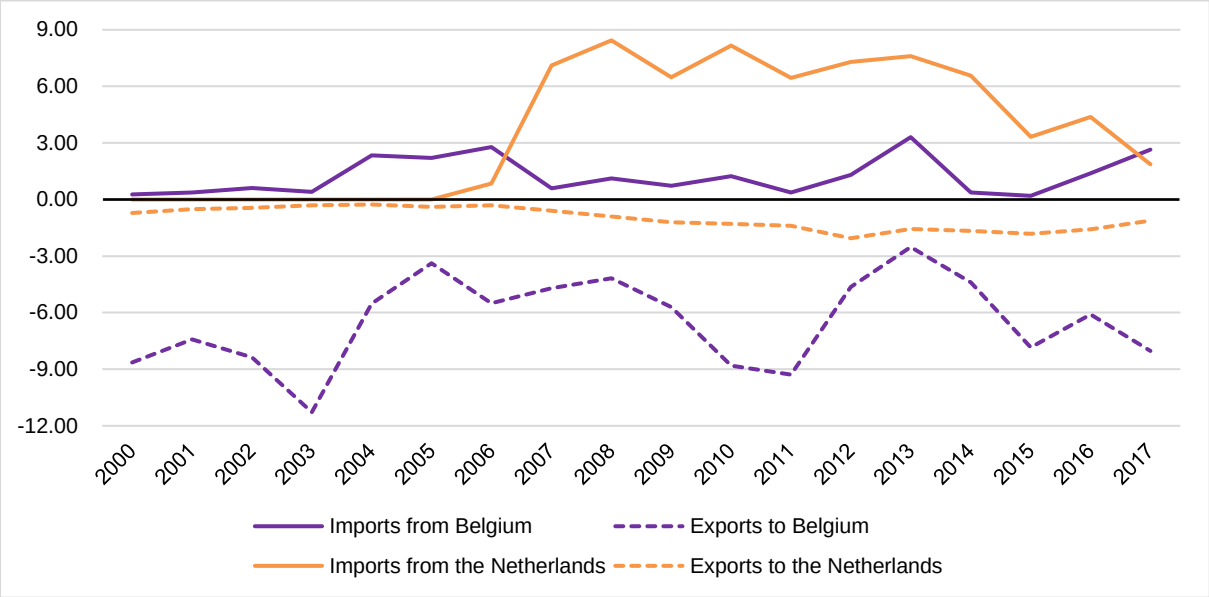
[44] UK Government, 2018. *Energy trends: Gas. Natural gas imports and exports (ET 4.3)*. https://www.gov.uk/government/statistics/gas-section-4-energy-trends. Sourced on 19 March 2018.

[45] BBL Company, 2006. New pipeline to supply gas from the Netherlands to the UK. *Press Release*, 01 Dec. https://www.bblcompany.com/news/new-pipeline-to-supply-gas-from-the-netherlands-to-the-uk. Sourced on 16 March 2018.

[46] BBL Company, 2017. Gas transportation in both directions through the BBL pipeline from 2019. *Press Release*, 14 Dec. https://www.bblcompany.com/news/gas-transportation-in-both-directions-through-the-bbl-pipeline-fr. Sourced on 27 March 2018.

[47] UK Government, 2018. *Energy trends: Gas. Natural gas imports and exports (ET 4.3)*. https://www.gov.uk/government/statistics/gas-section-4-energy-trends. Sourced on 19 March 2018.

Figure 17: UK gas imports from and exports to Belgium and the Netherlands (bcm)



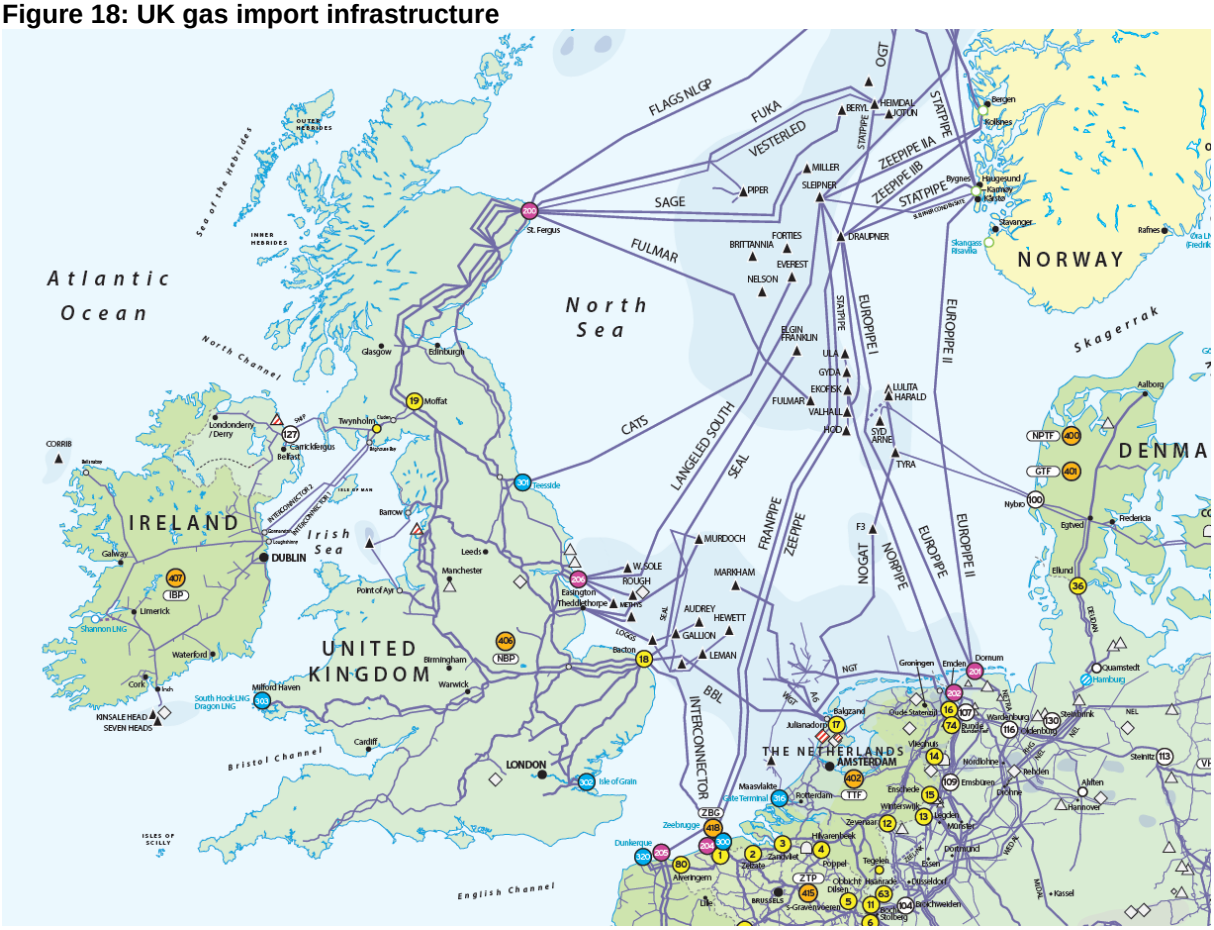
Source: Data from UK government statistics[48]

The experience of recent years suggests that the operation of these two pipelines has been, and will continue to be, primarily for the purposes of gas trading and seasonal balancing, delivering smaller volumes, rather than as a source large-scale imports to the UK purchased under long-term contracts. The gas volumes available via these interconnectors have multiple sources, as a result of the availability of Dutch gas production, Belgian and Dutch LNG imports, and pipeline gas supplies from Norway and Russia, all being traded on a liberalised market. For large-scale imports, which will become increasingly important as UK gas import dependency grows in the coming years, the UK gas industry will look to sustained imports from Norway and LNG sourced from the global market.

UK gas imports from Norway are predominantly sourced via three offshore pipelines: Frigg/Vesterled, FLAGS, and Langeled.[49] UK government statistics report deliveries via these pipelines from 2000, 2003, and 2006, respectively,[50] although the Vesterled pipeline was only launched in 2001 as an extension of the pre-existing Frigg system.[51] The launch of these pipelines enabled the build-up of UK gas imports from Norway between 2001 and 2008, as illustrated in Fig.16, above. Since 2000, these three pipelines have delivered between 93 and 100% of Norwegian annual gas exports to the UK. The Vesterled pipeline to St Fergus has a maximum capacity of 38.6 million cubic metres/day (mmcm/d, or around 11 bcm/year), while the Langeled pipeline to Easington has a capacity of around 72 mmcm/d (around 26.3 bcm/year).[52] The IEA reports the total pipeline capacity for Norwegian gas deliveries to the UK as 161.28 mmcm/d (58.9 bcm/year), including Langeled (72 mmcm/d), Vesterled (36 mmcm/d), and the Flags (Statfjord) system to St Fergus (42 mmcm/d).[53]

[48] Ibid.
[49] Norsk Oljemuseum, 2011. *Oil and gas fields in Norway*. http://www.norskolje.museum.no/en/home/oil-facts/publications/oil-and-gas-fields-in-norway/. Sourced on 19 March 2018. See pages 231-239
[50] UK Government, 2018. *Energy trends: Gas. Natural gas imports and exports (ET 4.3)*. https://www.gov.uk/government/statistics/gas-section-4-energy-trends. Sourced on 19 March 2018.
[51] Norsk Oljemuseum, 2011. See page 232
[52] Norsk Oljemuseum, 2011. See pages 232, 236
[53] IEA, 2018. *Gas trade flow in Europe*. https://www.iea.org/gtf/. Sourced on 19 March 2018. (Requires Adobe Flash Player)

Figure 18: UK gas import infrastructure



Source: ENTSOG[54]

Between 2008 and 2014, Norwegian gas exports to the UK remained relatively stable at around 25 bcm/year, within a corridor of 22.5-29.0 bcm. However, Norwegian supplies to the UK have grown in recent years, reaching a record 35.9 bcm in 2017, a year in which Norwegian supplies accounted for 75.3% of total UK gas imports and 99.0% of UK net gas imports.[55] Norway is, and will continue to be, the most important supplier of natural gas to the UK. However, while the pipeline capacity exists to bring Norwegian gas to the UK, the ability of Norway to provide these gas supplies (as the UK's import dependency grows) will depend on Norway's gas production levels. These are predicted to remain stable at the 2017 level of 122 bcm through to 2022, before a slight decline to 112 bcm by 2025 and a further decline to 90-92 bcm/year by 2030-2035.[56] If these projections are broadly accurate, the UK will find itself competing with its European neighbours for declining volumes of Norwegian gas.

The final source of UK gas imports is liquefied natural gas (LNG), with supplies purchased on the global market and delivered by a variety of suppliers. The UK has three LNG import terminals. The Isle of Grain terminal is owned by National Grid and has been operational since July 2005. The terminal now has an import capacity of 14.8 million tonnes/year (mtpa) of LNG, which is equivalent to around 20 bcm

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[54] ENTSOG, 2017. *Capacity map*. https://www.entsog.eu/maps/transmission-capacity-map. Sourced on 19 March 2018.

[55] UK Government, 2018. *Energy trends: Gas. Natural gas imports and exports (ET 4.3)*. https://www.gov.uk/government/statistics/gas-section-4-energy-trends. Sourced on 19 March 2018.

[56] Hall, M., 2018. *Norwegian Gas Exports – Assessment of Resources and Supply to 2035.* NG 127, OIES, https://www.oxfordenergy.org/publications/norwegian-gas-exports-assessment-resources-supply-2035/. Sourced on 19 March 2018.

of natural gas. At the end of 2017, National Grid reported long-term contracts with BP, Iberdrola, Sonatrach, Centrica, Uniper, and Engie for use of the terminal for importing LNG into the UK.[57] According to Grain LNG, the contract with BP/Sonatrach is for 3.3 mtpa of LNG (4.5 bcm/year of natural gas), for 20 years, from 2005, while unspecified long-term contracts were awarded to Centrica, Engie, and Sonatrach in December 2008, and to Uniper, Iberdrola and Centrica in December 2010.[58]

The UK has a further two LNG import terminals in the port of Milford Haven. The first, South Hook, received its first LNG cargo in March 2009.[59] Since its launch, South Hook has only received Qatari gas, due to limitations on the oxygen content of LNG imported via the terminal, which effectively precludes the import of non-Qatari LNG.[60] That terminal has an annual import capacity of 15.6 mtpa (21.5 bcm), and is jointly owned by Qatar Petroleum (67.5%), Exxon Mobil (24.15%), and Total (8.35%).[61] According to the South Hook LNG website:

> South Hook Gas Company Ltd, a UK Joint Venture of Qatar Petroleum International (70%) and ExxonMobil Qatargas (II) Trading Company Limited (30%), purchased 100% of primary capacity at South Hook LNG Terminal under a Terminal Capacity Agreement. South Hook Gas' management of the import capacity is separate to the operation of the Terminal, which is owned and operated by South Hook LNG Terminal Company Ltd. As Base User, South Hook Gas Company has acquired all primary capacity rights at the Terminal and is the first point of contact for LNG suppliers seeking to access secondary capacity.[62]

The second terminal in Milford Haven, Dragon LNG, is jointly owned (50-50) by Shell and Petronas.[63] The terminal received its first cargo in July 2009, and has an import capacity of 7.6 bcm/year.[64] Finally, the Teesside GasPort – a floating regasification facility – was operational from 2007 to 2015. However, it was decommissioned due to low demand, and declared to not be "commercially viable".[65]

Together, the three UK LNG import terminals have a combined annual gas import capacity of 49.0 bcm, in addition to 56.5 bcm of pipeline import capacity from Norway and 43.3 bcm of import capacity from continental Europe. This gives a total UK gas import capacity of 148.8 bcm/year.[66] As illustrated by Fig.19 (below), since the launch of the Isle of Grain terminal in 2005, UK LNG import volumes in a calendar year have been higher than 15 bcm only twice: in 2010 (19.0 bcm) and 2011 (25.3 bcm). This suggests that the UK has yet to utilise more than half of its existing LNG import capacity in a given year. Furthermore, UK LNG supplies are overwhelmingly sourced from Qatar: Since 2011, Qatar has provided 85-98% of UK LNG imports. This is not entirely surprising, given both Qatar's status as the world's largest LNG exporter, and the Qatar Petroleum shareholding in the South Hook LNG import terminal, where the long-term capacity booking by the South Hook Gas Company ensures that Qatargas has a UK outlet for its LNG exports. In addition to smaller volumes of supplies from Norway, Algeria, and Trinidad & Tobago, supplies from 'Other' countries experienced spikes only in two years. In 2006, Egypt (1.14 bcm) provided 74% of the imports by 'Other' suppliers (1.54 bcm). In 2011, Nigeria (1.20 bcm) and Yemen 0.60 bcm) provided 89% of the imports by 'Other' suppliers (2.03 bcm).

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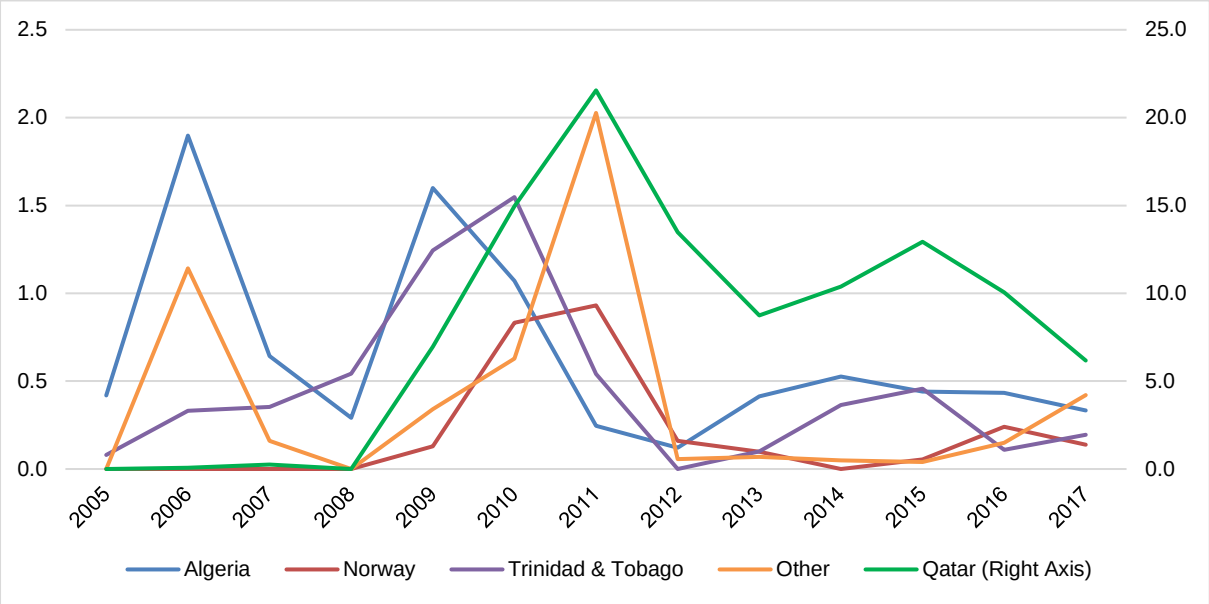
[57] National Grid, 2017. *Investor relations: Grain LNG*. http://investors.nationalgrid.com/~/media/Files/N/National-Grid-IR-V2/factsheets/2017/Grain%20Factsheet%20November%202017.pdf. Sourced on 19 March 2018.
[58] Grain LNG, 2018. *Our customers*. http://grainlng.com/who-are-we/our-customers/. Sourced on 19 March 2018.
[59] South Hook LNG, 2018. *The Qatargas 2 LNG supply chain*. https://www.southhooklng.com/liquefied-natural-gas/the-supply-chain/. Sourced on 19 March 2018.
[60] Argus Media, 28 March 2018. 'South Hook seeks to vary LNG imports'.
[61] South Hook LNG, 2018. *Shareholders*. https://www.southhooklng.com/about-us/shareholders/. Sourced on 19 March 2018.
[62] South Hook LNG, 2018. *Commercial agreements at our terminal*. https://www.southhooklng.com/commercial/. Sourced on 19 March 2018.
[63] Dragon LNG, 2018. *About us*. https://www.dragonlng.co.uk/about-us. Sourced on 19 March 2018.
[64] Dragon LNG, 2018. *Our terminal*. https://www.dragonlng.co.uk/about-us/our-terminal. Sourced on 19 March 2018.
[65] Excelerate Energy, 2018. *Teesside GasPort*. http://excelerateenergy.com/project/teesside-gasport/. Sourced on 19 March 2018.
[66] National Grid, 2017. *Gas Ten Year Statement 2017*. https://www.nationalgrid.com/sites/default/files/documents/GTYS%202017_3.pdf. Sourced on 19 March 2018. See page 147.

Figure 19: UK LNG imports by source (bcm)



Source: Data from UK government statistics[67]

The role of Russian gas in UK gas imports

The discussion thus far has identified UK dependence on pipeline gas imports from Norway, and the fluctuations in LNG imports, which are dominated by Qatari supplies, supplemented by smaller volumes from Algeria, Norway, Trinidad & Tobago and others. However, this examination of UK gas supplies raises two points that are embedded in recent developments. Firstly, the decline in Dutch gas production and related Dutch gas exports to the UK raises the possibility of UK gas traders sourcing larger volumes of gas supplies on the European market and importing them into the UK through the two interconnectors that link the UK to the continental European gas market. Indeed, the modest increase in UK imports from Belgium since 2015 suggests this is already happening, although the UK remains a net exporter to Belgium. Secondly, the UK received its first Russian LNG imports in early 2018, following the launch of a new LNG export terminal in northern Russia. Amidst the deterioration in UK-Russian diplomatic relations in March 2018, those LNG imports prompted discussions of the extent of the UK's dependence on Russian gas supplies.[68]

Gazprom's gas purchases on the European market for delivery to the UK

As discussed above, the vast majority of UK natural gas imports are either sourced by pipeline from Norway, or in the form of LNG from Qatar. In 2017, pipeline imports from Norway reached 35.9 bcm (up from 31.7 bcm in 2016), while LNG imports reached 6.9 bcm (down from 10.5 bcm in 2016), of which Qatar supplied 6.2 bcm (down from 10.0 bcm in 2016). In the same year, the UK imported 1.87 bcm of natural gas by pipeline from the Netherlands (down from 4.38 bcm in 2016), as net imports from the Netherlands fell to 0.7 bcm. By contrast, imports from Belgium grew from 1.39 bcm to 2.65 bcm, although the UK remained a net exporter to Belgium (Fig.17, above).

In the context of total UK gas imports of 47.7 bcm in 2017 (down from 48.5 bcm in 2016), the volumes imported from the Netherlands and Belgium are small, but it is here that it is possible to find the only

[67] UK Government, 2018. *Energy trends: Gas. Supplementary information on the origin of UK gas imports (ET 4.4).* https://www.gov.uk/government/statistics/gas-section-4-energy-trends. Sourced on 19 March 2018.
[68] Platts, 14 March 2018, 'UK 'looking to other countries' for natural gas supply amid Russia spy row: Prime Minister'.

pipeline imports of 'Russian' gas molecules into the UK. Specifically, this refers to gas purchased on European trading hubs and delivered to the UK via the two interconnectors. Given that Russian gas (that is, gas supplies that are physically delivered from Russia) accounted for 40% of total EU gas imports in 2016[69], a significant share of the gas purchased on European hubs and delivered to the UK could be physically 'Russian' gas.

One of those traders is Gazprom Marketing & Trading (GM&T), which is a London-based subsidiary of Gazprom Export. GM&T trades gas "across Europe's major trade platforms" and sells gas to end consumers in the UK, France, Germany, and the Netherlands.[70] Although GM&T does not publish figures for how much gas it sells onto each market, Gazprom Export claims that Gazprom Group "supplied" 17.9 bcm to the UK market in 2016 – the equivalent of 37% of total UK gas imports. For the same year, Gazprom's Annual report claims supplies to the UK of 25.7 bcm.[71] Regardless of the discrepancy between these figures, two points should be made. Firstly, it is highly unlikely that those volumes were all consumed in the UK. Given that GM&T is London-based, but trades and supplies gas outside the UK, Gazprom may allocate gas volumes acquired by GM&T to the UK in its accounts, even if those gas volumes are not physically delivered to the UK and are subsequently sold onto other markets. Indeed, the structure of UK gas imports makes it highly unlikely that GM&T would be able to acquire, and subsequently re-sell, such a large volume solely on the UK market, as explained below.

Secondly, the gas traded by GM&T is not always Russian in origin, as Gazprom Export makes clear in its description of GM&T's business model:

> As well as Russian gas, GM&T's portfolio also includes gas from other producers. For instance, GM&T has a contract with DONG (Denmark) for purchasing natural gas from the Ormen Lange field in the North Sea. GM&T also buys significant volumes of gas directly in the market.[72]

GM&T's largest contract with a UK customer is with Centrica. GM&T initially signed a three-year contract for the delivery of 2.4 bcm/year from 2014, which was later expanded to 4.16 bcm/year from 2015 to 2021.[73] However, it would not be entirely accurate to state that GM&T's supplies to Centrica are of 'Russian' gas, given that GM&T sources its gas from producers operating fields in the Norwegian waters of the North Sea and from traders on the European market.

In May 2017, INEOS bought DONG's 14% share in the Ormen Lange field, where production was 16.2 bcm in 2017 (down from 17.3 bcm in 2016) and the field is estimated to have 116 bcm of reserves remaining in place.[74] [75] Therefore, if GM&T had purchased all of DONG's share of Ormen Lange production in 2016, this would have equated to 2.4 bcm of natural gas that would have been delivered to the UK from Norway. Given that a variety of energy companies (of various nationalities) produce natural gas on the Norwegian continental shelf (NCS) and deliver it by pipeline either to the UK or to continental Europe, it is entirely possible for GM&T to purchase gas from multiple producers on the NCS for resale onto the UK market, as it has been doing for many years. Despite Gazprom's involvement, the gas molecules are produced in Norway and delivered to the UK by the Norwegian

[69] Eurostat, 2018. *Imports-gas-annual data [nrg124a]*. http://ec.europa.eu/eurostat/data/database. Sourced on 19 March 2018.
[70] Gazprom Export, 2018. *Foreign partners: Great Britain*. http://www.gazpromexport.ru/en/partners/gb/. Sourced on 19 March 2018.
[71] Gazprom, 2017. *Annual report 2016*. http://www.gazprom.com/f/posts/11/885774/gazprom-annual-report-2016-en.pdf. Sourced on 21 March 2018. See page 78.
[72] Gazprom Export, 2018. *Foreign partners: Great Britain*. http://www.gazpromexport.ru/en/partners/gb/. Sourced on 19 March 2018.
[73] Centrica, 2015. Centrica extends gas supply contracts. *Press release*, 13 May. https://www.centrica.com/news/centrica-extends-gas-supply-contracts. Sourced on 19 March 2018.
[74] INEOS, 2017. INEOS to buy the entire Oil & Gas business from DONG Energy A/S for a headline price of $1.05 billion plus $250m contingent. *Press release*, 24 May. https://www.ineos.com/news/ineos-group/ineos-buy-entire-oil-and-gas-business-from-dong-energy/. Sourced on 19 March 2018.
[75] Norwegian Petroleum Directorate, 2018. *Fields: Ormen Lange*. http://factpages.npd.no/FactPages/default.aspx?nav1=field&nav2=PageView|All&nav3=2762452&culture=en. Sourced on 19 March 2018.

state-owned pipeline operator, Gassco. Therefore, these supplies are referred to as 'Norwegian' gas in the UK government statistics referenced throughout this paper.

It is also possible for GM&T to purchase natural gas on the European market. Indeed, the Dutch gas trading hub, the Title Transfer Facility (TTF), overtook the UK National Balancing Point (NBP) to become the European hub with the largest trading volumes in 2016.[76] Here, GM&T can buy gas from other European traders, and arrange for it to be shipped to the UK via the interconnectors from the Netherlands and Belgium. However, as noted above, these volumes are small, with UK imports from the Netherlands and Belgium combined reaching 4.5 bcm in 2017, down from 5.8 bcm in 2016.

Finally, traders such as GM&T have the option of purchasing LNG supplies on the international spot market and delivering them to the UK. According to the International Group of LNG Importers (GIIGNL), in 2016, approximately 21% of the UK's LNG imports (around 2.2 bcm) were delivered to the UK under spot contracts. However, approximately 2.1 bcm of those spot volumes were sourced from Qatar, which were likely to be spot sales offered by Qatargas in addition to its long-term contract (LTC) deliveries to the UK, leaving very little for purchase by other traders.[77]

The small amount of spot LNG volumes delivered to the UK by suppliers other than Qatargas, combined with the small volumes physically imported to the UK via the interconnectors with Belgium and the Netherlands, mean that in order to physically deliver 17.9 bcm to the UK in 2016, GM&T would have been obliged to purchase around one-third of the gas produced and shipped to the UK from the Norwegian continental shelf in that year, which seems rather unlikely. Therefore, the volumes traded by GM&T every year should not be equated with 'Russian' gas exports to the UK or used as a measurement of UK dependence on Russian energy supplies.

The very principle of the EU gas market is that gas can be shipped across the continent without regard to its geographical origin. The gas that GM&T purchases on European gas trading hubs for delivery to the UK could be Norwegian, Russian, Algerian, or re-gasified LNG from further afield. If GM&T did not purchase these volumes from producers on the Norwegian continental shelf or from traders on European hubs, there would be other traders willing to do so, if the UK market exhibits demand and has customers willing to pay for gas supplies at prices that are profitable for the traders. Therefore, UK dependence on 'Russian' gas is arguably negligible.

UK imports of Russian LNG cargoes

Until recently, Russia's only LNG export terminal was located in Russia's Far East, on the island of Sakhalin, with the purpose of supplying Russian gas to the East Asian market. However, in December 2017, the first train of the Yamal LNG terminal was launched on Russia's northern coast, with a further two trains under construction. Each of the three trains has a planned capacity of 5.5 mtpa. The shareholders are the Russian gas company, Novatek (50.1%), Total (20%), CNPC (20%), and the Chinese Silk Road Fund investment vehicle (9.9%).[78] The Yamal LNG consortium plan to deliver LNG to the Asian market during the summer via the Northern Sea Route (through the Arctic waters of northern Russia), and during winter the LNG is being shipped to Europe, for trans-shipment and either sale to European customers or onward delivery to Asia. Therefore, the launch of Yamal LNG has established Russia as a tentative player on the European LNG market.

The first cargo from Yamal LNG was sold to Malaysian state-owned Petronas, and was delivered to the Isle of Grain LNG terminal in the UK, where it was re-loaded onto a tanker chartered by Engie, for

[76] Heather, P., and Petrovich, B., 2017. *European traded gas hubs: an updated analysis on liquidity, maturity and barriers to market integration.* Energy Insight 13, OIES, https://www.oxfordenergy.org/publications/european-traded-gas-hubs-updated-analysis-liquidity-maturity-barriers-market-integration/. Sourced on 19 March 2018.

[77] GIIGNL, 2017. *Annual report 2017.* http://www.giignl.org/sites/default/files/PUBLIC_AREA/Publications/giignl_2017_report_2.pdf. Sourced on 21 March 2018.

[78] Yamal LNG, 2018. Yamal LNG ships first million tons of LNG. *Press release*, 5 March. http://yamallng.ru/en/press/news/36264/. Sourced on 19 March 2018.

onward delivery to the US.[79] In the weeks that followed, up to February 22, Yamal LNG delivered another 12 spot cargos, in advance of the start of long-term contract deliveries in April.[80] This suggests that, in Q1 2018, Russian LNG from Yamal was available at short notice to the highest bidder.

Between January 1 and March 31, the UK received eight cargoes of LNG for UK consumers. Of those, three (on January 18, March 8, and March 13) were sourced from Russia, with a total volume of 209 million cubic metres (mmcm). These were supplemented by three cargoes from Qatar (421 mmcm), one cargo from the US (79 mmcm), and one cargo from Norway (23 mmcm), with a combined volume of 523 mmcm.[81] [82] [83] The fact that Russian supplies accounted for 29% of UK LNG imports in Q1 2018, while LNG imports as a whole accounted for just 5.3% of UK gross gas imports in the same period, with pipeline supplies from Norway (64.8%) and Belgium/Netherlands (29.9%) providing the remainder, suggests that UK gas imports are certainly not being dominated by LNG supplies from Russia.[84]

Furthermore, it should be noted that all of Yamal LNG's production from April 2018 onwards has already been sold under long-term contracts. Those contracts have been signed with Total (4 mtpa), Engie (1 mtpa), Fenosa (2.5 mtpa), CNPC (3 mtpa), Novatek Gas & Power (2.4 mtpa), and Gazprom Marketing and Trading (2.9 mtpa).[85] The volumes purchased by CNPC are likely to contribute directly to China's LNG imports, while the volumes contracted by Novatek are likely to be supplied to the Asian market (to avoid competing with Gazprom's pipeline supplies to Europe) and the volumes contracted by Gazprom Marketing and Trading are most likely destined for India, given the recent entry into force of Gazprom's 3 mtpa LNG contract with GAIL. By contrast, the volumes contracted by European energy companies could be re-sold on European gas trading hubs for delivery anywhere in Europe. Once the long-term contract deliveries from Yamal LNG have begun, and these supplies have been added to the pool of gas supplies available on European hubs, it would be difficult to conceive of these supplies as a 'tool of Russian influence', as suggested by a UK politician in a debate on UK energy security in the context of the deterioration in UK-Russian diplomatic relations.[86]

Gas prices and gas storage

The arrival of spot-purchased LNG supplies in the UK, particularly during the cold weather in late February and throughout March highlighted an important point with regard to the functioning of the UK gas market. Specifically, there has been a shift away from the practice of storing gas during the summer periods of low demand ready for consumption during winter periods of high demand, to a practice of 'just in time' deliveries, with import volumes rising and falling in line with demand. This shift was illustrated by the closure of the UK's only large-scale gas storage facility, Rough, at the end of 2017.

The closure of Rough substantially altered the character of gas storage capacity in the UK. Before its closure, the Rough facility had a storage capacity of approximately 3 bcm and a daily send-out capacity of 42 mmcm/day.[87] With Rough removed from the picture, National Grid reported eight gas storage

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[79] Froley, A., 2018. Spot LNG holds firm, winter EAX up 28% on year. *ICIS LNG Markets Analysis*, 21 Feb. https://www.icis.com/press-releases/spot-lng-holds-firm-winter-eax-up-28-on-year/. Sourced on 19 March 2018.

[80] Argus Media, 14 Feb 2018. 'Yamal LNG ready for contract sales'.

[81] Argus Media, 15 March 2018. 'UK to receive first Cove Point LNG cargo'.

[82] Argus Media, 21 March 2018. 'UK LNG imports and re-exports'.

[83] GIIGNL, 2017. *GIIGNL annual report 2017*. http://www.giignl.org/sites/default/files/PUBLIC_AREA/Publications/giignl_2017_report_2.pdf. Sourced on 26 March 2018. See the Conversion Table on page 36. 1 cubic metre of LNG equates to 571 cubic metres of natural gas.

[84] National Grid, 2018. *Data Item Explorer*. http://mip-prod-web.azurewebsites.net/DataItemExplorer/Index. Sourced on 29 March 2018. Data for Q1 2018 covers January 1 to March 27 2018.

[85] Reuters, 2 June 2015, 'UPDATE 1-Russia's Novatek signs LNG supply contract with France's Engie'.

[86] UK Parliament, 2018. Salisbury incident: Further update. *House of Commons Record (Hansard)*, Volume 637, 14 March. https://hansard.parliament.uk/Commons/2018-03-14/debates/071C37BB-DF8F-4836-88CA-66AB74369BC1/SalisburyIncidentFurtherUpdate. Sourced on 20 March 2018.

[87] Centrica, 2006. *Overview of Centrica storage*. Presentation, 26 October. https://www.centrica.com/sites/default/files/20061026_csloverview_presentation.pdf. Sourced on 19 March 2018. See page 20.

sites in the UK in November 2017, with a combined gas storage capacity of 1.4 bcm, and a combined daily send-out capacity of 120.8 mmcm.[88]

Rough was the UK's only large-scale, seasonal storage facility. National Grid and UK government reports refer to such storage facilities as 'long-range'.[89] These long-range facilities are designed to be filled in the summer and drawn upon over a period of several months during winter. By contrast, 'medium-range' facilities have smaller-capacities. They are also referred to as 'multi-cycle' storage facilities, because they can undergo several 'cycles' of injections and withdrawals during a single season.[90] The UK's last short-range storage facility, at Avonmouth, closed in April 2016.[91] The Avonmouth facility was the last of five previously owned by National Grid, which had operated by taking gas from the gas pipeline system, converting it into LNG, storing it, and then re-gasifying it for injection back into the system when it was needed during periods of peak demand. Of the five short-range facilities, four were closed and the Isle of Grain was converted into an LNG import terminal.[92]

With domestic UK gas production relatively stable throughout the year, and demand fluctuating strongly between summer and winter, long-term, seasonal gas storage was designed to absorb excess gas supplies in the summer, and make them available in the winter to cope with increased demand. By contrast, the medium-term, multi-cycle storage facilities are used to provide short-term flexibility in supplies, which can smooth out some of the worst potential price spikes. This is achieved by 'topping up' the storage with LNG deliveries, drawing down the storage volume, and topping up again with further LNG deliveries, with this cycle repeated throughout the winter. Finally, the UK's three LNG terminals have their own storage facilities, which hold smaller volumes still, ready for injection to the grid.

The loss of the Rough storage facility means that the UK is now more dependent on additional imports to meet short-term demand spikes, particularly during the winter. Specifically, this means additional pipeline imports from continental Europe via the two interconnectors, and (particularly) additional LNG imports from an increasingly flexible spot market. As Le Fevre notes, the use of additional LNG supplies to repeatedly top up medium-term storage facilities can be characterised as the UK gas market version of Grimm's 'Magic Porridge Pot'.[93]

It is precisely this need for spot LNG cargoes in times of increased demand that attracted Russian LNG cargoes to the UK in February and March 2018, along with the cargo from the US. The fact that the UK gas import model, in the post-Rough period, will be based on increased flexibility means that we should expect more such cargoes during times of peak demand, whether from Russia or elsewhere.

A second key element in the functioning of the 'just in time' gas import model – in partnership with the multi-cycle gas storage infrastructure – is the ability of the liquid UK gas market to attract cargoes when they are needed. Specifically, the ability of the UK gas trading hub - the National Balancing Point (NBP) - to offer pricing signals that attract cargoes through price increases in times of high demand, thus preventing ongoing physical shortages.

This model was seen in action between February 22 and March 2, 2018, when day-ahead prices on the NBP broke through $8.50/million British thermal units (mmbtu), and briefly peaked at $31.58/mmbtu

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[88] National Grid, 2017. *Gas Ten Year Statement 2017*. https://www.nationalgrid.com/sites/default/files/documents/GTYS%202017_3.pdf. Sourced on 19 March 2018. See page 149.

[89] Ibid. See page 46, 47, 160, and 162.

[90] Le Fevre, C., 2013. *Gas storage in Great Britain.* NG 72, OIES, https://www.oxfordenergy.org/wpcms/wp-content/uploads/2013/01/NG-72.pdf. Sourced on 20 March 2018. See page 4.

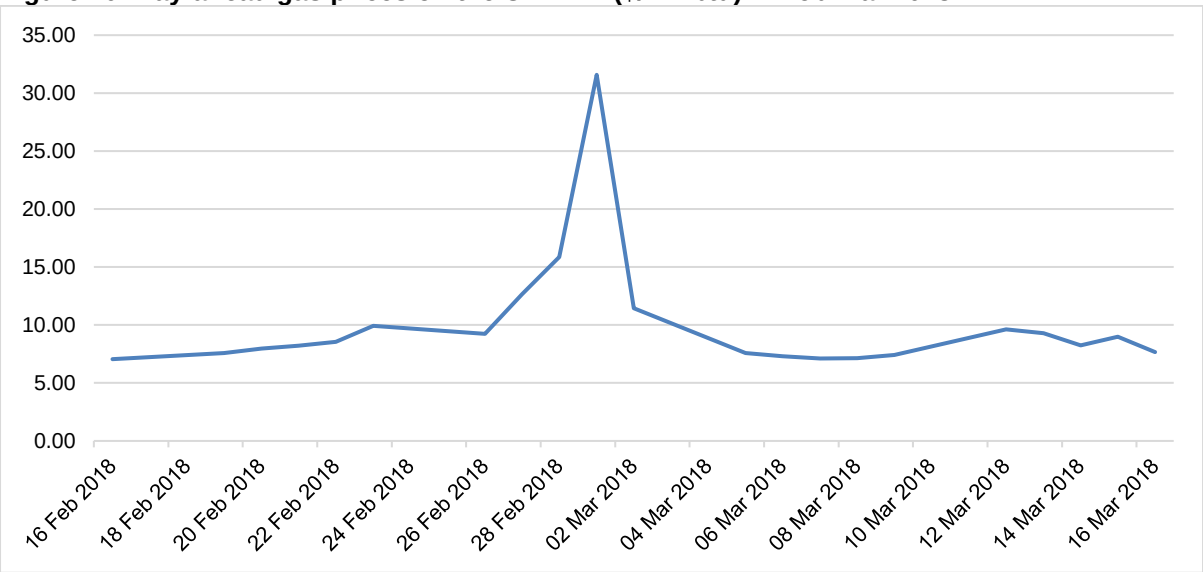
[91] Reuters, 29 Feb 2016, 'UK's Avonmouth LNG storage site to stop operations on April 30'.

[92] Ofgem, 2013. *Avonmouth liquefied natural gas facility price review: final proposals*. https://www.ofgem.gov.uk/sites/default/files/docs/2013/01/130131_avonmouthlngreview_finalproposals_0.pdf. Sourced on 27 March 2018. See page 6.

[93] Le Fevre, C., 2017. *UK Storage encounters a Rough patch.* Oxford Energy Comment, OIES, https://www.oxfordenergy.org/wpcms/wp-content/uploads/2017/05/UK-Storage-encounters-a-Rough-patch.pdf. Sourced on 20 March 2018. See page 2: Grimm's Magic Porridge Pot is a pot that produces endless supplies of porridge.

on March 1 (Fig.20). The price spike was triggered by a combination of factors, including unplanned outages affecting the South Hook LNG import facility, UK gas production assets, and pipeline connections with Norway, while temperatures significantly below the seasonal norm in both the UK and continental Europe triggered higher-than-usual gas demand, making it difficult for the UK to attract pipeline imports through the continental interconnectors. This led National Grid to issue a natural gas deficit warning on March 1.[94]

Figure 20: Day-ahead gas prices on the UK NBP ($/mmbtu) in Feb-Mar 2018



Source: Data from Argus Direct[95]

To cope with increased demand, volumes of LNG stored in tanks at the UK's three LNG terminals were released into the UK gas transmission system, and those storage tanks were then re-filled by LNG volumes that were purchased on the spot market and received during March. The spike in the price of gas on the NBP played a crucial role in attracted those spot LNG supplies.[96]

This example highlights the importance of multi-cycle storage, continental interconnectors and flexible LNG imports for the post-Rough UK gas market. It also highlights the possibility of increased price volatility in times of peak demand, as the UK will exhibit a greater exposure to price dynamics on the European market as a substitute for the lost 'smoothing' effects of seasonal gas storage. Indeed, this is the approach taken by the UK government, as stated in the October 2017 Security of Gas Supply report issued by the UK Department for Business, Energy, and Industrial Strategy:

> GB storage does not operate as a 'strategic reserve' of gas – providing a large volume of gas to be used in case of an emergency but otherwise not utilised. Instead, the value of storage lies in its ability to operate flexibly in response to relatively short-term price signals and ultimately reduce price volatility… In particular, seasonal spreads have declined significantly. While short range volatility may improve in the medium term, bringing on new short-range gas storage, the increased diversity of gas sources throughout the year makes it unlikely that high seasonal volatility will return.[97]

[94] Platts, 1 March 2018, 'UK National Grid issues natural gas deficit warning for Mar 1'.
[95] Argus Direct, 2018. *Prices and data.* Sourced on 19 March 2018.
[96] Froley, A., 2018. High UK prices bring spot cargoes. *ICIS LNG Markets Analysis*, 5 March.
[97] UK Government, 2017. *Gas security of supply: A strategic assessment of Great Britain's gas security of supply*. Dept. for Business, Energy, and Industrial Strategy. https://www.gov.uk/government/publications/gas-security-of-supply-strategic-assessment-and-review. Sourced on 19 March 2018. See page 14.

Conclusions

Compared to its European neighbours, the UK finds itself in a relatively fortunate position in terms of its energy production and consumption. The decline in coal production and consumption are running in parallel, with coal-based power generation being replaced by growing electricity generation from wind, solar, and bioenergy sources. The volume of electricity production from nuclear power is stable, but remains controversial with regard to longer-term plans for the sector. This leaves natural gas as the main source of UK power generation at present, and it has also experienced growth at the expense of coal. Natural gas is also by far the most widely-used source of heat generation, both on an industrial scale and in UK households. Given the shares of natural gas in heat and power generation, and final energy consumption across all non-transport sectors in the UK, its importance cannot be overstated.

In the medium term, the UK Oil and Gas Authority forecasts UK natural gas demand to decline more rapidly than production between 2017 and 2022 (thus reducing net imports), but for the gap to open up thereafter, leading to a long-term rise in import dependency. However, much will depend on both the profitability of gas production in the UK North Sea as a factor in gas production and the impact of prices on UK gas demand. In the period to 2025 (and possibly sooner), the shut-down of the UK's remaining coal-fired power plants offers some potential for a further rise in gas demand for power generation, but only in competition with growing power generation from renewable and bioenergy sources, and in a broader context of declining or stable UK power demand. Although the UK government has a long-term plan to 'decarbonise' heat generation in the UK, this is unlikely to have a substantial impact on UK gas consumption for space heating before 2030, given the sheer dominance of natural gas in the provision of space heating in the residential, commercial, and public service sectors, and the challenges of decarbonising the gas value chain or replacing gas infrastructure with electric heating systems.

With the UK dependent on imports to meet almost half of its natural gas demand, it is important to consider the source of those imports. At present, Norway provides three-quarters of total UK gas imports, and volumes equivalent to 99% of UK net gas imports. The difference between total and net UK gas imports is accounted for by UK gas exports to the Republic of Ireland and net exports to Belgium via the Interconnector, while net gas imports from the Netherlands have dwindled to virtually zero and UK LNG imports in 2017 reached their lowest level since 2008.

In this context, the purchase and re-sale of natural gas by Gazprom Marketing & Trading, sourced either from production on the Norwegian continental shelf or on European gas hubs, does not signal any substantial UK dependence on 'Russian' gas. Likewise, given the volume of pipeline imports from Norway and the year-round dominance of Qatar in UK LNG imports, the arrival of several Russian LNG cargoes in the UK (among cargoes from Norway, Qatar and the US) during a period of peak demand also does not point to any meaningful UK dependence on Russian gas.

However, the closure of the Rough gas storage facility, which deprived the UK of its only large-volume, seasonal gas storage, has left the UK more exposed to price spikes on the continental European market, from which UK gas traders will seek to acquire gas during short-term peaks in UK gas demand. It has also left the UK in greater need of LNG deliveries during winter, to replenish multi-cycle storage facilities, which may be drawn down and refilled several times during a single winter season. This means that the price spikes on the NBP are now part of the system – They are needed to attract spot market supplies of LNG at the times of high demand. Indeed, if the NBP price spikes had not attracted LNG deliveries to replenish storage tanks at the UK's LNG terminals, and the period of both cold weather and consequent increased UK gas demand had continued, the UK could have faced a more severe gas shortage. The notion that 'the system works' because the UK is able to attract LNG supplies from the international spot market is predicated on those LNG supplies being available on the first place. However, the availability of spot market LNG supplies is related to patterns of supply and demand on the global LNG market, and the price spreads between Europe and the Asian market, where the latter has traditionally commanded a price premium and has therefore attracted LNG supplies away from Europe in periods of market tightness.

How important is Russia?

The deterioration in diplomatic relations between the UK and Russia in the spring of 2018 coincided with the arrival of several cargoes of LNG that originated at the Russian Yamal LNG project. This triggered debates over the UK's 'dependence' on Russian energy sources. As this paper has demonstrated, these fears of over-dependence on Russia are misplaced. While Russia supplied approximately half the UK's steam coal imports and one-third of UK coking coal imports in 2017 (Figs.11 & 12), the share of steam coal in UK power generation has already dwindled to low levels and is likely to be phased out entirely by 2025. Russia supplied around 7% of crude oil and 13% of refined oil products imported to the UK in 2016, with reliable supplies of crude oil available from Norway and refined products being sourced from a variety of suppliers on the global market (Figs.13 & 14).

With regard to natural gas, a combination of pipeline supplies from Norway and LNG supplies from Qatar account for the vast majority of UK imports. While Russia is by far the largest supplier of natural gas to the EU, any gas molecules imported to the UK via the interconnectors with the Netherlands and Belgium are likely to be a mixture of Dutch, Norwegian, and Russian gas. More importantly, such gas could be supplied by any number of gas traders operating on European hubs. In this market context, concern about whether European gas traders supplying the UK with volumes that contain a percentage of gas produced in Russia, or Russian gas traders (such as Gazprom Marketing & Trading) supplying gas produced on the Norwegian continental shelf or purchased on European hubs, poses a threat to UK energy security is completely misplaced.

The greater challenge for UK energy security – as demonstrated by the price spike of March 1 2018 – is the exposure of the UK to such price fluctuations, given the crucial role played by natural gas in heating, power generation, and final energy consumption across all non-transportation sectors of the UK. These price fluctuations could be caused by any interruptions in UK gas supplies, whether those interruptions are unscheduled outages in production in the UK or Norway, or disruptions to UK pipeline or LNG imports, including 'Russian' pipeline or LNG supplies being re-exported to the UK from neighbouring European countries. Furthermore, the close pricing relationship between the gas trading hubs of the UK and north-west Europe (particularly the TTF) suggests that any interruption in physical flows to the European market (including Russian pipeline flows), would precipitate a price spike on European hubs that would feed through to the NBP. Furthermore, any gas supply risks faced by the UK may increase after Brexit, if the UK is no longer part of the gas-sharing mechanisms mandated by the EU Security of Gas Supply Regulation as a response to regional gas shortages. Finally, any additional trade barriers created by Brexit could hamper the ability of UK gas traders to source gas from the hubs of north-west Europe at times when it is needed to balance UK supply and demand.[98] [99]

To conclude, the greatest challenge to UK security of gas supplies in the medium-term future (to 2022) is not posed by UK dependence on Russian gas imports. Rather, it stems from the UK's increasing exposure to price volatility on the European gas market, in the context of the UK's increasing import dependence and loss of large-scale gas storage, which has left the UK increasingly reliant on a combination of limited-volume, multi-cycle gas storage and 'balancing' supplies in the form of spot-market LNG purchases and supplies from the continental European market (delivered via the two interconnectors). The prominent role of Russia in supplying gas to the European market renders it a factor in UK gas supply security, to the extent that the UK and European gas markets are inter-linked, both through the physical interconnectors and through competition for LNG deliveries that supplement pipeline supplies in times of high demand, including LNG supplies that originate in Russia.

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[98] Bros, T., 2017. *Brexit's impact on gas markets: Brexit and security of supply for the UK and Ireland*. UOIES, Energy Insight 2. https://www.oxfordenergy.org/publications/brexits-impact-gas-markets-brext-security-supply-uk-ireland/. Sourced on 22 March 2018.

[99] Bradshaw, M., 2017. *Future UK gas security: upstream security of supply*. Warwick Business School/UK Energy Research Council. http://www.ukerc.ac.uk/publications/future-uk-gas-security-upstream-security-of-supply.html. Sourced on 22 March 2018.