Physical gas flows across Europe and diversity of gas supply in 2016

Background

This article has two purposes. The first is to help illustrate gas flows through Europe using 2016[1] data published by the International Energy Agency (IEA). The second is to compare the resilience of the UK's supply infrastructure with that of other EU Member States using a metric that accounts for the diversity of gas supply.

European Physical Gas Flows

European Gas Production

The total EU-28 gas production in 2016 was 133.9 billion cubic metres (bcm), with the Netherlands and the UK accounting for 38 per cent and 31 per cent of this total respectively. This is 3.3 per cent lower than EU-28 production in 2015 which was 138.5 bcm. Out of all EU-28 countries, only the Netherlands and Denmark produced more gas than they consumed, demonstrating Europe's reliance on gas imports from outside the EU.

European Gas Consumption

The highest demand among EU-28 countries came from Germany, the United Kingdom and Italy. Similar to 2015, these countries together accounted for around 46 per cent of EU-28 consumption. Germany remained the largest net importer in Europe in 2016 at 79 bcm, followed by Italy at 43 bcm and then France at 39 bcm[2]. Overall EU-28 net imports increased by 9% compared to 2015.

Natural gas consumption[3] in the EU-28 increased in 2016 compared to 2015, from 445 bcm to 465 bcm. The majority of EU countries saw a rise in gas demand with France and Italy contributing most significantly to this increase.

Sources of Gas

The flow of physical gas throughout Europe is closely inter-related with disruptions in one part of the network having the ability to spread elsewhere, as witnessed in November of this year with the disruption of gas flows following the explosion at the Baumgarten Hub in Austria. However, this interconnectedness is also strength with countries able to avail themselves of multiple ways of obtaining gas.

There are four sources of gas supply available to EU Member States: indigenous production, imports via Liquefied Natural Gas (LNG) terminal, imports via pipeline and prior gas production/imports held in storage facilities. There is the potential for multiple sources within each of these categories.

The largest single category of gas supply to the EU-28 was indigenous production, supplying 29 per cent of EU-28 consumption in 2016. A total of 18 countries have at least some indigenous gas production with the largest being from the Netherlands and UK which met 11 and 9 per cent of total EU demand respectively.

Aside from indigenous production, Russia remained the single supplier of gas to the EU-28, delivering around 132 bcm in 2016 compared to 130 bcm in 2015. This accounted for 28 and 29

1 January 1st 2016 to December 31st 2016 data

2 These numbers differ slightly from the IEA's annual figures due to the adjustments necessary to balance supply. The supply for some countries may appear unbalanced as stock changes are not shown. Data were calculated primarily from 2016 monthly pipeline gas flows, with 2016 annual imports, exports, production and consumption used for quality assurance amendments.

3 Natural gas consumption has been calculated using 2016 monthly pipeline gas flows and production data from the IEA and may differ from the observed consumption figures quoted in the 2016 annual gas information provided by the IEA. See Annex 3 for statistical differences between these figures.

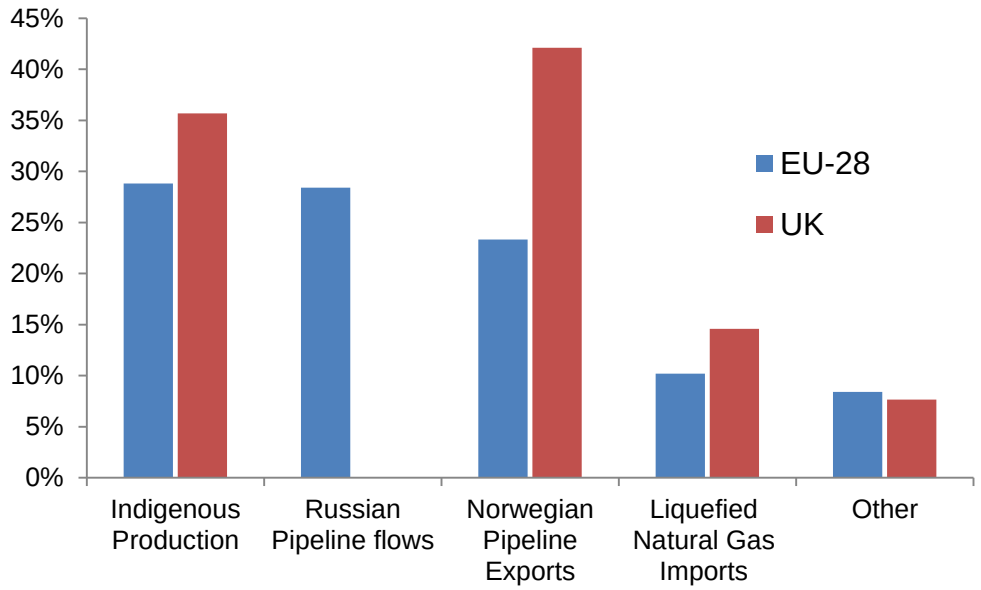
per cent of total EU-28 gas demand in 2016 and 2015 respectively. The European pipeline infrastructure means that Central and Eastern European countries receive almost all of their natural gas supply from Russia. It should be noted that the origin of all of this gas is not necessarily Russian, since Russia acts as a transit country for gas from Kazakhstan and Turkmenistan to reach European markets.

Norwegian pipeline exports to the EU-28 remained steady between 2015 and 2016. In 2016 pipeline exports were around 108 bcm, making up 23 per cent of total EU-28 gas consumption compared to 108 bcm (24 per cent) in 2015. An observed fall in exports to Germany was offset by an increase in exports to the UK; 30 per cent of Norwegian exports were directed to the UK in 2015. In addition to pipeline exports, Norway exported 4 bcm of LNG.

North African pipelines via Spain and Italy provided 39 bcm, or 8 per cent, of EU-28 demand. Algerian gas, coming direct from Algeria as well as via Morocco and Tunisia, accounted for 88 per cent of North African gas delivered to the EU-28, with Libya supplying the remainder.

EU-28 imports of LNG were 47.5 bcm in 2016 versus 47.2 bcm in 2015. LNG met 10 per cent of EU-28 demand. The largest suppliers of LNG to the EU-28 were Qatar, Algeria and Nigeria, who supplied 46, 23 and 16 per cent of total EU-28 LNG imports respectively.

Chart 1: Sources of all EU-28 and UK gas, 2016



UK Physical Gas Flows

UK consumption in 2016 was 81.5 bcm, up from 72.4 in 2015. Around 51 per cent of this was met by indigenous production in 2016, up compared to 2015 where 56 per cent was met by indigenous production. The rest were met by LNG imports and pipeline imports from Norway, Netherlands and Belgium.

Norway and Netherlands accounted for 85 per cent and 12 per cent of pipeline imports respectively, whilst the small remainder came from Belgium. The UK also exported 13.8 bcm through pipelines to Belgium (63 per cent), Ireland (21 per cent), Netherlands (16 per cent) and Isle of Man (1 per cent).

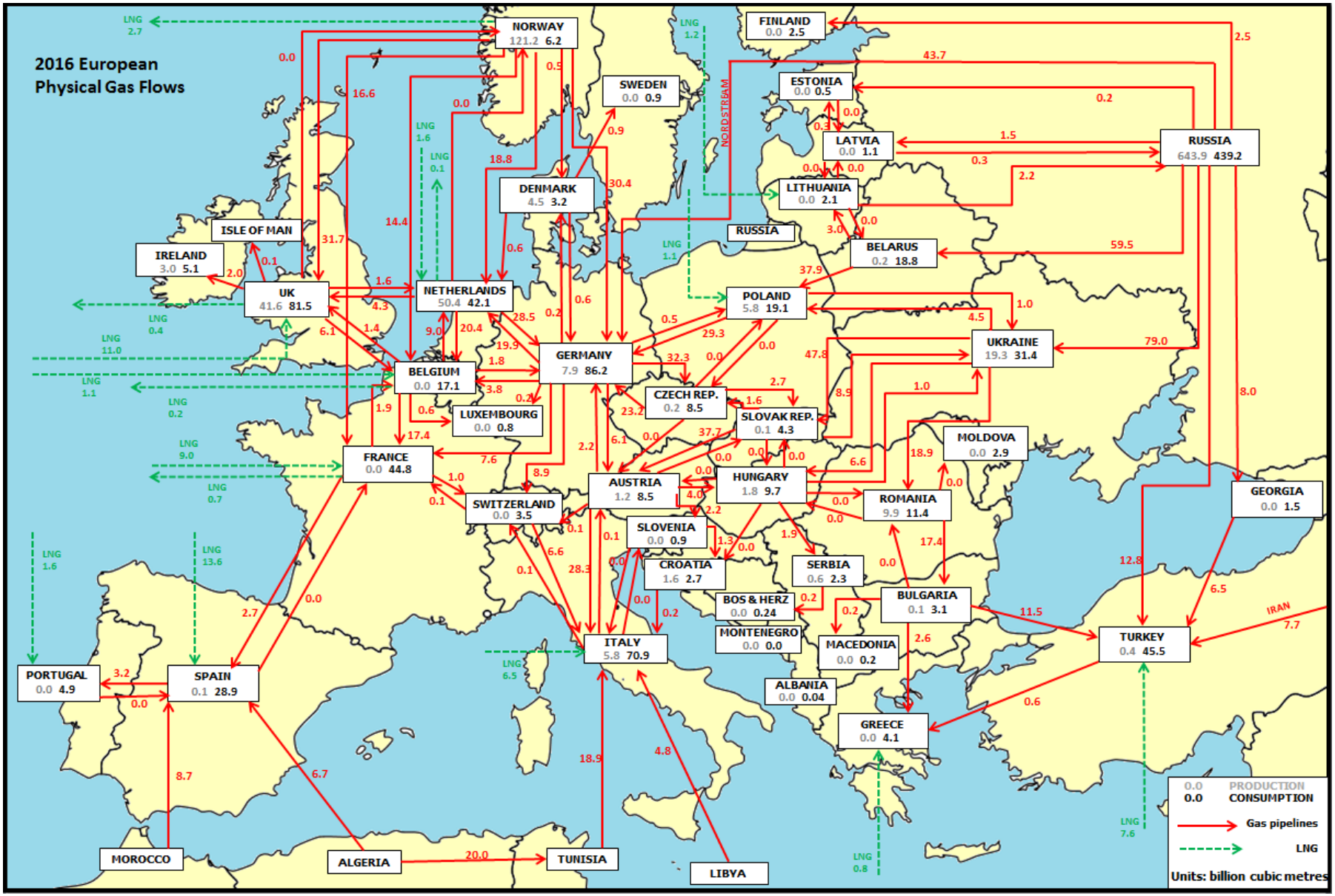
UK imports of LNG fell by 23 per cent, from 13.9 bcm in 2015 to 10.6 bcm in 2015 making the UK the second largest importer of LNG in 2016 within EU-28, with only Spain importing more. Ninety-five per cent of UK imports of LNG came from Qatar in 2016, remaining consistent with import levels in 2015 and 2014.

Note

The map below uses pipeline data from the IEA to show entry and exit flows between countries and does not necessarily indicate that the gas actually passed through the domestic infrastructure of a country (for instance: Russian gas is transmitted to Turkey through Bulgaria but is separate to the Bulgarian domestic network).

Further data

For readers wanting a greater level of detail, the IEA have made available an interactive gas map, based on entry and exit points throughout Europe. This map is available free of charge at: www.iea.org/gtf/index.asp


2016 European
Physical Gas Flows
NORWAY
121.2 6.2
SWEDEN
0.0 0.9
FINLAND
0.0 2.5
ESTONIA
0.0 0.5
LATVIA
0.0 1.1
LITHUANIA
0.0 2.1
RUSSIA
643.9 439.2
DENMARK
4.5 3.2
ISLE OF MAN
IRELAND
3.0 5.1
UK
41.6 81.5
NETHERLANDS
50.4 42.1
BELGIUM
0.0 17.1
LUXEMBOURG
0.0 0.8
GERMANY
7.9 86.2
POLAND
5.8 19.1
CZECH REP.
0.2 8.5
SLOVAK REP.
0.1 4.3
UKRAINE
19.3 31.4
MOLDOVA
0.0 2.9
FRANCE
0.0 44.8
AUSTRIA
1.2 8.5
HUNGARY
1.8 9.7
SWITZERLAND
0.0 3.5
SLOVENIA
0.0 0.9
CROATIA
1.6 2.7
SERBIA
0.6 2.3
ROMANIA
9.9 11.4
BULGARIA
0.1 3.1
BOS & HERZ
0.0 0.24
MONTENEGRO
0.0 0.0
MACEDONIA
0.0 0.2
ALBANIA
0.0 0.04
GREECE
0.0 4.1
TURKEY
0.4 45.5
GEORGIA
0.0 1.5
ITALY
5.8 70.9
PORTUGAL
0.0 4.9
SPAIN
0.1 28.9
MOROCCO
ALGERIA
TUNISIA
LIBYA
RUSSIA
BELARUS
0.2 18.8
NORDSTREAM
IRAN
LNG
0.0 PRODUCTION
0.0 CONSUMPTION
Gas pipelines
LNG
Units: billion cubic metres

EU-28 Infrastructure peak daily gas supply in 2016

As noted above, there are four sources of gas supply available to EU Member States: indigenous production, imports via Liquefied Natural Gas (LNG) terminal, imports via pipeline and prior gas production/imports held in storage facilities. There is the potential for multiple sources within each of these categories. We have used the peak flow (i.e. the maximum gas deliverable in billion cubic metres per day) as a comparative measure of gas supply for each individual source for each country. For pipeline and LNG terminal, peak flow data were extracted from IEA physical gas flows data[4]. Similarly, peak outputs for storage facilities were extracted from the IEA Natural Gas Information 2017[5]. Storage facilities are assumed to be capable of working at peak capacity during times of peak demand. Although this is susceptible to inaccuracies, because peak capacity from storage facilities may not be achievable by the point of peak demand in EU member states, it does allow a consistent metric across all storage facilities. Data for peak outputs for production was estimated by taking the maximum monthly production (bcm) in 2016 for each gas-producing member state and dividing this by the number of days in that month.

Chart 2 shows peak gas supply for each individual country as a stacked bar chart, with different colours representing different categories of gas supply. Stacks have been arranged with production and storage facilities shown at the base of the chart and imports via LNG terminals and pipelines shown above. Further, for these imports and storage sources, data were divided within categories by individual source (represented by horizontal lines within an individual bar colour). Please note these data were collected from a range of sources and we have not confirmed each of the data items with the countries who submit data to the IEA.

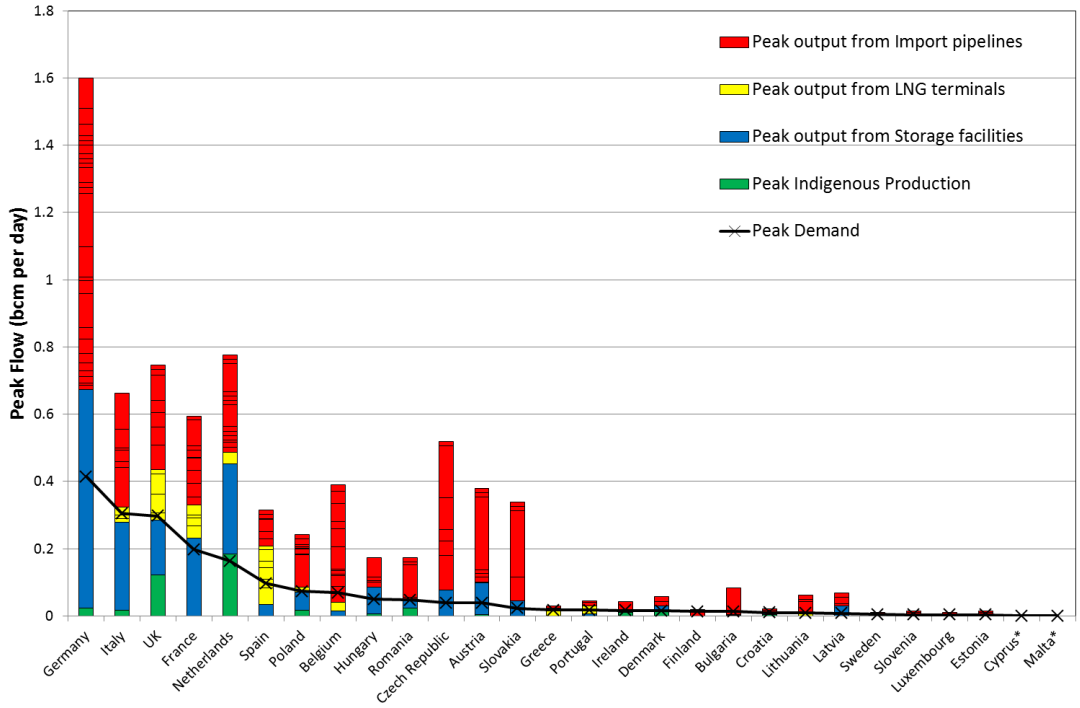
Chart 2 includes all EU-28 member states in order of peak gas demand. Estimated peak gas demand data (bcm per day) are shown by the single line-and-cross plot running across the graph. Peak gas demand acts as a comparator for peak gas supply, and was estimated for each country by taking the maximum monthly demand in 2016 (bcm) divided by the number of days within that month. Whilst this is a conservative estimate, it does allow for a common metric for comparison. Data for peak flows are provided in the table in Annex 1.

Chart 2 illustrates that in all EU countries where data were available, maximum gas supply exceeded peak demand. According to the data, Germany had the highest peak demand in 2016, but also had the largest potential peak output from both indigenous storage facilities and import pipelines. The data indicated that only the Netherlands had sufficient indigenous production capacities to meet peak daily demand. The majority of countries had a peak supply more than double that of peak demand, with the exception of Finland and Greece.

The UK had the third largest peak demand of the EU member states after Germany and Italy

[4] www.iea.org/gtf/index.asp
[5] Natural Gas Information 2017, International Energy Agency, ISBN 978-92-64-27814-1

Chart 2: Estimated Peak outputs for gas supply sources versus estimated peak demand for EU-28 Member States



Source: BEIS analysis of IEA data. *Cyprus and Malta have no consumption and are included for completeness only. For import data, stacks are further divided by number/volume of pipelines/terminals. Data are provided in Table in Annex 1.

Looking at the pipeline import data in Chart 2 (red stacks), it is clear that the five member states with the largest peak demand have a diverse range of import pipelines. Germany in particular has a large number of import pipelines, 26 in total. There are substantially fewer import pipelines in EU countries east of Germany. Of particular note, the Slovak Republic appeared to have a peak supply that far exceeded demand, where almost all of this came via a single pipeline from Russia, which has pipelines transiting through to several other member states.

Aside from Spain (seven), the UK and Italy (four), France (three) and Sweden (two) all other member states had at most a single LNG terminal.

EU-28 Gas Infrastructure Resilience 2016

In order to given an indication of the resilience of the gas supply infrastructure, we have developed a simple methodology that takes the sum of all gas supplies coming into a country running at maximum capacity (*PF*, peak flow), removes the largest supply route, and looks at the remaining percentage supply relative to peak demand. The equation below indicates PF as

$$PF - 1[\%] = \frac{EP_{max} + P_{max} + S_{max} + LNG_{max} - I_{max}}{D_{max}} \qquad \text{Equation 1}$$

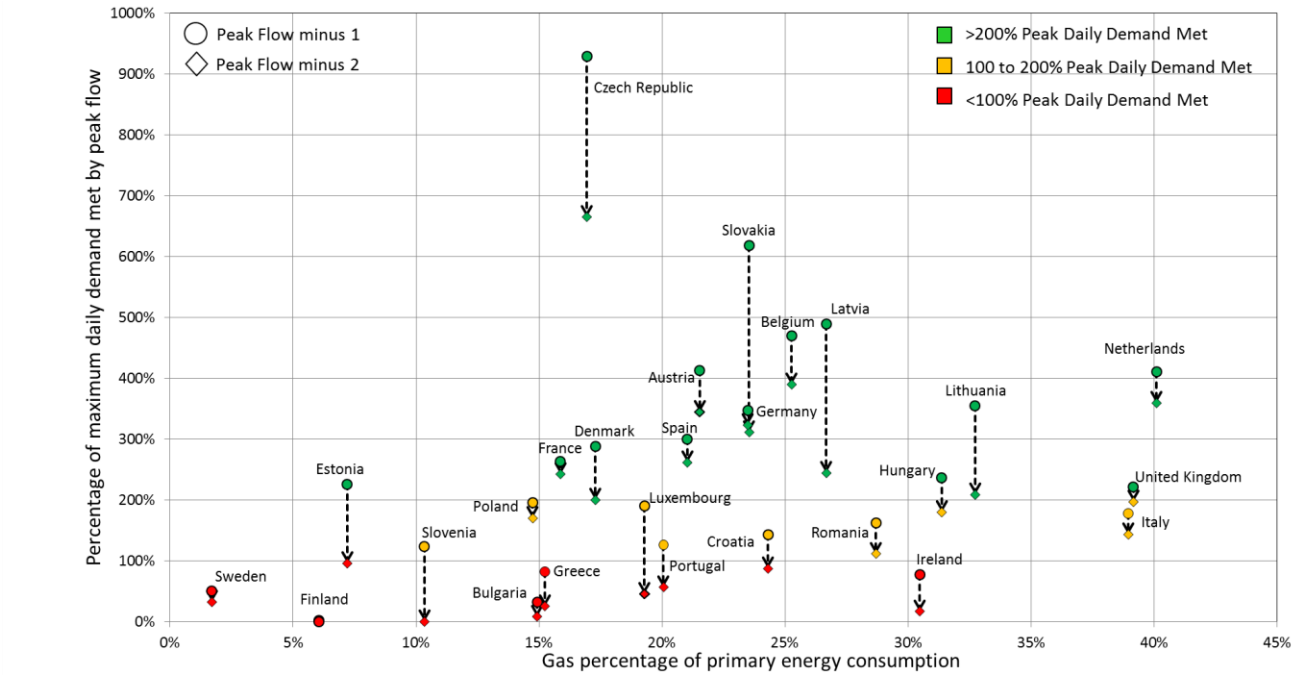
Where:

PF = Peak Flow (bcm/day)
EP_{max} = Peak capacity of entry points (bcm/day)
P_{max} = Peak capacity for each indigenous production pipeline (bcm/day)
S_{max} = Peak output for each storage facility (bcm/day)
LNG_{max} = Peak output for each LNG terminal (bcm/day)
D_{max} = Average 2013 peak gas demand (bcm/day)
I_{max} = Peak daily capacity of single largest supply route (bcm/day)

This formula is similar to a more widely used metric - the 'N-1' measure of supply outlined in the EU Regulation No. 994/2010 - but differs to that due to both the historical nature of the data used here and the definition of demand. In the EU regulation, peak demand (D_{max}) is defined as the total daily gas demand of the country during a day of exceptionally high gas demand occurring with a statistical probability of once in 20 years. In this report, because we are calculating resilience for 2016, we use the estimated peak gas demand in each country for 2016 (January 1st 2016 to December 31st 2016), taking the maximum monthly demand in 2016 (bcm) and dividing this by the number of days within that month. Beyond *PF*-1, *PF*-2 was also calculated using the same methodology but removing the two largest supply routes as a more rigorous test of infrastructure resilience.

As well as considering infrastructure resilience, it is also important to consider the extent to which each EU-28 country relies on gas to meet its primary energy demand. If the *PF*-1 score is less than 100 per cent, it could have considerable consequences for a country that relies on gas for a large proportion of its primary energy demand, compared to a lesser extent for a country that mainly uses other energy sources. We therefore plotted out *PF*-1 and *PF*-2 against the percentage of total primary energy demand met by gas for each EU Member State (Chart 3).

Chart 3: EU-28* gas infrastructure resilience versus percentage of primary energy consumption met by gas, 2016



*Data for Cyprus and Malta not available. Peak flow minus 1 = total gas supply capacity minus largest gas supply route (*PF*-1). Peak flow minus 2 = total gas supply capacity minus two largest gas supply routes (*PF*-2). For each member state, top circle represents *PF*-1 and bottom diamond represents *PF*-2. Red-amber-green are illustrative, and do not reflect any pre-defined or standard resilience metric.

Chart 3 shows France, Czech Republic, Denmark, Austria, Spain, Germany, Slovakia, Latvia, Belgium and the Netherlands to have particularly resilient gas infrastructure. In all nine countries, the gas infrastructure was able to provide more than double the estimated –if conservative - peak gas demand in 2016, even with the loss of their two largest gas supply routes. Finland, Sweden, Ireland, Bulgaria and Greece appear particularly vulnerable to infrastructure disruptions, with these five countries unable to meet peak daily demand after the loss of the largest gas supply route. Sweden and Finland use very little gas however in Ireland gas accounts for nearly 30 per cent of primary energy demand. Ireland's indigenous

gas production has increased significantly due to production at the Corrib gas field. PF-1 Scores increased from 23 per cent in 2015 to 78 per cent in 2016 leaving Ireland more resilient than in previous years.

Including both *PF*-1 and *PF*-2 scores in Chart 2 gives further insight into infrastructure resilience which would not be captured by the *PF*-1 score alone. For example, the data indicate that Slovenia clearly has two major import routes. Although resilient to a single supply disruption (meeting 124 per cent of peak demand), Slovenia would be vulnerable after the loss of these two main routes. This is also the case for Portugal, Croatia and Luxembourg.

UK gas infrastructure resilience 2016

From the UK perspective there are a diverse range of gas sources including pipeline and LNG imports, storage and indigenous production, with good resilience to disruption of major supply sources. According to these data in 2016 the UK would have met 222 and 197 per cent of the estimated peak demand with the loss of the largest and two largest gas supply routes respectively. Overall, according to *PF-2* scores, the UK was the eleventh most resilient Member State to gas supply infrastructure disruptions, but it was the second most dependent on gas for primary energy demand in 2016. The planned closure of the Rough facility, the largest gas storage facility in the UK, highlights the importance of maintaining a resilient gas supply due to the reduction of gas reserves that can be drawn from in the event of UK gas infrastructure disruption.

EU regulations, enforcing that all Member States must have an *N*-1 score of greater than 100 per cent (using the larger value of peak gas demand based on a statistical probability of once in 20 years) came into force from 3rd December 2014. Given the similarity between the EU *N*-1 methodology and the *PF*-1 methodology used here, the UK remains well-placed to meet this requirement.

For further information on European natural gas flows please contact:

Benjamin Lucking
Oil and Gas Statistics Team
Tel. 020 7215 5010
E-mail: benjamin.lucking@beis.gov.uk

Tavey Jerrard
Oil and Gas Statistics Team
Tel. 0300 068 5053
E-mail: tavey.jerrard@beis.gov.uk

Annex 1: Table of key data for gas use in the EU-28* countries, 2016

	Peak daily [X] (Billion cubic metres per day)								
EU-28 MS	**Demand ****	**Indigenous production ****	**Import pipelines**	**Storage output**	**LNG out-put**	***PF*-1 score**	***PF*-2 score**	**Natural Gas Consumption (Mtoe)**	**Total Primary Energy Consumption (Mtoe)**
Austria	0.039	0.004	0.281	0.094	0.000	413%	344%	7.2	33.3
Belgium	0.069	0.000	0.349	0.015	0.026	470%	390%	14.3	56.5
Bulgaria	0.013	0.001	0.078	0.003	0.000	32%	9%	2.7	18.1
Croatia	0.010	0.004	0.012	0.006	0.000	143%	87%	2.2	9.1
Cyprus*	0.000	0.000	0.000	0.000	0.000	0%	0%	0.0	2.5
Czech Republic	0.039	0.001	0.442	0.076	0.000	929%	665%	7.0	41.4
Denmark	0.015	0.014	0.028	0.016	0.000	288%	200%	2.9	16.5
Estonia	0.003	0.000	0.014	0.000	0.000	226%	96%	0.4	6.0
Finland	0.013	0.000	0.019	0.000	0.000	2%	0%	2.1	33.9
France	0.197	0.000	0.265	0.231	0.099	263%	243%	38.3	241.2
Germany	0.415	0.022	0.926	0.652	0.000	347%	323%	73.2	311.5
Greece	0.018	0.000	0.015	0.000	0.014	82%	26%	3.5	22.9
Hungary	0.049	0.005	0.088	0.080	0.000	237%	180%	8.0	25.6
Ireland	0.016	0.010	0.030	0.003	0.000	78%	17%	4.2	13.8
Italy	0.304	0.017	0.339	0.262	0.043	178%	143%	58.1	149.0
Latvia	0.008	0.000	0.038	0.030	0.000	489%	244%	1.1	4.2
Lithuania	0.009	0.000	0.050	0.000	0.011	355%	209%	1.8	5.5
Luxembourg	0.003	0.000	0.011	0.000	0.000	190%	46%	0.7	3.7
Malta*	0.000	0.000	0.000	0.000	0.000	0%	0%	0.0	2.3
Netherlands	0.163	0.184	0.289	0.268	0.035	411%	359%	30.2	75.2
Poland	0.074	0.017	0.157	0.054	0.014	196%	170%	14.6	99.2
Portugal	0.017	0.000	0.015	0.007	0.022	126%	57%	4.3	21.4
Romania	0.047	0.024	0.122	0.027	0.000	162%	112%	9.5	33.1
Slovak Republic	0.023	0.000	0.292	0.045	0.000	618%	311%	3.9	16.5
Slovenia	0.004	0.000	0.015	0.000	0.000	124%	0%	0.7	6.8
Spain	0.097	0.000	0.108	0.034	0.199	300%	262%	25.0	119.0
Sweden	0.005	0.000	0.009	0.001	0.002	50%	32%	0.8	48.2
United Kingdom	**0.297**	**0.122**	**0.310**	**0.162**	**0.151**	**222%**	**197%**	**69.6**	**177.7**

Source: BEIS analysis of IEA data. *No data available for Cyprus and Malta **Calculated by peak month divided by number of days in that month.

Annex 2: Table of *PF*-1 and *PF*-2 values for EU-28* countries, 2016

EU-28 MS	PF (bcm/day)	PF-1 (bcm/day)	Nature of the largest supply source	PF-2 (bcm/day)	Nature of the second largest supply source
Austria	0.379	0.161	Import pipeline	0.134	Storage
Belgium	0.390	0.324	Import pipeline	0.269	Import pipeline
Bulgaria	0.082	0.004	Import pipeline	0.001	Storage
Croatia	0.022	0.015	Import pipeline	0.009	Storage
Cyprus*	0.000	0.000	-	0.000	-
Czech Republic	0.519	0.363	Import pipeline	0.260	Import pipeline
Denmark	0.058	0.043	Import pipeline	0.030	Import pipeline
Estonia	0.014	0.007	Import pipeline	0.003	Import pipeline
Finland	0.019	0.000†	Import pipeline	0.000	LNG
France	0.595	0.519	Import pipeline	0.479	Import pipeline
Germany	1.600	1.440	Import pipeline	1.340	Import pipeline
Greece	0.029	0.015	LNG	0.005	Import pipeline
Hungary	0.173	0.116	Import pipeline	0.088	Storage
Ireland	0.042	0.013	Import pipeline	0.003	Indigenous Production
Italy	0.662	0.542	Import pipeline	0.436	Import pipeline
Latvia	0.068	0.038	Storage	0.019	Import pipeline
Lithuania	0.062	0.030	Import pipeline	0.018	Import pipeline
Luxembourg	0.011	0.006	Import pipeline	0.001	Import pipeline
Malta*	0.000	0.000	-	0.000	-
Netherlands	0.775	0.670	Indigenous production	0.586	Import pipeline
Poland	0.242	0.144	Import pipeline	0.125	Storage
Portugal	0.044	0.022	LNG	0.010	Import pipeline
Romania	0.173	0.077	Import pipeline	0.053	Storage
Slovak Republic	0.338	0.140	Import pipeline	0.071	Import pipeline
Slovenia	0.015	0.004	Import pipeline	0.000	Import pipeline
Spain	0.341	0.292	LNG	0.254	Import pipeline
Sweden	0.011	0.003	Import pipeline	0.002	Storage
United Kingdom	**0.733**	**0.658**	**Import pipeline**	**0.584**	**Import pipeline**

Source: BEIS analysis of IEA data. *PF* = peak flow (defined in Equation 1 in report). *No data available for Cyprus and Malta.
†Finland PF-1 value too small for the number of decimal places shown.

Annex 3: Table of Statistical differences between observed and calculated consumption for EU-28* countries, 2016

EU-28 MS	Observed Consumption (bcm)	Calculated Consumption (bcm)	Statistical Difference (bcm)	Statistical Difference (Per cent)
Austria	8.7	8.5	0.3	3.2%
Belgium	17.4	17.1	0.3	1.7%
Bulgaria	3.2	3.1	0.1	3.5%
Croatia	2.7	2.7	0.0	-1.7%
Cyprus	0.0	0.0	0.0	0.0%
Czech Republic	8.5	8.5	0.0	0.0%
Denmark	3.2	3.2	0.0	1.0%
Estonia	0.5	0.5	0.0	0.3%
Finland	2.5	2.5	0.0	0.9%
France	43.2	44.8	-1.6	-3.6%
Germany	86.1	86.2	-0.1	-0.1%
Greece	4.1	4.1	0.0	-0.8%
Hungary	9.7	9.7	0.0	0.0%
Ireland	5.1	5.1	0.0	0.0%
Italy	70.9	70.9	0.0	0.0%
Latvia	1.4	1.1	0.3	22.3%
Lithuania	2.2	2.1	0.1	6.8%
Luxembourg	0.8	0.8	0.0	0.6%
Malta	0.0	0.0	0.0	0.0%
Netherlands	42.1	42.1	0.0	0.1%
Poland	19.1	19.1	0.1	0.3%
Portugal	5.1	4.9	0.2	4.2%
Romania	11.5	11.4	0.1	0.5%
Slovakia	4.7	4.3	0.4	9.0%
Slovenia	0.9	0.9	0.0	-3.4%
Spain	28.6	28.9	-0.3	-1.1%
Sweden	0.9	0.9	0.0	0.0%
United Kingdom	81.6	81.5	0.1	0.2%

Table shows differences between IEA observed consumption and calculated consumption based on pipeline import and export flows. As this article prioritises pipeline flows the data reported are calculated flows. Source: BEIS analysis of IEA data. *No data available for Cyprus and Malta.