Combined Heat and Power in Scotland, Wales, Northern Ireland and the regions of England in 2017

Background

Combined Heat and Power (CHP) is the simultaneous generation of usable heat and power (usually electricity) in a single process. CHP data for the UK as a whole are updated annually and published in the Digest of United Kingdom Energy Statistics (DUKES), the latest edition of which was published in July 2018. This article updates statistics published in the September 2017 edition of Energy Trends and provides a breakdown of CHP in the Devolved Administrations and English regions in 2017[1].

The data presented originates from a CHP database maintained by Ricardo Energy & Environment on behalf of The Department of Business Energy and Industrial Strategy (BEIS). Data relating to the overwhelming majority of CHP electrical capacity (>99 per cent of total capacity) is received annually from the reliable sources of the Combined Heat and Power Quality Assurance (CHPQA) programme, the Iron and Steel Statistics Bureau (ISSB) and from Ofgem's Renewable Obligations Certificates (ROCs) returns. Another source of data is the sales databases of the Association for Decentralised Energy (ADE). Data from CHP schemes not covered by the above sources are extrapolated from historic data. There is an ongoing data quality assurance exercise in respect of these schemes.

Between 2016 and 2017 there was a net increase in Good Quality CHP[2] capacity of 209 MWe and a net increase of 162 in the number of CHP schemes in the database (194 new schemes and the removal of 32 schemes). Good Quality CHP capacity in the UK increased from 5,625 MWe (revised 2016 figure) to 5,835 MWe in 2017. As discussed in the 2018 edition of the Digest, the availability of new information regarding a number of Anaerobic Digestion (AD) schemes has made it possible to classify these schemes as CHP, as defined for the purposes of Chapter 7 of the Digest and this paper. These AD schemes have made a significant contribution to the aforementioned 209 MWe increase in capacity and the increase in renewable fuel consumption, discussed later in the paper.

Regional Trends[3]

Tables 1 and 1B show a comparison of the number of schemes, electrical capacity, electricity generated and heat generated in the regions[4] for the period 2015 to 2017. During this time, the total number of schemes increased from 2,130 to 2,386 and the capacity increased from 5,708 MWe to 5,835 MWe. Over this period, every region saw an increase in the number of CHP schemes and the capacity increased in all regions with the exception of North East, North West and South East. Capacity falls in these three regions were substantially driven by the closure of large industrial CHP plant, with closures in the Chemicals, Paper and Iron and Steel sectors driving the falls in the North West, South and North East regions, respectively.

[1] Similar articles on CHP have appeared in previous Energy Trends publications from 2001 to 2016. The figures within any one article are a snapshot of the position as seen at the time and therefore figures between articles do not constitute a time series. For example, there have been revisions made to the installed capacity for 2014 and 2015 shown in this article compared to the installed capacity shown for those years in last year's edition of this article.

[2] Good Quality CHP denotes schemes that have been certified as being highly efficient through the UK's CHP Quality Assurance (CHPQA) programme.

[3] Note: The figures for previous years are revised on an annual basis to account for late information submitted after the publication date of the article. This is to ensure that the true trends are captured in the data. The figures herein therefore supersede the previous articles published.

[4] These regions are the Government Office Regions of England and Devolved Administrations of Scotland, Wales and Northern Ireland.

Table 1: Trend in number of CHP schemes and their electrical capacity over the period 2015-2017

	Number of Schemes			Electrical Capacity (MWe)		
	2015	**2016**	**2017**	**2015**	**2016**	**2017**
England	**1,799**	**1,878**	**1,998**	**4,918**	**4,772**	**4,948**
East Midlands	115	116	130	130	131	151
Eastern	168	183	196	310	313	340
London	303	323	336	226	244	236
North East	111	113	127	374	333	360
North West	291	295	312	741	695	721
South East	298	316	323	896	819	851
South West	144	153	165	116	120	132
West Midlands	176	182	200	110	111	135
Yorkshire/Humberside	193	197	209	2,016	2,006	2,022
Scotland	137	150	170	525	553	557
Wales	117	120	132	184	220	235
Northern Ireland	77	76	86	82	81	96
UK Total	**2,130**	**2,224**	**2,386**	**5,708**	**5,625**	**5,835**

Table 1B: Trend in CHP electricity and heat generated over the period 2015-2017

	Electricity Generated (GWh)			Heat Generated (GWh)		
	2015	**2016**	**2017**	**2015**	**2016**	**2017**
England	**16,228**	**17,027**	**17,840**	**32,020**	**32,108**	**33,538**
East Midlands	622	636	725	1,355	1,336	1,433
Eastern	1,381	1,341	1,495	1,994	1,820	1,921
London	584	649	720	1,194	1,299	1,341
North East	1,078	1,079	1,341	4,094	3,580	4,018
North West	2,527	2,533	2,688	7,678	7,610	7,956
South East	2,726	2,747	3,009	6,393	6,509	6,778
South West	407	603	666	503	555	576
West Midlands	480	472	595	761	843	878
Yorkshire/Humberside	6,424	6,966	6,601	8,048	8,555	8,638
Scotland	2,435	2,329	2,655	5,760	6,121	6,205
Wales	613	712	769	1,931	1,934	1,989
Northern Ireland	258	337	384	524	507	506
UK Total	**19,534**	**20,405**	**21,648**	**40,234**	**40,670**	**42,238**

The region with the highest proportion of the UK's electrical capacity is still the Yorkshire and Humberside region with a 35 per cent share, followed by the South East (15 per cent) the North West (12 per cent) and Scotland (10 per cent). The Yorkshire and Humberside region hosts the largest CHP scheme in the UK and this contributes significantly to the dominance of this region in terms of capacity. In all, 80 per cent of the electricity capacity shown in Table 1 for 2017 is taken up by just 136 of the 2,386 schemes.

The four largest regions in terms of installed capacity were also the four largest regions in terms of electricity generation. In 2017, the Yorkshire and Humberside region accounted for 30 per cent of all Good Quality electricity generated in the UK, which is a decrease from 34 per cent (revised) in 2016. As with capacity, a very large proportion of Good Quality electricity generated is taken up by a very small number of schemes.

With 20 per cent of the total CHP heat delivered, the Yorkshire and Humber region provided the largest share of CHP heat in 2017. However, the dominance of CHP heat generation of this region is not as great as for CHP electricity generation. This is a consequence of the CHP technology supplying the very large majority of electricity generated (Combined Cycle Gas Turbines), where the ratio of heat to power generation is much lower than for other CHP technologies.

Chart 1: CHP generation by area in 2017

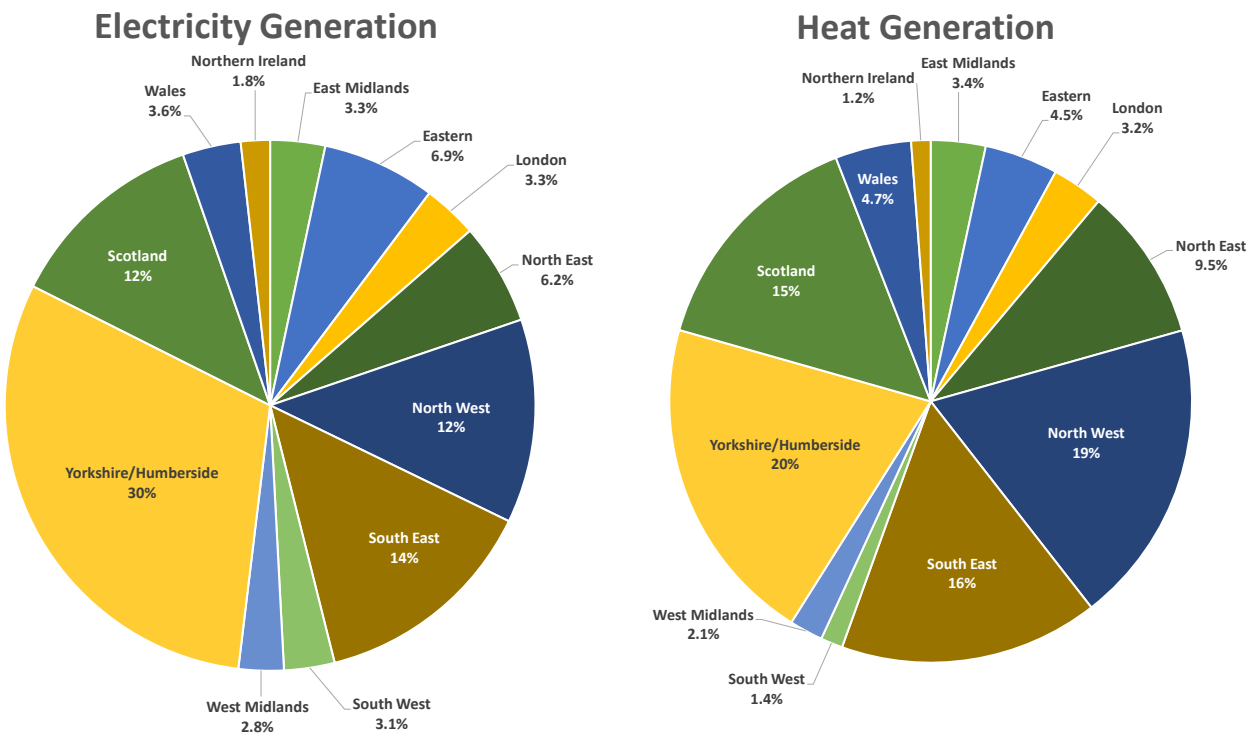


Table 2 shows an overview of CHP plant data broken down between the English regions and devolved administrations. The extent to which CHP capacity is utilised can be expressed by the Load Factor (LF). LF is the actual power generation as a proportion of the theoretical maximum power that can be generated for a given total installed capacity (TPC). The power output that is actually generated is the total power output (TPO). For 2017, the TPC was 8,615 MWe[5] and the TPO was 42,586 GWh, giving a LF of 56.4 per cent. This is a lower value than for 2016 (60.0 per cent). In 2016 there were notably large LF values at a number of large power generating sites in the Yorkshire and Humber and South East regions which was not repeated in 2017.

Higher LF values tend to be found when CHP is deployed to satisfy industrial heat loads. This is because the demand for heat extends over a greater proportion of the year at industrial sites than at sites where CHP is deployed to satisfy space heating, where demand is seasonal. The regions with the highest load factors tend to be those with very large proportions of power output generated at CHP situated at industrial sites, while low load factors tend to be found in regions where large proportions of power is generated at CHP situated at non-industrial sites.

[5] The Total Power Capacity (TPC) is the registered maximum power generating capacity of a CHP scheme. It should be distinguished from Qualifying Power Capacity (QPC). QPC is defined under the CHPQA Standard and is also known as Good Quality capacity. QPC is the registered power generation capacity that achieves a QI of 100 or more under conditions of Maximum Heat Output under Normal Operating Conditions, as defined in the CHPQA Standard. Where a CHP scheme does achieve a QI of 100 or more under these conditions, its TPC and QPC are the same. Where it does not, then the capacity considered Good Quality is scaled- back and under these circumstances TPC>QPC. Unless otherwise stated, QPC is the basis of all power capacities quoted in this article.

Table 2: Overview of CHP schemes in 2017

	Number of Schemes	Electrical Capacity (QPC)* MWe	Electrical Capacity (TPC) MWe	Heat Capacity MWth	Fuel Used* GWh	Electricity Generated (QPO)* GWh	Electricity Generated (TPO) GWh	Heat Generated GWh	Load Factor** (%)
England	**1,998**	**4,948**	**7,485**	**16,417**	**71,789**	**17,840**	**36,646**	**33,538**	55.9%
East Midlands	130	151	193	632	3,129	725	1,121	1,433	66.3%
Eastern	196	340	340	933	4,710	1,495	1,524	1,921	51.2%
London	336	236	270	953	2,801	720	1,091	1,341	46.1%
North East	127	360	386	936	7,090	1,341	1,885	4,018	55.7%
North West	312	721	864	4,213	13,928	2,688	4,099	7,956	54.2%
South East	323	851	2,054	3,182	13,468	3,009	8,562	6,778	47.6%
South West	165	132	132	305	2,332	666	692	576	59.9%
West Midlands	200	135	150	523	2,481	595	744	878	56.7%
Yorkshire/Humberside	209	2,022	3,096	4,740	21,850	6,601	16,927	8,638	62.4%
Scotland	170	557	710	2,629	12,698	2,655	3,863	6,205	62.1%
Wales	132	235	324	910	4,267	769	1,685	1,989	59.3%
Northern Ireland	86	96	96	235	1,525	384	392	506	46.7%
UK Total	**2,386**	**5,835**	**8,615**	**20,191**	**90,279**	**21,648**	**42,586**	**42,238**	**56.4%**

∗This represents Good Quality CHP capacity (QPC), Good Quality CHP power output (QPO) and the fuel associated with the Good Quality CHP outputs. For further details on how these are defined, see Dukes 2018 Chapter 7 and the Combined Heat and Power Quality Assurance (CHPQA) Standard Issue 5): www.gov.uk/government/uploads/system/uploads/attachment_data/file/335471/CHPQAStandardIssue5.pdf

** These load factors are based on the total power output (TPO) and total power capacity (TPC) of the CHP (for partially and fully qualified schemes). This gives the true utilisation of the power generating plant.

Importance of CHP in the Regional Economies

Chart 1 shows the CHP outputs of each region and is derived from the data contained in Table 1B. It portrays only a limited picture as it does not account for the varying size of each region's economy. To allow for this, CHP heat capacity and electrical capacity have been compared with the level of economic activity in each region as measured by Gross Value Added (in £ million) in Table 3. Chart 2 maps the heat capacity per unit of GVA for the different regions.

CHP continues to be a very important part of the economies of the Yorkshire/Humber, North West, Scotland and North East regions, as evidenced by the large heat capacities per unit of GVA in these regions. This is due to the prominence of the chemicals and oil refining industries in these regions, which are heat intensive sectors and are suited to CHP.

Table 3: Density of CHP in different areas, ordered by heat capacity

	Heat capacity per unit GVA kWt/ (£million)*	Electrical capacity per unit GVA kWe/ (£million)*
Yorkshire/Humberside	41.04	17.51
North West	25.48	4.36
Scotland	**19.56**	**4.14**
North East	18.17	6.98
Wales	**15.23**	**3.92**
South East	12.37	3.31
England	**10.98**	**3.31**
East Midlands	6.22	1.48
Eastern	6.21	2.26
Northern Ireland	**6.17**	**2.52**
West Midlands	4.07	1.05
London	2.41	0.60
South West	2.35	1.02
UK total	**11.69**	**3.38**

*GVA is provisional gross value added in 2016 (income approach) at current prices[6]

The distribution of CHP capacity across the regions and economic sectors is summarised in Table 4, which shows the proportion of total CHP capacity in a particular economic sector in each region. The most striking feature of Table 4 is the very large proportion (62 per cent) of CHP capacity serving the oil refineries and oil and gas terminals sector being located in the Yorkshire and Humber regions. Nearly 85 per cent of CHP capacity in the Chemicals sector is to be found in just three regions (Yorkshire and Humber, North West and North East), which is consistent with the

[6] www.ons.gov.uk/economy/grossvalueaddedgva/datasets/regionalgrossvalueaddedincomeapproach

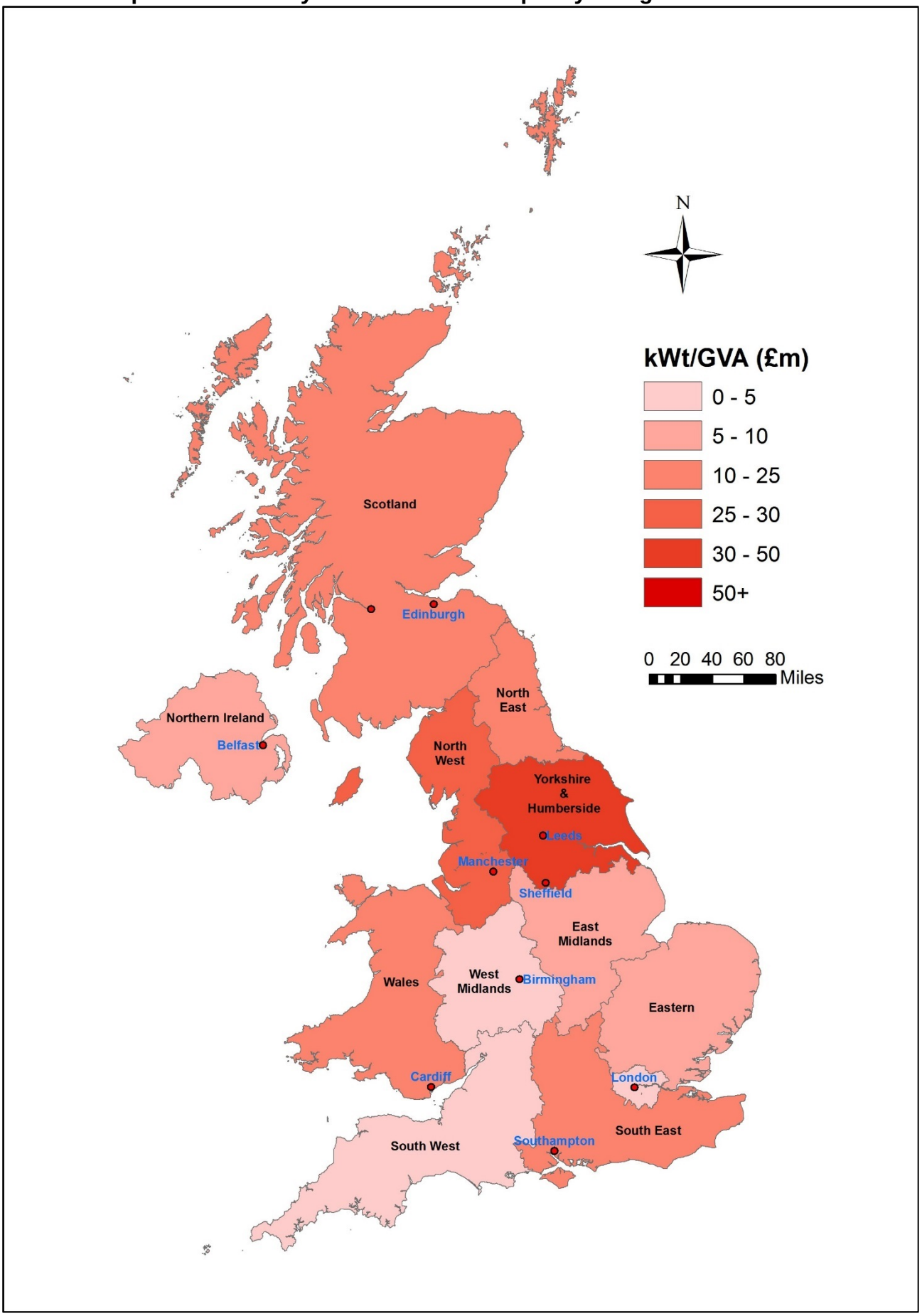
importance of the Chemical industry to the economies of these parts of the country. A large proportion (nearly 83 per cent) of CHP capacity serving the Paper sector is installed in just three regions (South East, North West and Scotland), attesting to the concentration of this industry in these regions. The dominance of the South East region for CHP serving the Paper sector has reduced in recent years due to site closures. In 2010 51 per cent of all CHP capacity operating in the paper sector was located in the South East. In 2017 this had fallen to 35 percent.

The large proportion of capacity installed in the Food and Drink sector in the Eastern region (42 per cent), is substantially due to that region's sugar from sugar beet refining operations. The predominance of services in London and the South East is reflected by these two regions having the highest and second highest shares, respectively, of capacity installed within the Transport Commerce and Administration sector.

Table 4: Distribution of CHP capacity across the regions and economic sectors in 2017

Region	Sector									
	Iron and Steel and Non-ferrous Metals	Chemicals	Oil Refineries and Oil and Gas Terminals	Paper, Publishing and Printing	Food, Beverages and Tobacco	Metal Products, Machinery and Equipment	Mineral Products	Other Industrial Branches	Transport, Commerce and Administration	Other
England	60.1%	88.6%	86.6%	72.9%	84.5%	81.5%	100.0%	70.7%	80.7%	89.1%
East Midlands	0.0%	1.3%	0.0%	0.0%	6.2%	4.1%	7.2%	7.7%	5.5%	7.0%
Eastern	14.6%	1.4%	0.0%	0.0%	42.3%	0.0%	0.0%	8.6%	5.1%	8.4%
London	7.3%	0.0%	0.0%	0.0%	5.7%	13.7%	0.0%	10.9%	15.2%	12.5%
North East	0.0%	23.9%	0.0%	0.0%	0.0%	0.0%	19.7%	4.2%	7.0%	5.4%
North West	0.0%	24.6%	5.0%	29.5%	16.4%	5.4%	51.3%	6.8%	9.9%	6.9%
South East	0.0%	0.2%	19.5%	35.0%	4.4%	6.2%	0.0%	12.8%	11.9%	22.9%
South West	0.0%	0.7%	0.0%	0.0%	1.7%	6.3%	21.9%	5.6%	8.9%	5.5%
West Midlands	0.0%	0.2%	0.0%	2.5%	0.0%	45.8%	0.0%	8.7%	8.0%	4.8%
Yorkshire and Humber	38.1%	36.3%	62.2%	5.9%	7.9%	0.0%	0.0%	5.5%	9.1%	15.7%
Scotland	0.0%	7.1%	11.2%	18.3%	8.1%	0.7%	0.0%	9.8%	9.7%	5.8%
Wales	36.4%	3.2%	2.2%	8.8%	1.9%	8.8%	0.0%	19.4%	3.4%	2.4%
Northern Ireland	3.5%	1.1%	0.0%	0.0%	5.4%	9.0%	0.0%	0.1%	6.2%	2.7%
UK Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Chart 2: Map of CHP density in terms of heat capacity and gross value added



Technology type and size

Tables 5 and 6 show the regional split of installed electrical capacity (which qualifies as Good Quality CHP capacity) by prime mover (Table 5) and by size range (Table 6). In a number of regions, disaggregation of the data by prime mover or size could result in the disclosure of confidential information and so, for these areas, only totals are shown. The following conclusions can be drawn from the tables:

- Gas turbines, whether on their own or as part of Combined Cycle Gas Turbines (CCGT), continue to dominate the CHP market. In 2017, gas turbine based schemes accounted for 65 per cent of total CHP capacity but only 6 per cent of the total number of CHP schemes. However, the dominance of gas turbine based CHP has reduced over the years. In 2010 it accounted for 81 per cent of capacity. The reduction in this share has taken place at the same time that the share of capacity taken up by reciprocating engines has increased from 13 per cent to 26 per cent.

- The North West remains the region with the largest steam turbine based capacity. All of this capacity is at industrial sites. Scotland is the region with the second largest steam turbine based capacity, followed by the Yorkshire and the Humber.

- Reciprocating Engines constitute the vast majority of all CHP schemes (92 per cent of all schemes). The region with the largest number of reciprocating engine schemes is London, followed by the South East and the North West. This is a well established pattern and is a reflection of the high number of leisure centres, hotels and retail outlets found in these regions, for which reciprocating engines are well suited.

Table 5: CHP electrical capacity (MWe) by area and prime mover in 2017

	Gas Turbines*	Steam Turbines	Organic Rankine Cycle	Gas, Steam Turbine and ORC Subtotal	Reciprocating Engines	Total
England	**3,326**	**350**	**6**	**3,681**	**1,267**	**4,948**
East Midlands	-	-	-	60	91	151
East of England	-	-	-	193	147	340
London	-	-	-	42	194	236
North East	-	-	-	271	89	360
North West	388	179	1	567	154	721
South East	595	3	-	598	253	851
South West	18	25	-	44	88	132
West Midlands	-	-	0.3	17	118	135
Yorkshire and The Humber	1,816	75	-	1,891	131	2,022
Scotland	365	95	3	463	93	**557**
Wales	-	-	3	148	87	**235**
Northern Ireland	-	-	-	33	63	**96**
Grand Total	**-**	**-**	**-**	**4,325**	**1,510**	**5,835**

*Includes Combined Cycle Gas Turbines (CCGT)

The CHP market continues to be dominated by large-scale (>10MWe) plants, with 72 per cent of all installed capacity being in this size range. However, this proportion has been in steady decline over a number of years as larger (usually) industrial based CHP has closed and smaller (often) non-industrial based schemes have opened. For example in 2010, the proportion of installed capacity that was taken up by schemes > 10 MWe capacity was 83 per cent.

The regional distribution of CHP by capacity tranche is given in Table 6. Over 44 per cent of all capacity greater than 10 MWe is to be found in the Yorkshire and Humber region. The region with the second largest share of CHP capacity greater than 10 MWe is the South East (14 per cent), followed by the North West (12 per cent) and Scotland (10 per cent). Again, this is consistent with

the tendency for heat intensive industries such as oil refineries, chemicals and paper, for which CHP is suitable, to be located in these regions.

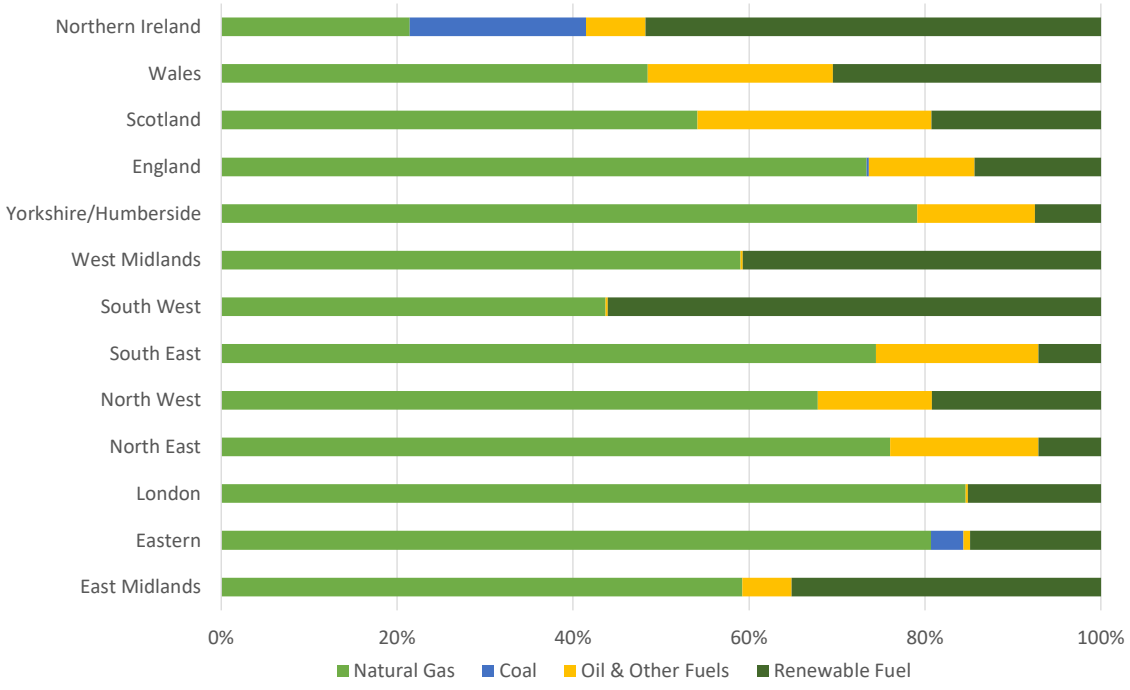
Table 6: CHP electrical capacity (MWe) by area and size in 2017

	<= 100 kWe	> 100 kWe to 1 MWe	>1 MWe to 2 MWe	> 2 MWe to 10 MWe	> 10 MWe +	Total
England	**37**	**278**	**228**	**847**	**3,558**	**4,948**
East Midlands	2	17	27	-	-	151
East of England	3	28	22	-	-	340
London	7	49	24	-	-	236
North East	3	11	11	83	252	360
North West	5	44	43	115	514	721
South East	5	44	35	165	602	851
South West	3	29	16	-	-	132
West Midlands	3	30	23	-	-	135
Yorkshire and The Humber	4	26	27	97	1,868	2,022
Scotland	2	20	29	84	421	557
Wales	3	19	9	47	157	235
Northern Ireland	1	20	5	-	-	96
Grand Total	**43**	**337**	**271**	**1,003**	**4,181**	**5,835**

The fuel mix

The proportion of coal, gas, renewable fuels and 'oil and other fuels' (comprising oil products, refinery gases, blast furnace gas and other industrial wastes) in the fuel mix for each region is shown in Chart 3.

Chart 3: Proportion of different fuels in the fuel mix for CHP in 2016 for each region



Special feature - CHP

Natural gas represented 69 per cent of all fuel burned in CHP in 2017, which is lower than in 2016 when the share was 71 per cent (revised). Since 2010, the share of all fuel burned that was natural gas has been within the range 69-73 per cent.

With the exception of Northern Ireland and the South West, natural gas accounts for the largest share of fuel burned in each of the English regions and Devolved Administrations. In Northern Ireland and the South West, renewable fuels account for the largest share of fuel burned, at 52 per cent and 56 per cent, respectively. In Northern Ireland the burning of biomass contributes significantly to the renewable fuel consumption in that region, while in the South West domestic refuse is a significant contributer. In 2017, the share of total fuel burned that was renewable was 16 per cent, which is an increase on the share for 2016 (13 per cent). The increase in the renewable fuel share is substantially due to the inclusion of a number of CHP schemes fuelled by biogas generated by anaerobic digestion fed with food waste for the first time.

In 2017 coal was only burned in Northern Ireland and the Eastern region and was confined to a very small number of schemes.

Summary

The well established patterns concerning the regional and sectoral distribution of CHP in the UK remain. However, over time these have become less pronounced. The subtle changes that have occurred are mainly driven by the closure of above average sized industrial CHP and the opening of below average sized non-industrial CHP, often based upon reciprocating engines.

Over the period 2015 to 2017, the number of CHP schemes increased in all regions of the UK. However, over the same period, the installed capacity decreased in three regions (South East, North East and North West) and these decreases were all driven by closure of industrial CHP capacity, specifically closures in the paper, Iron and Steel and Chemical sectors, respectively.

The use of renewable fuels in CHP has increased again. With the exception of London, all regions showed an increase in renewable fuel consumption between 2016 and 2017. Over the period 2015 to 2016 all regions have shown an increase in renewable fuel consumption. Natural gas continues to be the main fuel used in CHP, and makes up more than half of all CHP fuel consumed in all but three of the twelve region. Overall 69 per cent of all CHP fuel was natural gas.

For further information on UK CHP statistics, please contact:

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