Physical gas flows across Europe and diversity of gas supply in 2012

Background

This article has two main purposes. The first is to illustrate physical gas flows at the European level using 2012[1] data published by the International Energy Agency (IEA)[2], with the aim to improve gas data transparency and quality. 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-27[3] gas production in 2012 was 182 billion cubic metres (bcm), which equals 2,004 TWh[4], with the Netherlands and the UK accounting for 44 per cent and 26 per cent of this total respectively. Out of all EU-27 countries, only the Netherlands and Denmark produced more gas than they consumed.

European Gas Consumption

The greatest demand among EU-27 countries came from Germany, the United Kingdom and Italy. These countries together accounted for nearly 50 per cent of EU-27 consumption. Germany remained the largest net importer in Europe in 2012 at 70 bcm, followed by Italy at 68 bcm and then France at 43 bcm.

Natural gas consumption in the EU-27 decreased slightly in 2012 compared to 2011, from 489 bcm to 477 bcm. In particular, countries such as Italy, Spain, the Netherlands and the UK have seen a reduction in gas demand. This reflected the slower economic growth in 2012, warmer temperatures and a continuing shift in electricity generation away from natural gas and in to coal.

Sources of Gas

Thirty eight per cent of EU-27 consumption in 2012 was met by indigenous production, with production from Netherlands and UK meeting 17 and 10 per cent of total EU demand respectively.

The Russian Federation remained the largest single supplier of gas to the EU-27, delivering around 116 bcm, or 24 per cent, of total EU-27 gas demand in 2012. 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-27 increased by 10 per cent between 2011 and 2012, to around 102 bcm or 21 per cent of total EU-27 gas consumption; 21 per cent of Norwegian exports were directed to the UK in 2012.

North African pipelines via Spain and Italy provided 40 bcm, or 8.4 per cent, of EU-27 demand. Algerian gas, coming direct from Algeria and also via Morocco and Tunisia, accounted for 84 per cent of North African gas delivered to the EU-27, with Libya supplying the remainder.

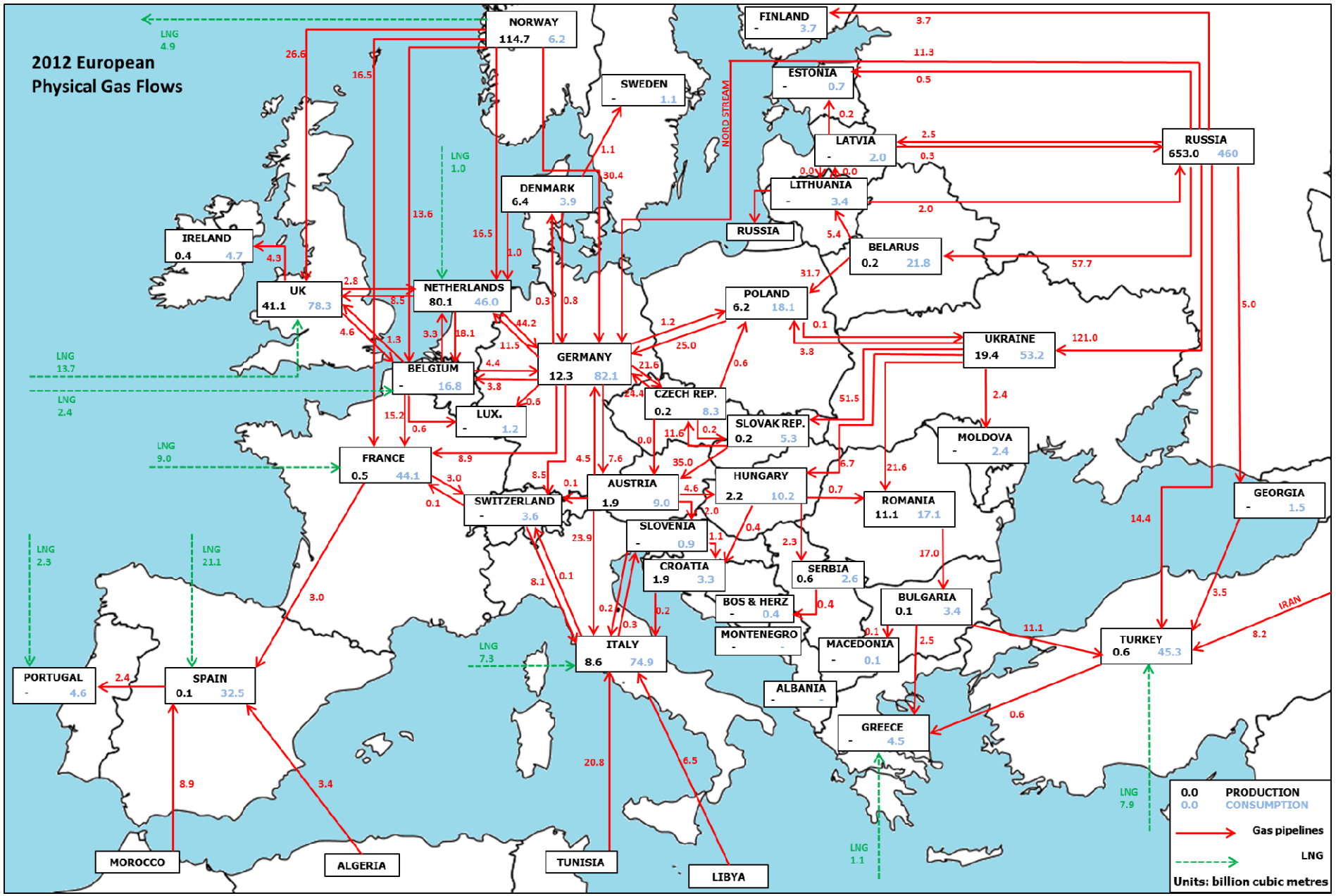
EU-27 imports of LNG were 58.1 bcm in 2012 versus 76.8 bcm in 2011, reflecting increased demand from Asia in 2012 (and henceforth higher prices relative to the previous year). LNG met 12 per cent of EU-27 demand and, in particular, 65 per cent of Spanish gas consumption. The largest suppliers of LNG to the EU-27 were Qatar, Nigeria and Algeria, who supplied 48, 18 and 17 per cent of total EU-27 LNG imports respectively.

[1] January 1st 2012 to December 31st 2012 data

[2] Please note that the analysis shows some differences with IEA data in order to provide a coherent view of gas flows. The supply for some countries may appear unbalanced as stock changes are not shown. Data were calculated primarily from 2012 monthly pipeline gas flows, with 2012 annual imports, exports, production and consumption used for quality assurance amendments.

[3] EU-27 as based on 2012 data, prior to Croatia officially joining EU.

[4] 1 bcm = 11.012 Terawatt hours (TWh)


2012 European
Physical Gas Flows
NORWAY 114.7 6.2
FINLAND - 3.7
SWEDEN - 1.1
ESTONIA - 0.7
LATVIA - 2.0
LITHUANIA - 3.4
RUSSIA 653.0 460
DENMARK 6.4 3.9
RUSSIA
IRELAND 0.4 4.7
UK 41.1 78.3
NETHERLANDS 80.1 46.0
BELARUS 0.2 21.8
POLAND 6.2 18.1
UKRAINE 19.4 53.2
GERMANY 12.3 82.1
BELGIUM - 16.8
LUX. - 1.2
CZECH REP. 0.2 8.3
SLOVAK REP. 0.2 5.3
MOLDOVA - 2.4
FRANCE 0.5 44.1
AUSTRIA 1.9 9.0
HUNGARY 2.2 10.2
ROMANIA 11.1 17.1
GEORGIA - 1.5
SWITZERLAND - 3.6
SLOVENIA - 0.9
CROATIA 1.9 3.3
SERBIA 0.6 2.6
BOS & HERZ - 0.4
BULGARIA 0.1 3.4
MONTENEGRO - -
MACEDONIA - 0.1
TURKEY 0.6 45.3
ITALY 8.6 74.9
ALBANIA - -
GREECE - 4.5
PORTUGAL - 4.6
SPAIN 0.1 32.5
MOROCCO
ALGERIA
TUNISIA
LIBYA
NORD STREAM
IRAN
LNG 4.9
LNG 1.0
LNG 13.7
LNG 2.4
LNG 9.0
LNG 2.3
LNG 21.1
LNG 7.3
LNG 7.9
LNG 1.1
0.0 PRODUCTION
0.0 CONSUMPTION
Gas pipelines
LNG
Units: billion cubic metres

UK imports in 2012

Total imports to the UK were 49.1 bcm in 2012, with pipelines accounting for 35.4 bcm (72 per cent) and LNG accounting for 13.7 bcm (18 per cent) of all imports. Although UK imports of LNG decreased by 45 per cent, from 24.8 bcm in 2011, the data showed the UK to be the second largest importer of LNG in 2012, behind Spain. 97 per cent of UK imports of LNG came from Qatar in 2012, up from 85 per cent in 2011.

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

EU-27 Infrastructure peak daily gas supply in 2012

There are four generic 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. This article uses 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[5]. Similarly, peak outputs for storage facilities were extracted from the IEA Natural Gas Information 2013[6]. 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 had to be estimated, by taking the maximum monthly production (bcm) in 2012[5] for each gas-producing member state and dividing this by the number of days in that month.

Chart 1 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 indigenous categories (production and storage facilities) stacked at the base of the chart and external categories (imports via LNG terminals and pipelines) stacked above. For these external sources, data were divided within categories by individual source (represented by horizontal lines within an individual bar colour).

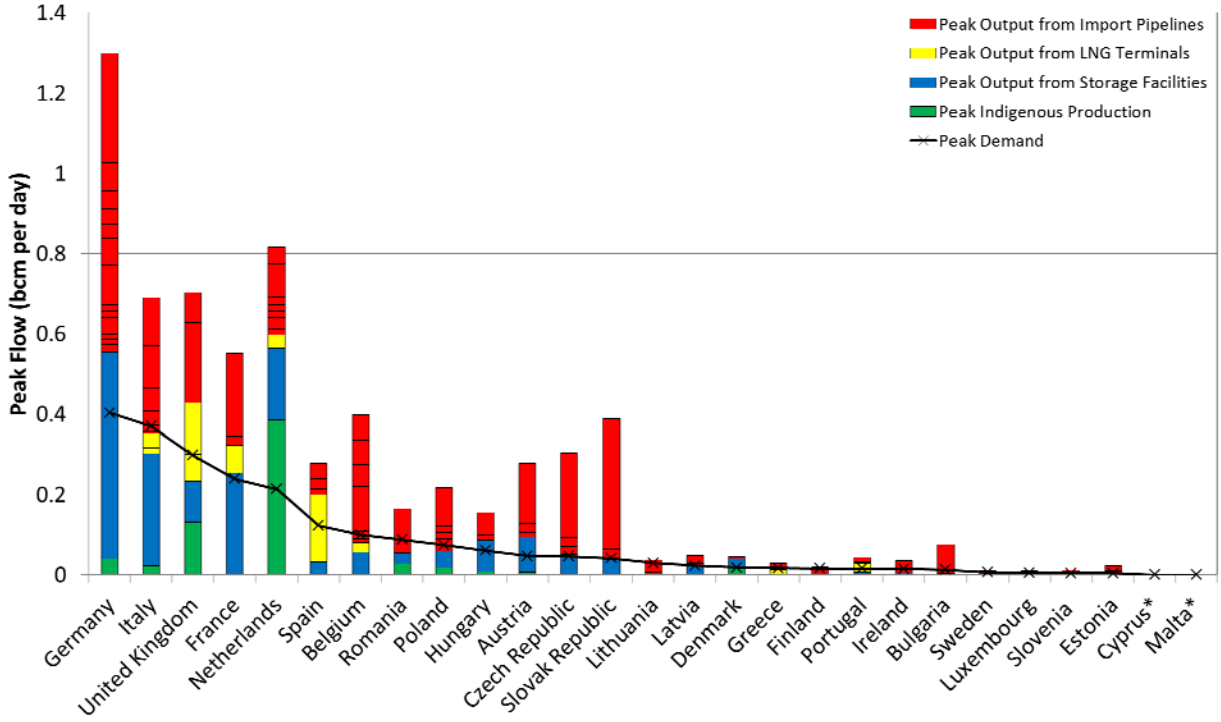
Chart 1 also shows all EU-27 member states in order of peak gas demand. Peak gas demand data (bcm per day) are included within Chart 1 as a single line-and-cross plot running across the graph. Peak gas demand acts as a comparator for peak gas supply, and was estimated for each country by taking the maximum monthly demand in 2012 (bcm) divided by the number of days within that month. Data for peak flows are provided in the table in Annex 1.

Chart 1 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 2012, but also had the largest potential peak supply from both indigenous storage facilities and import pipelines. The data indicated that only two member states had sufficient indigenous production capacities to meet peak daily demand: the Netherlands and Denmark. The majority of countries had a peak supply more than double that of peak demand, with the exception of Italy, Romania, Lithuania, Greece, Finland and Sweden.

The UK had the third largest peak demand of the EU member states. The UK also had the most diverse category breakdown for gas supplies, with each of the four potential gas sources making up at least 15 per cent of peak supply.

[5] www.iea.org/gtf/index.asp
[6] Natural Gas Information 2013, International Energy Agency, ISBN 9789264203143

Chart 1: Peak outputs for gas supply sources versus peak demand for EU-27 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 1 (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, 23 in total. There are substantially fewer import pipelines in EU countries east of Germany. Although the Slovak Republic appeared to have a peak supply that far exceeded demand, almost all of this came via a single pipeline. Only Spain (six), the UK (four) and Italy (two), had more than one LNG terminal (most member states do not have any), highlighting that this method of gas supply is still in its infancy.

EU-27 Gas Infrastructure Resilience 2012

In order to give 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:

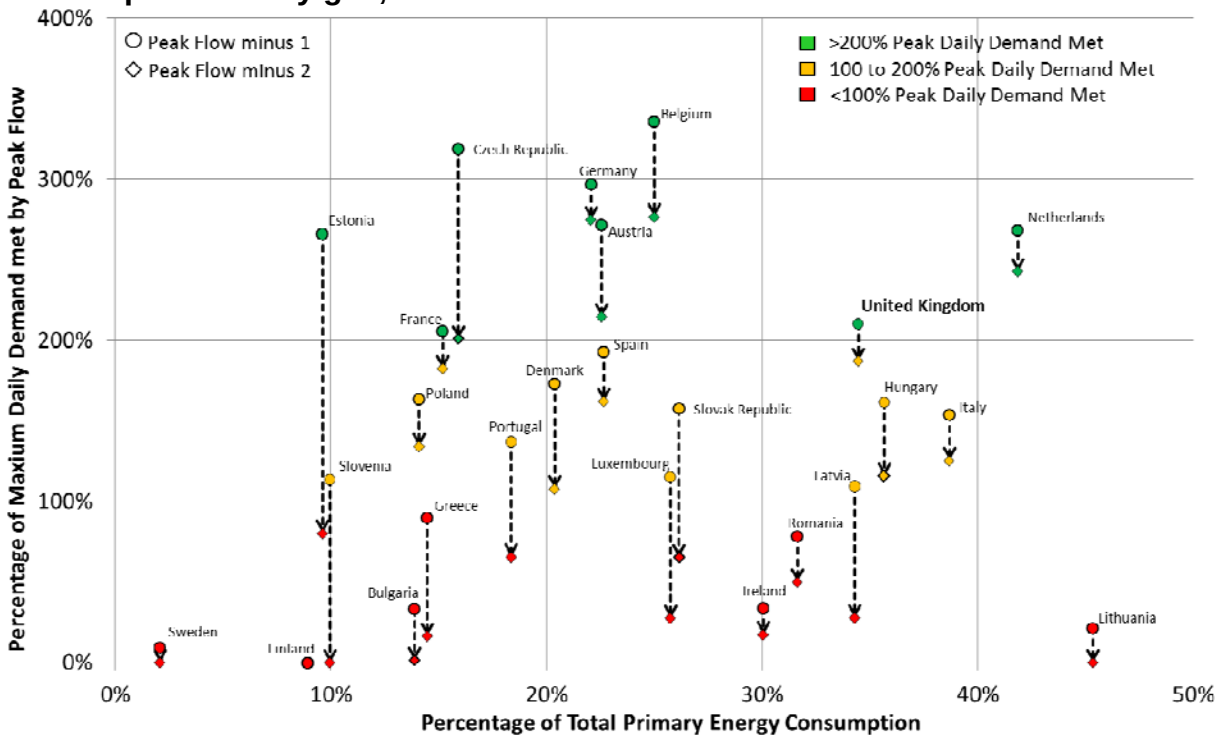
PF = Peak Flow (bcm/day)
EP_{max} = Peak capacity of entry points (bcm/day)
P_{max} = Peak capacity for each indigenous production pipeline (bcm/day)
S_{max} = Peak output for each storage facility (bcm/day)
LNG_{max} = Peak output for each LNG terminal (bcm/day)
D_{max} = Average 2012 peak gas demand (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 the historical nature of the data used here. Additionally, 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 2012, we use the peak gas demand in each country for 2012 (January 1st 2012 to December 31st 2012), taking the maximum monthly demand in 2012 (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. Limitations to this technique are discussed at the end of this report.

As well as considering infrastructure resilience, it is also important to consider the extent to which each EU-27 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 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 2). In Chart 2, the top circle shows *PF*-1 for each member state, with the vertical arrow indicating the loss of demand between *PF*-1 and *PF*-2 (diamond). The chart uses a red-amber-green as an indication of resilience, using less than 100 per cent and 100 to 200 per cent and greater than 200 per cent as arbitrary measures of resilience.

Chart 2: EU-27* gas infrastructure resilience versus percentage of primary energy consumption met by gas, 2012



*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 2 shows Belgium, Germany, the Netherlands, Austria and the Czech Republic have particularly resilient gas infrastructure, according to this analysis. In all five countries, the gas infrastructure was able to provide more than double the peak gas demand in 2012, even with the loss of their two largest gas supply routes. Resilience in France and the UK also appears robust. Finland, Sweden, Lithuania, Ireland, Bulgaria, Romania and Greece appeared particularly vulnerable to infrastructure disruptions, with these seven countries unable to meet peak daily demand after the loss of the largest gas supply route. Lithuania, Romania and Ireland seemed particularly vulnerable, given that they relied on gas for more than 30 per cent of their primary energy demand. For these seven countries most at risk (*PF*-1 and *PF*-2 both less than 100% in Chart 2), all have plans in place to increase their gas infrastructure[7].

[7] www.entsog.eu/maps/transmission-capacity-map

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 Estonia clearly has two major supply routes: although resilient to a single supply disruption (meeting 266 per cent of peak demand), Estonia becomes vulnerable after the loss of these two main routes. This is also the case for Latvia, Slovenia, Luxembourg, Portugal and the Slovak Republic.

According to the data, the UK was resilient to infrastructure disruptions in 2012, with 211 and 187 per cent of peak demand met with the loss of the largest and second largest gas supply routes respectively. Overall, according to the peak flow metric and data used in this report, the UK was the sixth most resilient Member State to gas supply infrastructure disruptions, and was the fifth most dependent on gas for primary energy demand in 2012. From a 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.

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), comes into force from 3rd December 2014. Given the similarity between the EU *N*-1 methodology and the *PF*-1 methodology used here, the UK appears well-placed to meet this requirement.

Limitations

It is important to note that these data were collected from IEA sources and thus our analysis may not accurately reflect each country's position if these data were not accurately recorded within the IEA data set at the time of collection. Additional data may be available in statistical publications for individual Member States.

This report shows the physical flow of natural gas around Europe and resilience of the EU Member States to infrastructure disruption. It has built on a previous report, published in Energy Trends June 2013[8], which examined diversity of pipeline and LNG import countries only, without considering number of pipelines/terminals or indigenous gas sources. Importantly, this report has focussed on within-country infrastructure disruptions, and not considered the more complex issue of supply disruptions impacting on the entire EU-27 infrastructure, such as difficulties in gas supply from major gas-supplying countries such as Russia or Norway. We aim to build on this report to consider these wider-ranging supply difficulties in future reports.

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[8] www.gov.uk/government/uploads/system/uploads/attachment_data/file/208560/et_june_2013.PDF

Annex 1: Table of key data for gas use in the EU-27* countries, 2012

EU-27 MS	Peak daily [X] (Billion cubic metres per day)					*PF*-1 score	*PF*-2 score	Natural Gas Consumption (Mtoe)	Total Primary Energy Consumption (Mtoe)
	Demand **	Indigenous production **	Import pipelines	Storage output	LNG output				
Austria	0.047	0.007	0.185	0.087	-	272%	215%	7.42	32.90
Belgium	0.100	-	0.317	0.057	0.023	336%	277%	14.32	57.29
Bulgaria	0.013	0.000	0.071	0.004	-	33%	1%	30.2	21.76
Cyprus*	-	-	-	-	-	-	-	-	3.57
Czech Republic	0.047	0.001	0.258	0.045	-	319%	201%	6.81	42.82
Denmark	0.018	0.021	0.005	0.020	-	173%	108%	3.47	17.04
Estonia	0.004	-	0.022	-	-	266%	80%	0.55	5.72
Finland	0.016	-	0.019	-	-	0%	0%	2.99	33.48
France	0.240	0.001	0.229	0.252	0.067	206%	183%	38.23	251.71
Germany	0.403	0.040	0.745	0.513	-	297%	275%	67.78	307.38
Greece	0.017	-	0.015	-	0.013	90%	17%	3.76	25.99
Hungary	0.061	0.008	0.068	0.079	-	162%	116%	8.38	23.50
Ireland	0.015	0.003	0.030	0.003	-	34%	17%	4.01	13.35
Italy	0.370	0.023	0.034	0.280	0.048	154%	125%	61.34	158.62
Latvia	0.023	-	0.025	0.022	-	110%	28%	1.56	4.56
Lithuania	0.029	-	0.037	-	-	21%	0%	3.36	7.41
Luxembourg	0.005	-	0.011	-	-	115%	28%	1.05	4.08
Malta*	-	-	-	-	-	-	-	-	2.83
Netherlands	0.214	0.385	0.218	0.178	0.035	269%	243%	32.74	78.22
Poland	0.746	0.018	0.157	0.042	-	164%	134%	13.60	96.54
Portugal	0.016	-	0.014	0.007	0.022	137%	66%	4.03	21.95
Romania	0.088	0.027	0.110	0.028	-	78%	50%	13.62	43.04
Slovak Republic	0.041	0.000	0.349	0.038	-	158%	65%	4.36	16.68
Slovenia	0.003	-	0.011	-	-	114%	0%	0.71	7.14
Spain	0.123	0.000	0.078	0.032	0.167	193%	162%	28.24	124.68
Sweden	0.006	-	0.009	0.001	-	10%	0%	1.01	48.88
United Kingdom	**0.300**	**0.130**	**0.275**	**0.103**	**0.194**	**211%**	**187%**	**66.29**	**192.38**

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-27* countries, 2012

EU-27 MS	*PF* (bcm/day)	*PF*-1 (bcm/day)	Nature of the largest supply source	*PF*-2 (bcm/day)	Nature of the second largest supply souce
Austria	0.279	0.128	Import pipeline	0.101	Storage
Belgium	0.397	0.335	Import pipeline	0.276	Import pipeline
Bulgaria	0.075	0.004	Import pipeline	0.000	Storage
Cyprus*	-	-	-	-	-
Czech Republic	0.303	0.149	Import pipeline	0.094	Import pipeline
Denmark	0.046	0.032	Indigenous production	0.020	Storage
Estonia	0.022	0.010	Import pipeline	0.003	Import pipeline
Finland	0.019	0.000	Import pipeline	-	-
France	0.550	0.493	Storage	0.437	Import pipeline
Germany	1.298	1.197	Import pipeline	1.108	Import pipeline
Greece	0.028	0.015	LNG	0.003	Import pipeline
Hungary	0.155	0.099	Import pipeline	0.071	Storage
Ireland	0.035	0.005	Import pipeline	0.003	Storage
Italy	0.689	0.569	Import pipeline	0.464	Import pipeline
Latvia	0.047	0.025	Storage	0.006	Import pipeline
Lithuania	0.037	0.006	Import pipeline	0.000	Import pipeline
Luxembourg	0.011	0.006	Import pipeline	0.001	Import pipeline
Malta*	-	-	-	-	-
Netherlands	0.816	0.574	Indigenous production	0.519	Storage
Poland	0.217	0.122	Import pipeline	0.100	Storage
Portugal	0.043	0.022	LNG	0.010	Import pipeline
Romania	0.165	0.069	Import pipeline	0.044	Storage
Slovak Republic	0.388	0.065	Import pipeline	0.027	Storage
Slovenia	0.011	0.004	Import pipeline	0.000	Import pipeline
Spain	0.278	0.231	LNG	0.193	Import pipeline
Sweden	0.009	0.0006	Import pipeline	0.000	Storage
United Kingdom	**0.702**	**0.628**	**Import pipeline**	**0.559**	**Import pipeline**

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