Physical gas flows across Europe and diversity of gas supply in 2014

Background

This article has two main purposes. The first is to illustrate physical gas flows at the European level using 2014[1] data published by the International Energy Agency (IEA). The second is to attempt to compare the resilience of the UK's supply infrastructure with that of other EU Member States.

European Physical Gas Flows

European Gas Production

The total EU-28 gas production in 2014 was 152.9 billion cubic metres (bcm), with the Netherlands and the UK accounting for 46 per cent and 25 per cent of this total respectively. This is 11.3% lower than EU-28 production in 2013 which was 172.4 bcm, mainly since Netherlands production decreased by nearly a fifth. 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 2013, these countries together accounted for over 50 per cent of EU-28 consumption. Germany remained the largest net importer in Europe in 2013 at 72 bcm, followed by Italy at 55 bcm and then France at 40 bcm[2]. Overall EU-28 net imports decreased by 7% compared to 2013.

Natural gas consumption in the EU-28 decreased considerably in 2014 compared to 2013, from 481 bcm to 430 bcm. All EU countries saw a reduction in gas demand with the Netherlands, Germany, Italy, France and UK contributing most significantly to this decrease. This partially reflected warmer weather in 2014 along with some fuel switching.

Sources of Gas

There are four sources of gas supply available to EU Member States: indigenous production, gas storage facilities, imports via Liquefied Natural Gas (LNG) terminals and imports via pipeline (see Chart 1, overleaf). Many counties use all four routes to meet their needs.

The largest single category of gas supply to the EU-28 was indigenous production, supplying 36 per cent of EU-28 consumption in 2014. A total of 14 countries have at least some indigenous gas production with the largest being from the Netherlands and UK which met 17 and 9 per cent of total EU demand respectively.

Aside from indigenous production, the Russian Federation remained the single supplier of gas to the EU-28, delivering around 116 bcm in 2014 compared to 131 bcm in 2013. In both years this accounted for 27 per cent of total EU-28 gas demand. 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 exports to the EU-28 increased between 2013 and 2014. In 2014 was around 108 bcm or 24 per cent of total EU-28 gas consumption compared to 22 per cent in 2013. This was due to an increase in exports to Germany; 23 per cent of Norwegian exports were directed to the UK in 2014.

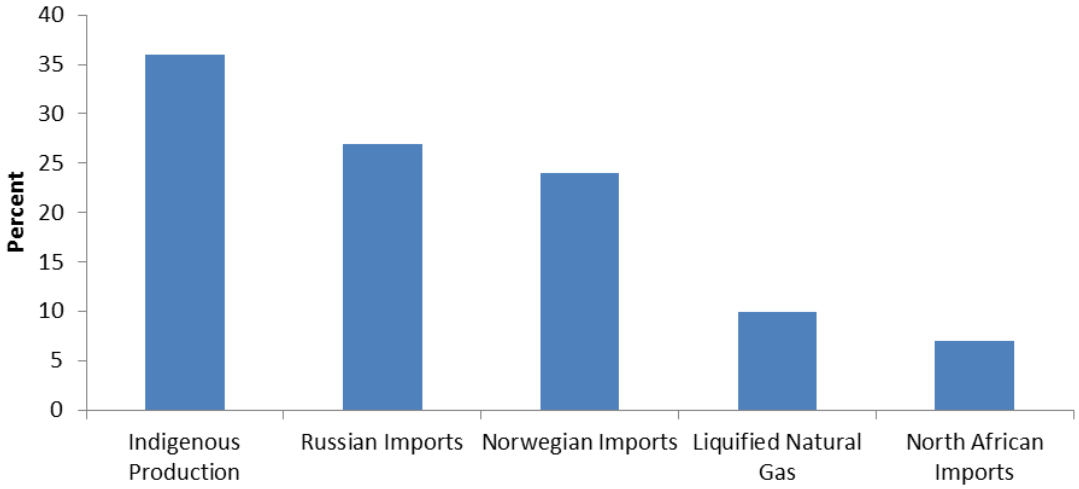
1 January 1st 2014 to December 31st 2014 data

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 2014 monthly pipeline gas flows, with 2014 annual imports, exports, production and consumption used for quality assurance amendments.

Imports of LNG into the EU-28 were 42.3 bcm in 2014 versus 39.7 bcm in 2013. 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 40, 29 and 11 per cent of total EU-28 LNG imports respectively.

North African pipelines via Spain and Italy provided 29 bcm, or 7 per cent, of EU-28 demand. Algerian gas, coming direct from Algeria as well as via Morocco and Tunisia, accounted for 78 per cent of North African gas delivered to the EU-28, with Libya supplying the remainder.

Chart 1: Sources of EU-28 gas, 2014



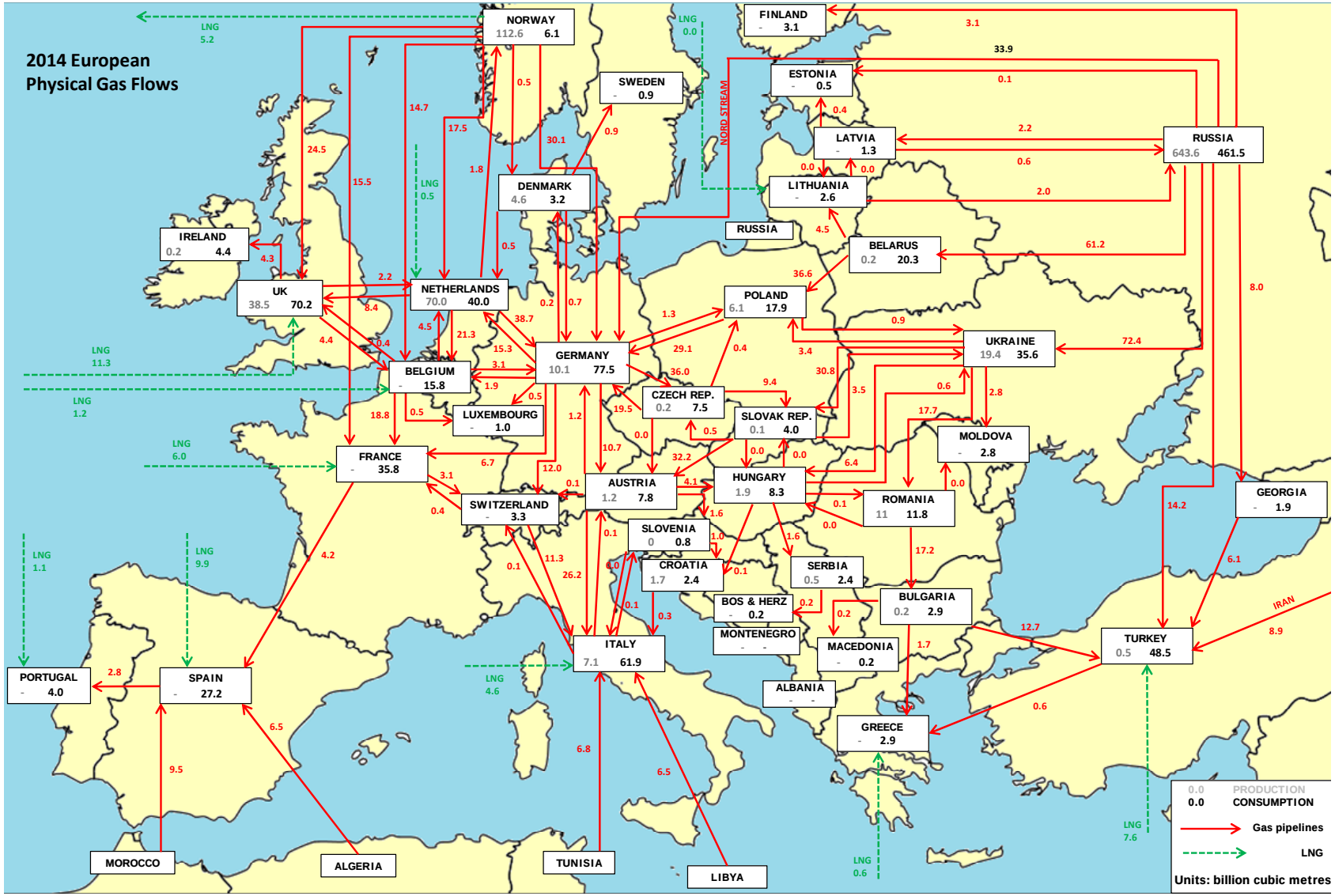
UK Flows in 2014

UK consumption in 2014 was 70.2 bcm, down from 77.9 in 2013. Around 55% of this was met by indigenous production in 2014, an increase on the 50% reported in 2013. The remaining demand was met by LNG imports (27 per cent) and pipeline imports from Norway (57 per cent of the total), Netherlands (15 per cent) and Belgium (1 per cent). There are no direct imports of Russian gas, though small volumes may exist in the Dutch and Belgian flows. Despite the large volume of imports, the UK is also a major exporter to the rest of the EU, exporting 10.9 bcm to Ireland (37% of total exports), Belgium (40%) and the Netherlands (20%).

UK imports of LNG increased by 21 per cent, from 9.4 bcm in 2013 to 11.3 bcm in 2014, keeping the UK as the second largest importer of LNG in 2014, behind Spain. 92 per cent of UK imports of LNG came from Qatar in 2014, down from 93 per cent in 2013 and 98 per cent in 2012.

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).


2014 European
Physical Gas Flows
NORWAY 112.6 6.1
FINLAND - 3.1
SWEDEN - 0.9
ESTONIA - 0.5
LATVIA - 1.3
LITHUANIA - 2.6
RUSSIA 643.6 461.5
DENMARK 4.6 3.2
RUSSIA
BELARUS 0.2 20.3
IRELAND 0.2 4.4
UK 38.5 70.2
NETHERLANDS 70.0 40.0
POLAND 6.1 17.9
UKRAINE 19.4 35.6
GERMANY 10.1 77.5
BELGIUM - 15.8
CZECH REP. 0.2 7.5
SLOVAK REP. 0.1 4.0
MOLDOVA - 2.8
LUXEMBOURG - 1.0
FRANCE - 35.8
HUNGARY 1.9 8.3
AUSTRIA 1.2 7.8
ROMANIA 11 11.8
GEORGIA - 1.9
SWITZERLAND - 3.3
SLOVENIA 0 0.8
CROATIA 1.7 2.4
SERBIA 0.5 2.4
BOS & HERZ - 0.2
BULGARIA 0.2 2.9
MONTENEGRO - -
MACEDONIA - 0.2
TURKEY 0.5 48.5
ITALY 7.1 61.9
ALBANIA - -
PORTUGAL - 4.0
SPAIN - 27.2
GREECE - 2.9
MOROCCO
ALGERIA
TUNISIA
LIBYA
NORD STREAM
IRAN
LNG
PRODUCTION
CONSUMPTION
Gas pipelines
LNG
Units: billion cubic metres

EU-28 Infrastructure peak daily gas supply in 2014

As noted above, there are four sources of gas supply available to EU Member States: indigenous production, gas storage facilities, imports via LNG terminals and imports via pipeline, with many countries making use of all of these routes to meet their demand. 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[3]. Similarly, peak outputs for storage facilities were extracted from the IEA Natural Gas Information 2015[4]. 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 2014 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 2014 (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.

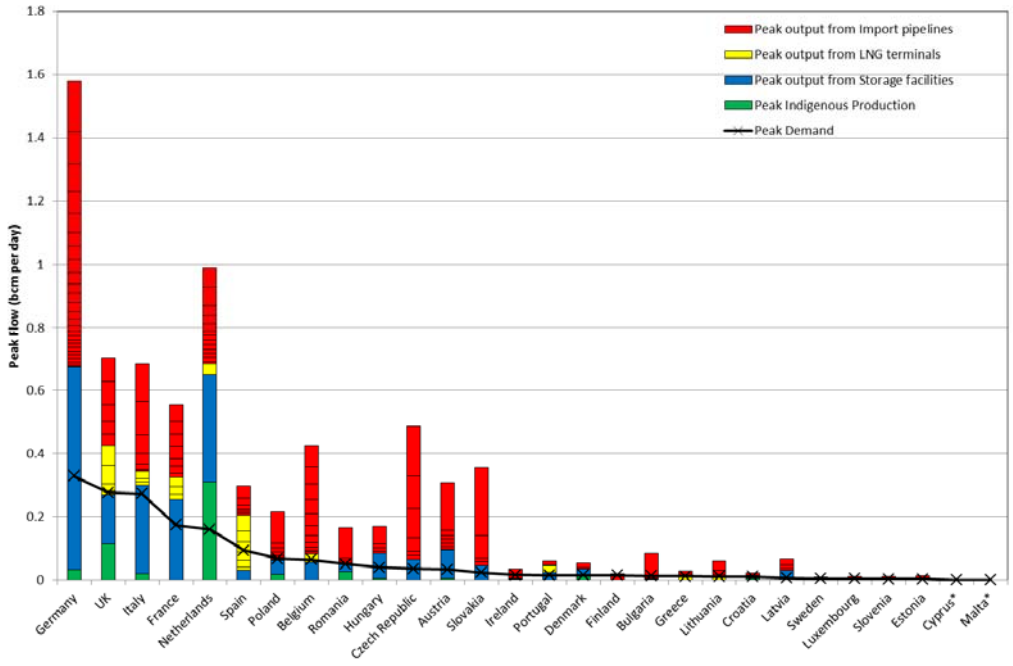
Chart 2 shows that in all EU countries for which data were available, maximum gas supply exceeded peak demand. According to the data, Germany had the highest peak demand in 2014, but also had the largest potential peak output from both indigenous storage facilities and import pipelines. The data indicated 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 Sweden.

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

[3] www.iea.org/gtf/index.asp

[4] Natural Gas Information 2015, International Energy Agency, ISBN 9789264238930

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



Source: DECC 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 2014

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

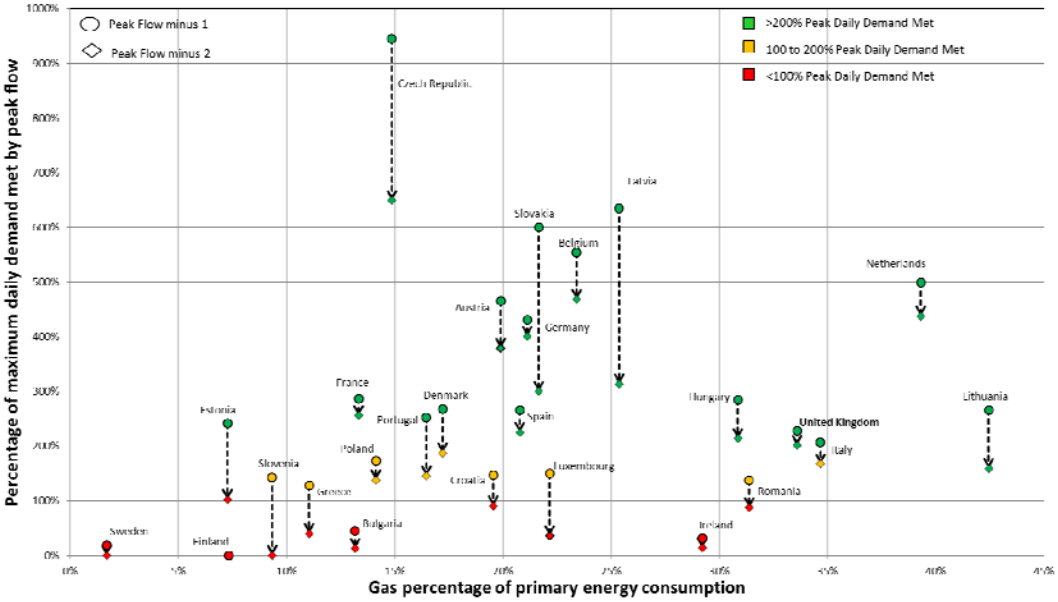
$$PF - 1[\%] = \frac{EP_{\max} + P_{\max} + S_{\max} + LNG_{\max} - I_{\max}}{D_{\max}} \qquad \text{Equation 1}$$

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 2014, we use the estimated peak gas demand in each country for 2014 (January 1st 2014 to December 31st 2014), taking the maximum monthly demand in 2014 (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, 2014



*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 Czech Republic, Belgium, Germany, Austria, Hungary, Slovakia, Netherlands, Latvia, United Kingdom, Spain and France to have particularly resilient gas infrastructure. In all ten countries, the gas infrastructure was able to provide more than double the estimated –if conservative peak - gas demand in 2014, even with the loss of their two largest gas supply routes. Finland, Sweden, Ireland and Bulgaria appeared 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 also vulnerable, given that gas accounts for nearly 30 per cent of primary energy demand.

The inclusion of both *PF*-1 and *PF*-2 scores in Chart 3 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 138 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 2014

For the UK's perspective, there are a diverse range of gas sources, including pipeline and LNG imports, storage and indigenous production, with consequent good resilience to disruption of major supply sources According to these data, in 2014 the UK would have met 228 and 201 per cent of the estimated peak demand with the loss of the largest and two largest gas supply routes respectively. Overall, according to the common peak flow metric and data used in this report, the UK was the tenth most resilient Member State to gas supply infrastructure disruptions, but it was the fourth most dependent on gas for primary energy demand in 2014.

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.

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

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Annex 1: Table of key data for gas use in the EU-28* countries, 2014

	Peak daily [X] (Billion cubic metres per day)								
EU-28 MS	**Dem-and ****	**Indig-enous prod-uction ****	**Import pipelines**	**Storage output**	**LNG out-put**	***PF*-1 score**	***PF*-2 score**	**Natural Gas Consum-ption (Mtoe)**	**Total Primary Energy Consumption (Mtoe)**
Austria	0.034	0.004	**0.213**	0.091	0.000	465%	379%	32.1	6.4
Belgium	0.065	0.000	**0.341**	0.057	0.026	554%	469%	54.0	12.6
Bulgaria	0.012	0.002	**0.078**	0.004	0.000	45%	13%	17.9	2.4
Croatia	0.010	0.005	**0.012**	0.006	0.000	147%	91%	10.0	2.0
Cyprus*	0.000	0.000	**0**	0.000	0.000	0%	0%	3.1	0.0
Czech Republic	0.035	0.001	**0.420**	0.065	0.000	945%	650%	41.5	6.2
Denmark	0.015	0.015	**0.019**	0.020	0.000	268%	187%	16.4	2.8
Estonia	0.003	0.000	**0.014**	0.000	0.000	241%	102%	6.1	0.4
Finland	0.015	0.000	**0.019**	0.000	0.000	0%	0%	34.2	2.5
France	0.174	0.000	**0.230**	0.255	0.069	287%	256%	242.1	32.3
Germany	0.329	0.034	**0.905**	0.640	0.000	431%	401%	303.6	64.1
Greece	0.011	0.000	**0.015**	0.000	0.014	128%	40%	22.5	2.5
Hungary	0.040	0.005	**0.085**	0.080	0.000	284%	214%	22.6	7.0
Ireland	0.016	0.002	**0.030**	0.003	0.000	31%	14%	12.8	3.7
Italy	0.273	0.020	**0.339**	0.280	0.044	207%	168%	146.2	50.7
Latvia	0.006	0.000	**0.0376**	0.030	0.000	635%	314%	4.3	1.1
Lithuania	0.011	0.000	**0.050**	0.000	0.012	266%	159%	5.4	2.3
Luxembourg	0.004	0.000	**0.011**	0.000	0.000	150%	36%	3.8	0.8
Malta*	0.000	0.000	**0**	0.000	0.000	0%	0%	2.0	0.0
Netherlands	0.160	0.311	**0.305**	0.339	0.035	500%	437%	72.4	28.4
Poland	0.068	0.018	**0.153**	0.044	0.000	173%	138%	94.9	13.4
Portugal	0.015	0.000	**0.015**	0.023	0.022	252%	146%	21.1	3.5
Romania	0.050	0.027	**0.110**	0.028	0.000	138%	88%	33.7	10.6
Slovak Republic	0.023	0.000	**0.310**	0.045	0.000	601%	300%	15.4	3.3
Slovenia	0.003	0.000	**0.011**	0.000	0.000	143%	0%	6.8	0.6
Spain	0.093	0.000	**0.092**	0.032	0.173	265%	225%	113.9	23.7
Sweden	0.005	0.000	**0.008**	0.001	0.000	19%	0%	46.7	0.8
United Kingdom	0.276	0.115	**0.277**	0.154	0.155	228%	201%	177.8	59.7

Source: DECC 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, 2014

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	0.128	Storage
Belgium	0.424	0.358	Import pipeline	0.303	Import pipeline
Bulgaria	0.084	0.006	Import pipeline	0.002	Storage
Croatia	0.022	0.015	Import pipeline	0.009	Storage
Cyprus	0	0.000	-	0.000	-
Czech Republic	0.486	0.330	Import pipeline	0.227	Import pipeline
Denmark	0.054	0.040	Import pipeline	0.028	Storage
Estonia	0.014	0.007	Import pipeline	0.003	Import pipeline
Finland	0.019	0.000	Import pipeline	0.000	-
France	0.554	0.499	Storage	0.445	Import pipeline
Germany	1.579	1.419	Import pipeline	1.318	Import pipeline
Greece	0.029	0.015	LNG	0.005	Import pipeline
Hungary	0.170	0.114	Import pipeline	0.090	Storage
Ireland	0.035	0.005	Import pipeline	0.002	Storage
Italy	0.683	0.563	Import pipeline	0.458	Import pipeline
Latvia	0.068	0.038	Storage	0.019	Import pipeline
Lithuania	0.061	0.030	Import pipeline	0.018	Import pipeline
Luxembourg	0.011	0.006	Import pipeline	0.001	Import pipeline
Malta	0	0.000	-	0.000	-
Netherlands	0.990	0.801	Indigenous production	0.701	Import pipeline
Poland	0.215	0.117	Import pipeline	0.093	Storage
Portugal	0.060	0.038	LNG	0.022	Storage
Romania	0.165	0.069	Import pipeline	0.044	Storage
Slovakia	0.355	0.139	Import pipeline	0.070	Import pipeline
Slovenia	0.011	0.004	Import pipeline	0.000	Import pipeline
Spain	0.297	0.248	LNG	0.210	Import pipeline
Sweden	0.010	0.001	Import pipeline	0.000	Storage
United Kingdom	0.701	0.627	Import pipeline	0.553	Import pipeline

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