Physical gas flows across Europe and diversity of gas supply in 2015

Background

This article has two purposes. The first is to help illustrate gas flows through Europe using 2015[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.

Key Points

- Natural gas consumption among EU-28 countries rose in 2015 by 5 per cent, from 430 billion cubic metres (bcm) to 445 bcm,
- Indigenous production among the EU-28 countries fell by nearly 10 per cent on 2014, due in part to production caps. Indigenous production is equivalent to around 31 per cent of demand, and is the single biggest source of gas to the EU.
- Aside from indigenous production, the Russian Federation remained the largest single supplier of gas to the EU-28 meeting 28 per cent of EU-28 demand in 2015.
- EU-28 imports of Liquefied Natural Gas (LNG) increased by 9 per cent in 2015 largely driven by falling LNG prices and rising supply.
- The UK has a diverse range of gas sources and would have met 217 and 194 per cent of the estimated peak demand with the loss of the largest and two largest gas supply routes respectively.

European physical gas flows

European gas production

The total EU-28 gas production in 2015 was 138.2 billion cubic metres (bcm), with the Netherlands and the UK accounting for 39 per cent and 30 per cent of this total respectively. This is 9.7 per cent lower than EU-28 production in 2014 which was 152.9 bcm, mainly since Netherlands production nearly decreased by a quarter. The fall in production from the Netherlands can largely be attributed to production caps set by the Dutch Government to reduce output from the Groningen gas field due to the risk of earthquakes in the area being linked to gas extraction. 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 largest demand among EU-28 countries came from Germany, the United Kingdom and Italy. Similar to 2014, these countries together accounted for over 50 per cent of EU-28 consumption. Germany remained the largest net importer in Europe in 2015 at 73 bcm, followed by Italy at 61 bcm and then France at 39 bcm[2]. Overall EU-28 net imports increased by 9 per cent compared to 2014 to meet demand following a fall in indigenous production.

Natural gas consumption[3] in the EU-28 increased in 2015 compared to 2014, from 430 bcm to 445 bcm. The majority of EU countries saw a rise in gas demand with Italy, Germany, France, Spain and Belgium contributing most significantly to this increase. This reflected the warmer weather in experienced in 2014 in comparison to 2015, particularly a mild winter in 2014.

1 January 1st 2015 to December 31st 2015 data using the following sources
"IEA (2015), IEA Natural Gas Information (database), www.iea.org/statistics/. (Accessed on [14 December 2016])"
"IEA (2016), Gas Trade Flows in Europe (GTF), www.iea.org/gtf/"

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 2015 monthly pipeline gas flows, with 2015 annual imports, exports, production and consumption used for quality assurance amendments.

3 Natural gas consumption has been calculated using 2015 monthly pipeline gas flows and production data from the IEA and may differ from the observed consumption figures quoted in the 2015 annual gas information provided by the IEA. See Annex 3 for statistical differences between these figures.

Sources of gas

There are three sources of gas supply available to EU Member States: indigenous production, imports via Liquefied Natural Gas (LNG) terminal, and imports via pipeline. Countries can also draw on gas stocks from the other three sources that have been put into storage.

The largest single category of gas supply to the EU-28 was indigenous production, supplying 31 per cent of EU-28 consumption in 2015. A total of 18 countries have at least some indigenous gas production with the largest being from the Netherlands and UK which met 12 and 9 per cent of total EU demand respectively.

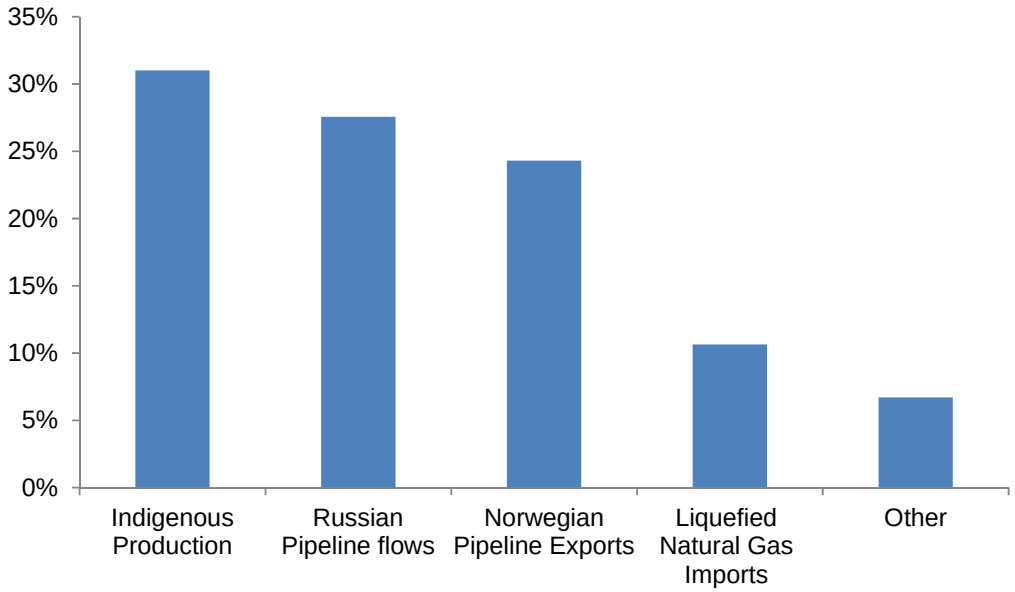
Aside from indigenous production, the Russian Federation remained the largest single supplier of gas to the EU-28, delivering around 123 bcm in 2015 compared to 108 bcm in 2014. This accounted for 28 and 25 per cent of total EU-28 gas demand in 2015 and 2014 respectively. The European pipeline infrastructure 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 increased between 2014 and 2015 but remained steady as a proportion of EU-28 gas consumption. In 2015 pipeline exports were around 108 bcm or 24 per cent of total EU-28 gas consumption compared to 101 bcm or 24 per cent in 2014. This was due to an increase in exports to UK, France and particularly Germany; 26 per cent of Norwegian exports were directed to the UK in 2015. In addition to pipeline exports, Norway exported 3bcm of LNG.

North African pipelines via Spain and Italy provided 30 bcm, or 7 per cent, of EU-28 demand. Algerian gas, coming direct from Algeria as well as via Morocco and Tunisia, accounted for 77 per cent of North African gas delivered to the EU-28, with Libya supplying the remainder.

EU-28 imports of LNG were 47.4 bcm in 2015 versus 43.5 bcm in 2014. This increase could be driven by falling LNG prices along with LNG supply increasing globally. LNG met 10.6 per cent of EU-28 demand. The largest suppliers of LNG to the EU-28 were Qatar, Algeria and Nigeria, who supplied 53, 20 and 13 per cent of total EU-28 LNG imports respectively.

Chart 1: Sources of EU-28 gas, 2015



UK physical gas flows

UK consumption in 2015 was 72.4 bcm, up from 72.2 in 2014. Around 57 per cent of this was met by indigenous production in 2015, slightly up compared to 2013 where 55 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 89 per cent and 11 per cent of pipeline imports respectively, whilst the small remainder came from Belgium. UK also exported 14.5 bcm to Belgium (54 per cent), Ireland (31 per cent) and Netherlands (13 per cent).

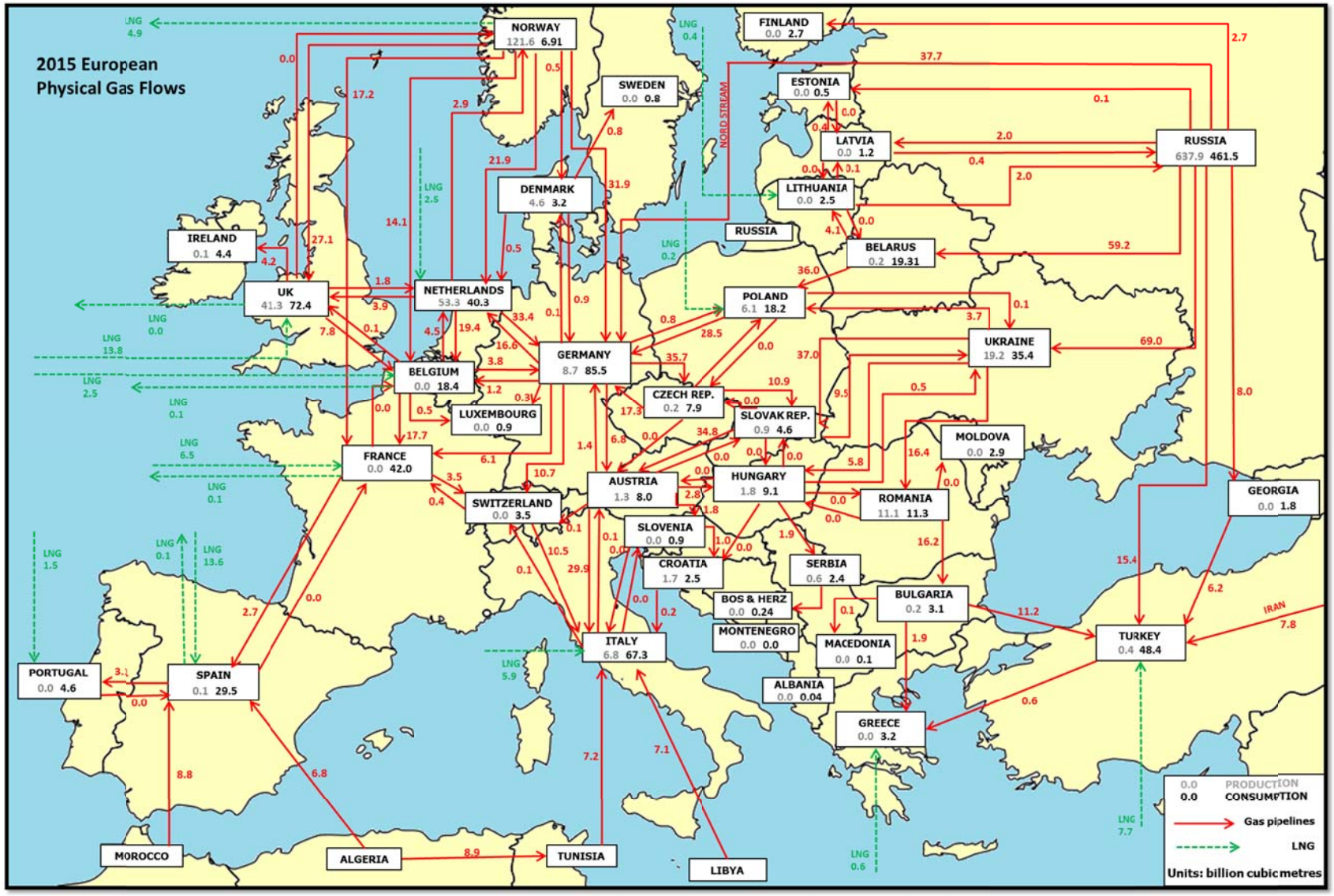
UK imports of LNG increased by 21 per cent, from 11.3 bcm in 2014 to 13.9 bcm in 2015, making the UK as the largest importer of LNG in 2015 within EU-28, ahead of Spain. 92 per cent of UK imports of LNG came from Qatar in 2015, remaining consistent with import levels in 2014 and 2013.

Note

The map 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


2015 European
Physical Gas Flows
NORWAY 121.6 6.91
SWEDEN 0.0 0.8
FINLAND 0.0 2.7
ESTONIA 0.0 0.5
LATVIA 0.0 1.2
LITHUANIA 0.0 2.5
RUSSIA 637.9 461.5
DENMARK 4.6 3.2
IRELAND 0.1 4.4
UK 41.3 72.4
NETHERLANDS 53.3 40.3
BELGIUM 0.0 18.4
LUXEMBOURG 0.0 0.9
FRANCE 0.0 42.0
GERMANY 8.7 85.5
POLAND 6.1 18.2
BELARUS 0.2 19.31
UKRAINE 19.2 35.4
MOLDOVA 0.0 2.9
CZECH REP. 0.2 7.9
SLOVAK REP. 0.9 4.6
AUSTRIA 1.3 8.0
HUNGARY 1.8 9.1
ROMANIA 11.1 11.3
SWITZERLAND 0.0 3.5
SLOVENIA 0.0 0.9
CROATIA 1.7 2.5
SERBIA 0.6 2.4
BOS & HERZ 0.0 0.24
MONTENEGRO 0.0 0.0
MACEDONIA 0.0 0.1
ALBANIA 0.0 0.04
BULGARIA 0.2 3.1
GREECE 0.0 3.2
TURKEY 0.4 48.4
GEORGIA 0.0 1.8
ITALY 6.8 67.3
PORTUGAL 0.0 4.6
SPAIN 0.1 29.5
MOROCCO
ALGERIA
TUNISIA
LIBYA
NORD STREAM
IRAN
LNG
0.0 PRODUCTION
0.0 CONSUMPTION
Gas pipelines
LNG
Units: billion cubic metres

EU-28 Infrastructure peak daily gas supply in 2015

As noted above, there are four sources of gas supply available to EU Member States: indigenous production, gas storage facilities, imports via LNG terminal and imports via pipeline, with the potential of 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 2016[5]. Storage facilities are assumed to be capable of working at peak capacity during times of peak demand. Although this is susceptible to inaccuracies, as peak capacity from storage facilities may not indeed 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 2015 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 were arranged with production and storage facilities stacked at the base of the chart and imports via LNG terminals and pipelines stacked 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.

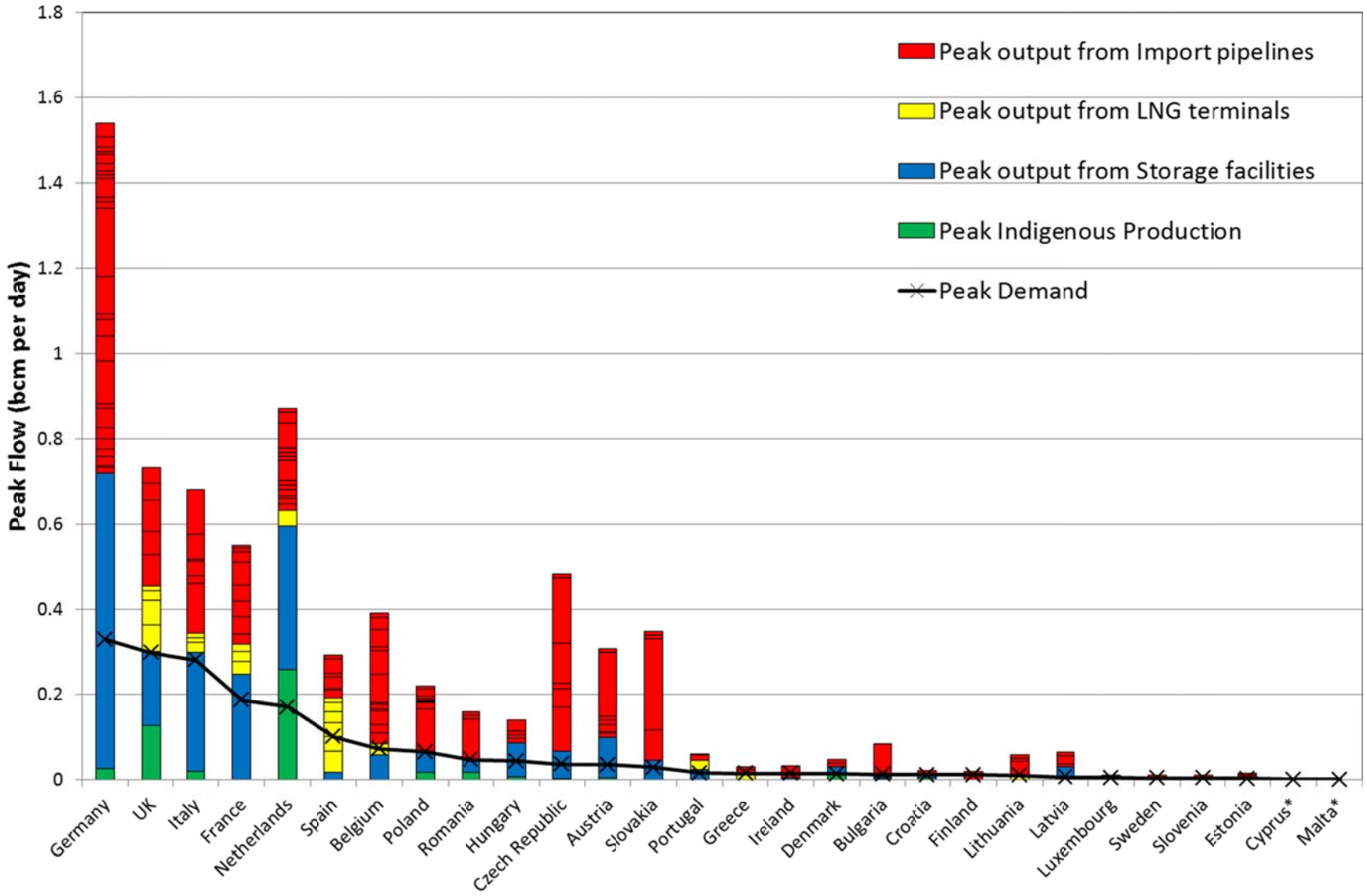
Chart 2 includes all EU-28 member states in order of peak gas demand. The estimated peak gas demand data (bcm per day) are included within Chart 2 as a single line-and-cross plot running across the graph. Peak gas demand acts as a comparator for peak gas supply, and was estimated for each country by taking the maximum monthly demand in 2015 (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 for which data were available, maximum gas supply exceeded peak demand. According to the data, Germany had the highest peak demand in 2015, but also had the largest potential peak output from both indigenous storage facilities and import pipelines. The data indicated that only the Netherlands and Denmark had sufficient indigenous production capacities to meet or nearly 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 Croatia.

The UK had the second largest peak demand of the EU member states.

[4] www.iea.org/gtf/index.asp
[5] Natural Gas Information 2016, International Energy Agency, ISBN 978-92-64-25858-7

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 (six), the UK (four) and Italy and France (three), all other member states had at most a single LNG terminal.

EU-28 Gas infrastructure resilience 2015

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

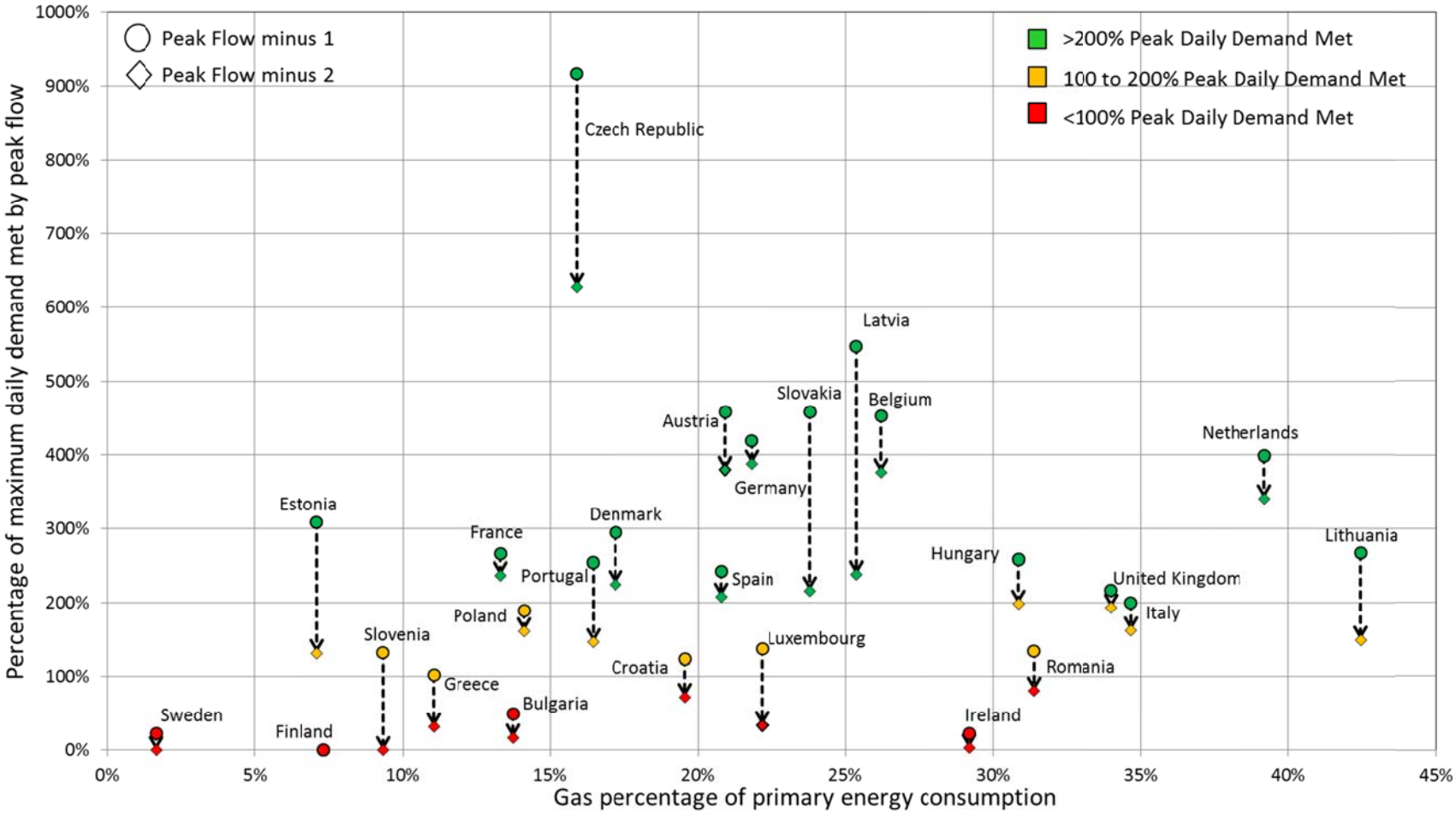
$$PF - 1[\%] = \frac{EP_{\max} + P_{\max} + S_{\max} + LNG_{\max} - I_{\max}}{D_{\max}} \qquad \text{Equation 1}$$

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 2015, we use the estimated peak gas demand in each country for 2015 (January 1st 2015 to December 31st 2015), taking the maximum monthly demand in 2015 (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, 2015



*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 Netherlands to have particularly resilient gas infrastructure. In all nine countries, the gas infrastructure was able to provide more than double the estimated –if conserved peak - gas demand in 2015, even with the loss of their two largest gas supply routes. Finland, Sweden, Ireland and Bulgaria appear particularly vulnerable to infrastructure disruptions, with these four countries unable to meet peak daily demand after the loss of the largest gas supply route. Sweden and Finland use very little gas but it appears that Ireland was particularly vulnerable, given that gas accounts for nearly 30 per cent of primary energy demand.

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 Romania clearly has two major import routes: although resilient to a single supply disruption (meeting 134 per cent of peak demand), Romania would be vulnerable after the loss of these two main routes. This is also the case for Slovenia, Greece, Croatia and Luxembourg.

UK gas infrastructure resilience 2015

For 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 2015 the UK would have met 217 and 194 per cent of the estimated peak demand with the loss of the largest and two largest gas supply routes respectively. Overall, according to the peak flow metrics and data used in this report, the UK was the eleventh most resilient Member State to gas supply infrastructure disruptions, but it was the fourth most dependent on gas for primary energy demand in 2015.

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 is well-placed to meet this requirement.

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Annex 1: Table of key data for gas use in the EU-28* countries, 2015

	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	0.034	0.004	0.209	0.094	0.000	459%	380%	6.9	32.8
Belgium	0.072	0.000	0.309	0.057	0.026	453%	377%	13.9	52.9
Bulgaria	0.012	0.002	0.078	0.004	0.000	49%	16%	2.6	18.9
Croatia	0.011	0.003	0.013	0.006	0.000	124%	72%	2.2	9.1
Cyprus*	0.000	0.000	0.000	0.000	0.000	0%	0%	0.0	2.5
Czech Republic	0.036	0.001	0.416	0.066	0.000	917%	628%	6.5	40.7
Denmark	0.013	0.013	0.018	0.016	0.000	295%	225%	2.8	16.0
Estonia	0.002	0.000	0.014	0.000	0.000	309%	131%	0.4	5.5
Finland	0.011	0.000	0.019	0.000	0.000	0%	0%	2.2	32.5
France	0.187	0.000	0.234	0.248	0.069	266%	237%	35.1	245.7
Germany	0.329	0.026	0.819	0.695	0.000	419%	388%	68.0	311.8
Greece	0.014	0.000	0.015	0.000	0.014	102%	32%	2.7	23.6
Hungary	0.043	0.005	0.054	0.080	0.000	259%	199%	7.5	23.9
Ireland	0.014	0.000	0.030	0.003	0.000	23%	3%	3.8	13.3
Italy	0.281	0.019	0.339	0.280	0.044	200%	162%	55.3	150.7
Latvia	0.006	0.000	0.034	0.030	0.000	547%	238%	0.9	3.6
Lithuania	0.010	0.000	0.046	0.000	0.012	267%	149%	2.1	5.3
Luxembourg	0.004	0.000	0.011	0.000	0.000	138%	33%	0.8	3.7
Malta*	0.000	0.000	0.000	0.000	0.000	0%	0%	0.0	2.3
Netherlands	0.171	0.257	0.238	0.339	0.035	399%	341%	28.1	71.7
Poland	0.065	0.018	0.153	0.049	0.000	189%	161%	13.8	94.6
Portugal	0.015	0.000	0.015	0.023	0.022	254%	147%	4.0	22.1
Romania	0.047	0.017	0.113	0.028	0.000	134%	81%	9.3	33.1
Slovak Republic	0.029	0.000	0.302	0.045	0.000	301%	58%	3.9	16.3
Slovenia	0.003	0.000	0.011	0.000	0.000	132%	0%	0.7	6.6
Spain	0.100	0.000	0.102	0.016	0.173	243%	208%	24.6	119.4
Sweden	0.004	0.000	0.009	0.001	0.000	23%	0%	0.7	50.0
United Kingdom	**0.298**	**0.126**	**0.276**	**0.175**	**0.155**	**217%**	**194%**	**61.2**	**180.0**

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, 2015

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	0.307	0.157	Import pipeline	0.130	Storage
Belgium	0.392	0.326	Import pipeline	0.271	Import pipeline
Bulgaria	0.084	0.006	Import pipeline	0.002	Storage
Croatia	0.022	0.014	Import pipeline	0.008	Storage
Cyprus*	0.000	0.000	-	0.000	-
Czech Republic	0.483	0.327	Import pipeline	0.224	Import pipeline
Denmark	0.048	0.038	Import pipeline	0.029	Indigenous Production
Estonia	0.014	0.007	Import pipeline	0.003	Import pipeline
Finland	0.019	0.000	Import pipeline	0.000	-
France	0.551	0.496	Storage	0.442	Import pipeline
Germany	1.540	1.380	Import pipeline	1.279	Import pipeline
Greece	0.029	0.015	LNG	0.005	Import pipeline
Hungary	0.139	0.111	Storage	0.086	Import pipeline
Ireland	0.033	0.003	Import pipeline	0.000	Storage
Italy	0.682	0.562	Import pipeline	0.457	Import pipeline
Latvia	0.064	0.034	Storage	0.015	Import pipeline
Lithuania	0.057	0.026	Import pipeline	0.018	Storage
Luxembourg	0.011	0.006	Import pipeline	0.001	Import pipeline
Malta*	0.000	0.000	-	0.000	-
Netherlands	0.869	0.681	Indigenous production	0.581	Indigenous Production
Poland	0.220	0.122	Import pipeline	0.104	Storage
Portugal	0.060	0.038	LNG	0.022	Storage
Romania	0.158	0.062	Import pipeline	0.037	Storage
Slovak Republic	0.302	0.086	Import pipeline	0.016	Import pipeline
Slovenia	0.011	0.004	Import pipeline	0.000	Import pipeline
Spain	0.292	0.243	LNG	0.208	Import pipeline
Sweden	0.010	0.001	Import pipeline	0.000	Storage
United Kingdom	**0.732**	**0.649**	**Import pipeline**	**0.575**	**Import pipeline**

Source: BEIS analysis of IEA data. *PF* = peak flow (defined in Equation 1 in report). *No data available for Cyprus and Malta.

Annex 3: Table of statistical differences between observed and calculated consumption for EU-28* countries, 2015

EU-28 MS	Observed Consumption (bcm)	Calculated Consumption (bcm)	Statistical Difference (bcm)	Statistical Difference (Per cent)
Austria	8.4	8.0	0.3	4.1%
Belgium	17.0	18.4	-1.4	-7.8%
Bulgaria	2.9	3.1	-0.3	-8.1%
Croatia	2.6	2.5	0.1	2.6%
Cyprus*	0.0	0.0	0.0	-
Czech Republic	7.9	7.9	0.0	0.0%
Denmark	3.2	3.2	0.0	0.4%
Estonia	0.5	0.5	0.0	0.0%
Finland	2.7	2.7	0.0	0.4%
France	39.1	42.0	-2.9	-7.0%
Germany	81.4	85.5	-4.2	-4.9%
Greece	3.1	3.2	0.0	-0.9%
Hungary	9.0	9.1	-0.1	-0.9%
Ireland	4.4	4.4	0.0	0.0%
Italy	67.5	67.3	0.2	0.3%
Latvia	1.4	1.2	0.2	14.8%
Lithuania	2.3	2.5	-0.2	-8.7%
Luxembourg	0.9	0.9	0.0	0.5%
Malta*	0.0	0.0	0.0	-
Netherlands	40.3	40.3	0.0	0.1%
Poland	18.3	18.2	0.1	0.7%
Portugal	4.7	4.6	0.1	3.2%
Romania	11.3	11.3	0.0	-0.4%
Slovak Republic	4.6	4.6	0.0	-0.1%
Slovenia	0.8	0.9	0.0	-5.4%
Spain	27.9	29.5	-1.7	-5.6%
Sweden	0.8	0.8	0.0	0.1%
United Kingdom	72.2	72.4	-0.2	-0.3%

Table shows differences between IEA observed consumption and calculated consumption based on pipeline import and export flows without stock change. 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.