Physical gas flows across the EU-28 and diversity of gas supply in 2013

Background

This article has two main purposes. The first is to illustrate physical gas flows at the European level using 2013[1] data published by the International Energy Agency (IEA), 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-28 gas production in 2013 was 172.4 billion cubic metres (bcm), with the Netherlands and the UK accounting for 50 per cent and 22 per cent of this total respectively. Out of all EU-28 countries, only the Netherlands and Denmark produced more gas than they consumed.

European Gas Consumption

During 2013 total EU-28 gas consumption was 471 bcm with the greatest demand coming from Germany, the United Kingdom and Italy. These countries together accounted for 50 per cent of EU-28 consumption. Germany remained the largest net importer in Europe in 2013 at 84 bcm, followed by Italy at 61 bcm and then France at 45 bcm[2].

Countries such as Italy, Spain, Romania and Hungary have seen a reduction in gas demand. This reflected sluggish economic growth in 2013 and a continuing shift in electricity generation away from natural gas and in to coal.

Sources of Gas

Thirty seven per cent of EU-28 consumption in 2013 was met by indigenous production, with production from Netherlands and UK meeting 18 and 8 per cent of total EU demand respectively.

The Russian Federation remained the largest single supplier of gas to the EU-28, delivering around 122 bcm, or 26 per cent, of total EU-28 gas demand in 2013. 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.

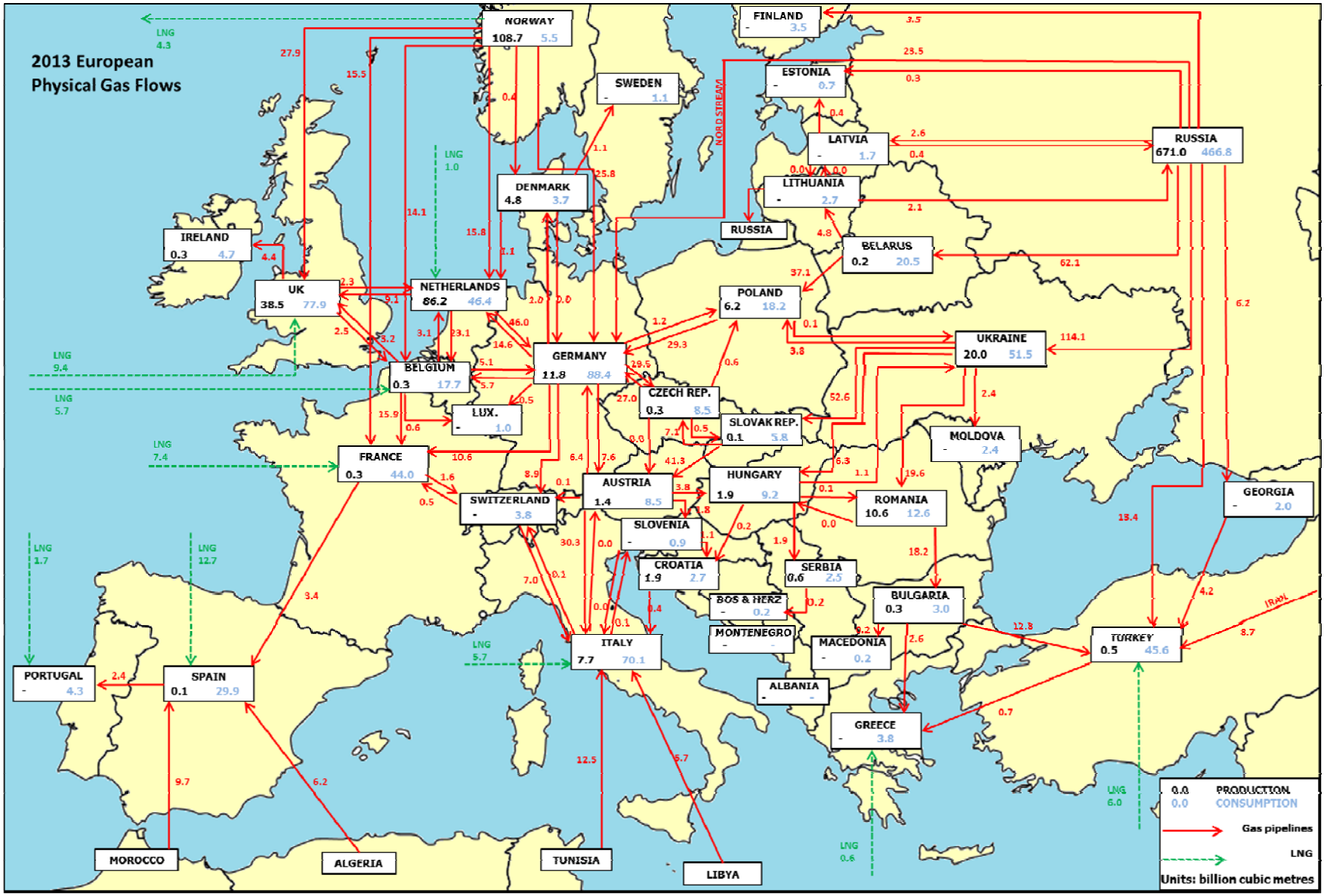
Norwegian exports to the EU-28 remained the same between 2012 and 2013, at around 102 bcm or 21 per cent of total EU-28 gas consumption; 27 per cent of Norwegian exports were directed to the UK in 2013.

North African pipelines via Spain and Italy provided 34 bcm, or 7 per cent, of EU-28 demand. Algerian gas, coming direct from Algeria and also via Morocco and Tunisia, accounted for 83 per cent of North African gas delivered to the EU-28, with Libya supplying the remainder.

EU-28 imports of LNG were 44.3 bcm in 2013 versus 55.8 bcm in 2012, reflecting increased demand from Asia in 2013 (and henceforth higher prices relative to the previous year). LNG met 9 per cent of EU-28 demand and, in particular, 42 per cent of Spanish gas consumption. The largest suppliers of LNG to the EU-28 were Qatar, Algeria and Nigeria, who supplied 40, 29 and 16 per

1 January 1st 2013 to December 31st 2013 data

2 These numbers differ slightly from the IEA's annual figures due to the adjustments necessary to balance supply to within +/- 5% of observed consumption. The supply for some countries may appear unbalanced as stock changes are not shown. Data were calculated primarily from 2013 monthly pipeline gas flows, with 2013 annual imports, exports, production and consumption used for quality assurance amendments.


2013 European
Physical Gas Flows
NORWAY
108.7 5.5
FINLAND
- 3.5
SWEDEN
- 1.1
ESTONIA
- 0.7
LATVIA
- 1.7
LITHUANIA
- 2.7
RUSSIA
671.0 466.8
DENMARK
4.8 3.7
RUSSIA
IRELAND
0.3 4.7
UK
38.5 77.9
NETHERLANDS
86.2 46.4
BELARUS
0.2 20.5
POLAND
6.2 18.2
UKRAINE
20.0 51.5
GERMANY
11.8 88.4
BELGIUM
0.3 17.7
LUX.
- 1.0
CZECH REP.
0.3 8.5
SLOVAK REP.
0.1 5.8
MOLDOVA
- 2.4
FRANCE
0.3 44.0
AUSTRIA
1.4 8.5
HUNGARY
1.9 9.2
ROMANIA
10.6 12.6
GEORGIA
- 2.0
SWITZERLAND
- 3.8
SLOVENIA
- 0.9
CROATIA
1.9 2.7
SERBIA
0.6 2.5
BOS & HERZ
- 0.2
BULGARIA
0.3 3.0
MONTENEGRO
-
MACEDONIA
- 0.2
TURKEY
0.5 45.6
ALBANIA
-
GREECE
- 3.8
ITALY
7.7 70.1
PORTUGAL
- 4.3
SPAIN
0.1 29.9
MOROCCO
ALGERIA
TUNISIA
LIBYA
IRAN
NORD STREAM
LNG
4.3
LNG
1.0
LNG
9.4
LNG
5.7
LNG
7.4
LNG
1.7
LNG
12.7
LNG
5.7
LNG
6.0
LNG
0.6
0.0 PRODUCTION
0.0 CONSUMPTION
Gas pipelines
LNG
Units: billion cubic metres

cent of total EU-28 LNG imports respectively.

UK imports of LNG in 2013

Although UK imports of LNG decreased by 32 per cent, from 13.9 bcm in 2012 to 9.4 bcm in 2013, the data showed the UK to be the second largest importer of LNG in 2013, behind Spain. 93 per cent of UK imports of LNG came from Qatar in 2013, down from 98 per cent in 2012.

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-28 Infrastructure peak daily gas supply in 2013

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 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 2014[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 had to be estimated, by taking the maximum monthly production (bcm) in 2013 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 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).

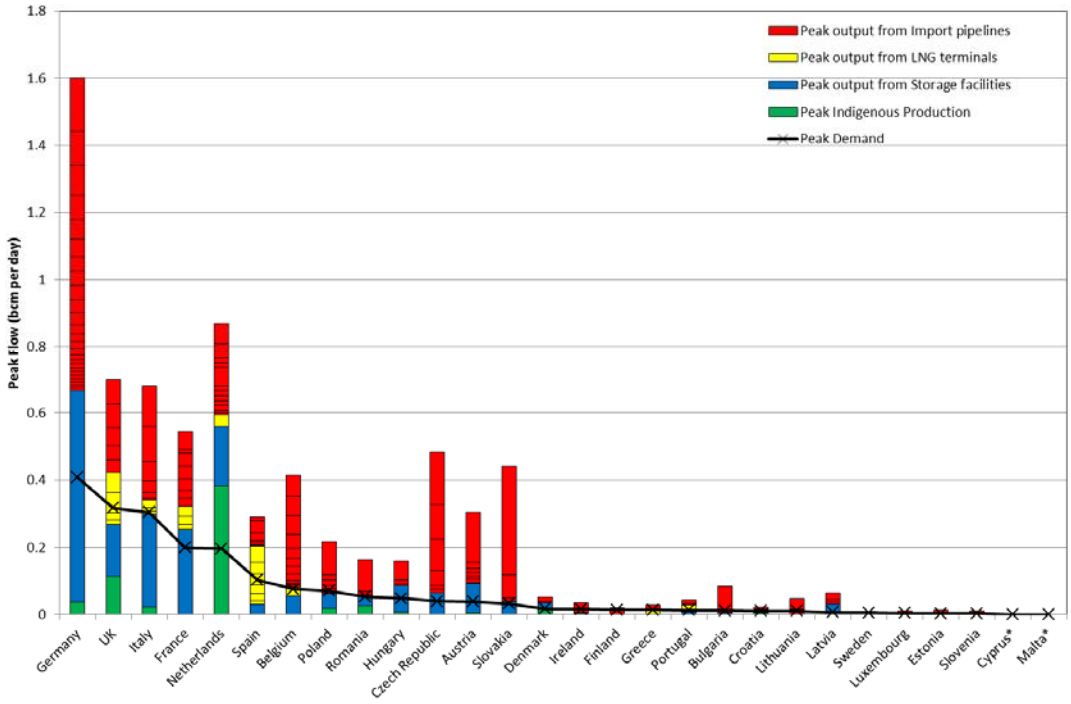
Chart 1 includes all EU-28 member states in order of peak gas demand. Peak gas demand data (bcm per day) are included within Chart 1 as a single line-and-cross plot running across the graph. Peak gas demand acts as a comparator for peak gas supply, and was estimated for each country by taking the maximum monthly demand in 2013 (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 2013, 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. The UK also had the most diverse category breakdown for gas supplies, with each of the four potential gas sources making up at least 16 per cent of peak supply.

[3] www.iea.org/gtf/index.asp
[4] Natural Gas Information 2014, International Energy Agency, ISBN 9789264217058

Chart 1: Peak outputs for gas supply sources versus 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 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, 26 in total. There are substantially fewer import pipelines in EU countries east of Germany. Of particular note, although the Slovak Republic appeared to have a peak supply that far exceeded demand, almost all of this came via a single pipeline. 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 2013

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

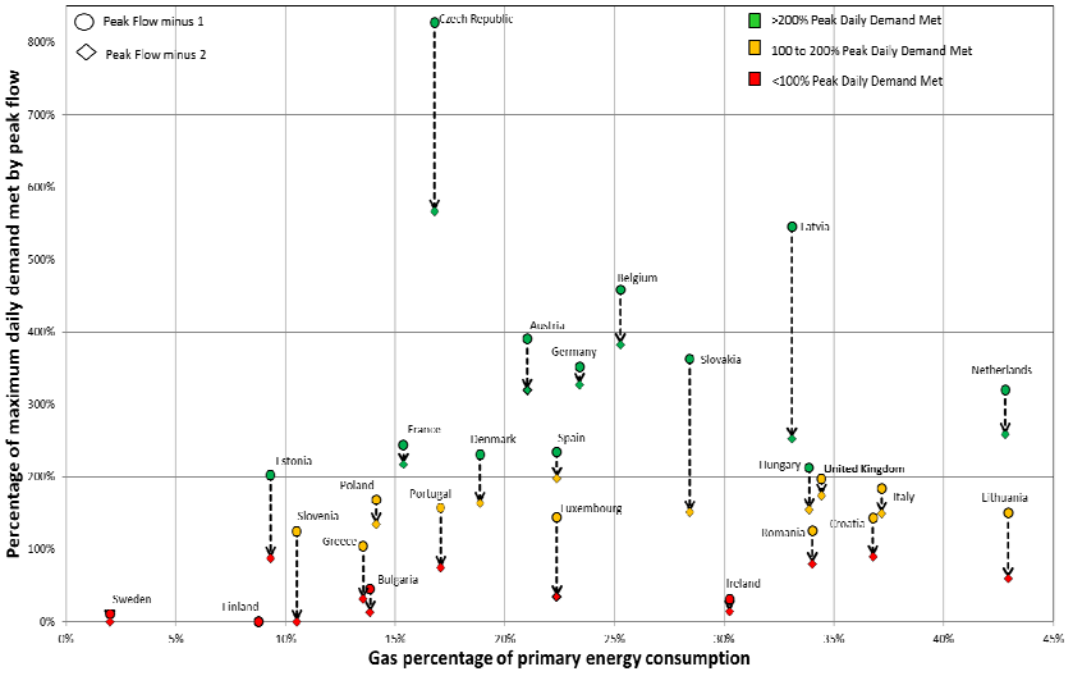
$$PF - 1[\%] = \frac{EP_{\max} + P_{\max} + S_{\max} + LNG_{\max} - I_{\max}}{D_{\max}} \qquad \text{Equation 1}$$

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 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 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 2013, we use the peak gas demand in each country for 2013 (January 1st 2013 to December 31st 2013), taking the maximum monthly demand in 2013 (bcm) and dividing this by the number of days within that month. In addition to *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 2).

Chart 2: EU-28* gas infrastructure resilience versus percentage of primary energy consumption met by gas, 2013



*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 Czech Republic, Belgium, Germany, Austria, Netherlands, Latvia and France to have particularly resilient gas infrastructure. In all seven countries, the gas infrastructure was able to provide more than double the peak gas demand in 2013, even with the loss of their two largest gas supply routes, although in the case of Latvia peak demand was lower than 2012 whilst peak supply was similar. The Czech Republic effectively doubled its resilience following the completion of the Gazelle pipeline project which became operational in January 2013 connecting into German pipelines receiving flows from Russia through the Nord Stream. Finland, Sweden, Ireland and Bulgaria were particularly vulnerable to infrastructure disruptions, with these four countries unable to meet peak daily demand after the loss of the largest gas supply route. Ireland was particularly vulnerable, given that they relied on gas for more than 30 per cent of their 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 Estonia has two major supply routes: although resilient to a single supply disruption (meeting 203 per cent of peak demand), Estonia becomes vulnerable after the loss of these two main routes. This is also the case for Slovenia, Greece, Portugal, Luxembourg, Romania, Croatia and Lithuania.

According to the data, the UK was resilient to infrastructure disruptions in 2013, with 197 and 175 per cent of peak demand met with the loss of the largest and two largest gas supply routes respectively. Overall, according to the peak flow metric and data used in this report, the UK was the ninth most resilient Member State to gas supply infrastructure disruptions, but was the fifth most dependent on gas for primary energy demand in 2013.

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 appears well-placed to meet this requirement. For those seven countries most at risk (*PF*-1 and *PF*-2 both less than 100% in Chart 2), all apart from Luxembourg have plans in place to increase their gas infrastructure[5]. Further, it is important to note these data was 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.

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 March 2014[6]. From a UK perspective, there are a diverse range of gas sources, from pipelines LNG imports, storage and indigenous production, with good resilience to disruption of major supply sources. In general, North-western Europe has the highest resilience to infrastructure disruption.

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-28 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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[5] www.entsog.eu/maps/transmission-capacity-map
[6] www.gov.uk/government/uploads/system/uploads/attachment_data/file/295263/Physical_gas_flows.pdf

Annex 1: Table of key data for gas use in the EU-28* countries, 2013

	Peak daily [X] (Billion cubic metres per day)							(annual)	(annual)
EU-28 MS	**Demand ****	**Indigenous production ****	**Import pipelines**	**Storage supply**	**LNG output**	***PF*-1 score**	***PF*-2 score**	**Natural Gas Consum-ption (Mtoe)**	**Total Primary Energy Consumption (Mtoe)**
Austria	0.03942	0.00435	0.211	0.0896	0	391%	320%	7.00	33.30
Belgium	0.07681	0	0.332	0.057	0.026	459%	383%	14.19	56.14
Bulgaria	0.0122	0.00159	0.08	0.004	0	46%	13%	2.37	17.09
Croatia	0.01088	0.005	0.012	0.0058	0	143%	90%	2.99	8.12
Cyprus*	0	0	0	0	0	0%	0%	0.00	2.90
Czech Republic	0.03958	0.00061	0.418	0.065	0	828%	567%	6.95	41.37
Denmark	0.01713	0.0151	0.016	0.0202	0	231%	164%	3.31	17.54
Estonia	0.00355	0	0.014	0	0	203%	88%	0.55	5.90
Finland	0.01435	0	0.019	0	0	0%	0%	2.83	32.27
France	0.20019	0.00132	0.222	0.2521	0.069	245%	218%	38.81	252.29
Germany	0.40884	0.03806	0.933	0.6295	0	352%	328%	73.13	312.39
Greece	0.01426	0	0.015	0	0.0145	104%	32%	3.24	23.93
Hungary	0.04829	0.00658	0.073	0.0798	0	213%	155%	7.75	22.88
Ireland	0.01613	0.00229	0.03	0.0028	0	32%	14%	4.05	13.39
Italy	0.30474	0.022	0.339	0.2758	0.0444	184%	150%	57.37	154.31
Latvia	0.00648	0	0.035	0.03	0	545%	253%	1.36	4.11
Lithuania	0.01088	0	0.048	0	0	150%	60%	2.43	5.67
Luxembourg	0.00416	0	0.011	0	0	144%	35%	0.89	3.98
Malta*	0	0	0	0	0	0%	0%	0.00	2.32
Netherlands	0.19632	0.38245	0.274	0.1778	0.0348	320%	259%	33.05	77.20
Poland	0.07081	0.01829	0.155	0.0439	0	169%	135%	13.72	97.05
Portugal	0.01371	0	0.014	0.0072	0.0219	158%	75%	3.77	22.08
Romania	0.05444	0.02674	0.11	0.028	0	126%	80%	11.24	33.04
Slovak Republic	0.03294	0.00071	0.403	0.0393	0	363%	152%	4.81	16.92
Slovenia	0.00345	0	0.011	0	0	125%	0%	0.69	6.56
Spain	0.10271	0.00019	0.085	0.0315	0.1734	235%	198%	26.07	116.56
Sweden	0.00568	0	0.009	0.0006	0	11%	0%	0.96	48.01
United Kingdom	0.3179	0.11535	0.277	0.154	0.1545	197%	175%	65.50	190.22

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, 2013

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	Peak demand (bcm/d)
Austria	0.305	0.15	Import pipeline	0.13	Storage	0.04
Belgium	0.415	0.35	Import pipeline	0.29	Import pipeline	0.08
Bulgaria	0.085	0.01	Import pipeline	0.00	Storage	0.01
Croatia	0.023	0.02	Import pipeline	0.01	Storage	0.01
Cyprus	0.000	0.00	-	0.00	-	0.00
Czech Republic	0.484	0.33	Import pipeline	0.22	Import pipeline	0.04
Denmark	0.052	0.04	Storage	0.03	Import pipeline	0.02
Estonia	0.014	0.01	Import pipeline	0.00	Import pipeline	0.00
Finland	0.019	0.00	Import pipeline	0.00	-	0.01
France	0.545	0.49	Storage	0.44	Import pipeline	0.20
Germany	1.600	1.44	Import pipeline	1.34	Import pipeline	0.41
Greece	0.029	0.01	LNG	0.00	Import pipeline	0.01
Hungary	0.159	0.10	Import pipeline	0.07	Storage	0.05
Ireland	0.035	0.01	Import pipeline	0.00	Storage	0.02
Italy	0.681	0.56	Import pipeline	0.46	Import pipeline	0.30
Latvia	0.065	0.04	Storage	0.02	Import pipeline	0.01
Lithuania	0.048	0.02	Import pipeline	0.01	Import pipeline	0.01
Luxembourg	0.011	0.01	Import pipeline	0.00	Import pipeline	0.00
Malta	0.000	0.00	-	0.00	-	0.00
Netherlands	0.869	0.63	Indigenous production	0.51	Import pipeline	0.20
Poland	0.217	0.12	Import pipeline	0.10	Storage	0.07
Portugal	0.044	0.02	LNG	0.01	Import pipeline	0.01
Romania	0.165	0.07	Import pipeline	0.04	Storage	0.05
Slovakia	0.443	0.12	Import pipeline	0.05	Import pipeline	0.03
Slovenia	0.011	0.00	Import pipeline	0.00	Import pipeline	0.00
Spain	0.290	0.24	LNG	0.20	Import pipeline	0.10
Sweden	0.009	0.00	Import pipeline	0.00	Storage	0.01
United Kingdom	**0.701**	**0.626915**	**Import pipeline**	**0.555395387**	**Import pipeline**	**0.317903226**

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