Combined Heat and Power using renewable fuels

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 2015.

This article summarises the policy support measures that have given support to CHP installations that use renewable fuels, and presents various breakdowns of such CHP over the last ten years (2003 to 2014).

The data presented originates from a CHP database maintained by Ricardo Energy & Environment on behalf of the Department of Energy and Climate Change (DECC). Data relating to the overwhelming majority of CHP electrical capacity (about 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. Data from CHP schemes not covered by the above sources are extrapolated from historic data.

UK Policies supporting renewable CHP

Combined Heat and Power Quality Assurance programme

The Combined Heat and Power Quality Assurance programme (CHPQA) is a government initiative providing a practical, determinate method for assessing all types and sizes of Combined Heat & Power (CHP) schemes throughout the UK. CHP (or cogeneration) is the simultaneous generation of heat and power in a single process, and provides one of the most cost-effective approaches for making carbon savings. CHPQA aims to monitor, assess and improve the quality of UK Combined Heat and Power.

CHPQA certification grants CHP owners/operators access, depending on specific circumstances, to a number of benefits, including eligibility for support for CHP using certain renewable fuels via the following:

- Renewables Obligation Certificates (ROCs)
- Contracts for Difference (CfD)
- Renewable Heat Incentive (RHI)

In addition, Feed-in Tariffs (FiTs) are available for electricity generated from anaerobic digestion (excluding sewage and landfill gases), applying equally to CHP plant or power-only generation of this type.

The Renewables Obligation

The Renewables Obligation (RO) was introduced to support electricity generation from renewable sources. The RO came into effect in 2002 in England and Wales, and Scotland, followed by Northern Ireland in 2005. It places a mandatory requirement on UK electricity suppliers to source a growing percentage of electricity from eligible renewable generation capacity. Suppliers are required to produce evidence of their compliance with this obligation via certificates, referred to as Renewables Obligation Certificates (ROCs).

Support for CHP technology under the RO commenced on 1st April 2006 across the whole of the UK through the Renewables Obligation Order 2006, covering England and Wales, and the equivalent Orders for Scotland and Northern Ireland. The eligible renewables sources included those CHP generating stations fuelled wholly or partly by waste, and which were accredited under the CHPQA programme.

The 2009 Renewables Obligation Orders covering the UK came into effect on 1st April 2009. They introduced the concept of "banding" to the RO, meaning the provision of varying levels of support

(ROCs/MWh) for different types of renewable generation. In addition to energy from waste with CHP, the 2009 Orders introduced four further specific CHP generation types. With the exception of dedicated energy crops, this provided a higher level of support than the equivalent power-only generation types (Table 1).

Table 1 : Renewables Obligation Orders 2009: banding for CHP and equivalent power-only generation types

	ROCs per MWh	
Fuel	**With CHP**	**Power-only**
Energy from waste	1.0	Not eligible
Co-firing of biomass	1.0	0.5
Co-firing of energy crops	1.5	1.0
Dedicated biomass	2.0	1.5
Dedicated energy crops	2.0	2.0

In 2011-2012 DECC undertook a review of banding under the Renewables Obligation, including a consultation on proposals for the levels of banded support for the period 2013-17. This culminated in the Renewables Obligation (Amendment) Order 2013, which split co-firing into low, medium and high-range generation types, both power-only and with CHP. Station/unit conversion with CHP was added and co-firing with bio-liquids given a separate band. Furthermore, differing levels of support were specified for capacity in 2013/14, 2014/15, 2015/16 and post 2016. Except for dedicated energy crops, for each year all CHP generation types were assigned an uplift of 0.5 ROCs/MWh compared with the level of support for their power-only equivalents.

However, from 1 April 2015 no ROC uplift for CHP is available where the heat produced would be eligible for the Renewable Heat Incentive (RHI). This effectively excludes all technologies from receiving the CHP uplift except co-firing of regular bioliquid with CHP or station/unit conversion with CHP where the fuel is regular bioliquid. Energy from Waste (EfW) with CHP remains at 1 ROC/MWh for all years. EfW CHP schemes certified by CHPQA are not eligible for RHI.

The RO is scheduled to close to new capacity on 31 March 2017, as set out in the RO Closure Order 2014. Support for capacity accredited under the RO by that date will be retained at existing support levels (i.e. support is grandfathered) and will receive its full lifetime of support, with grace periods offered to those who miss the closure date in certain circumstances.

The government introduced the Contracts for Difference (CFD) scheme in 2014 which will replace the RO when it closes. During the transition period, when both schemes are open, generators are able to choose between the schemes, subject to eligibility.

Renewables Obligation statistics are available at:
https://renewablesandchp.ofgem.gov.uk/Public/ReportManager.aspx?ReportVisibility=1&ReportCategory=0

Contracts for Difference

The Contracts for Difference (CfD) regulations came into force in Great Britain on 1 August 2014; CfDs will replace the Renewables Obligation for new projects from 1 April 2017, although RO grace periods allow certain slippage to commissioning beyond 31 March 2017. A final decision has still to be taken by Northern Ireland as to its inclusion in the CfD mechanism. CfDs are awarded competitively to the best value projects via an allocation-round process.

A generator party to a CfD is paid the difference between the 'strike price' (a price for electricity reflecting the cost of investing in a particular low carbon technology), and the 'reference price' (a measure of the average market price for electricity). In the event that the reference price exceeds the strike price the generator pays the difference to the Low Carbon Contracts Company (LCCC), a Government-owned but arms-length company.

Dedicated Biomass with CHP and Energy from Waste with CHP are eligible to compete for support in CfD allocation rounds; their counterpart power-only projects are not eligible for CfD support. Dedicated biomass means that the station is fuelled by solid biomass.

Energy from waste (EfW) with CHP schemes are not eligible for CfDs support if they have also applied for support under the RHI, as the CfD strike prices for EfW with CHP are based on both the power and heat component supplied (unlike those for biomass CHP schemes that are based on 'power only').

To be eligible for CHP specific CfDs, the operator will need to provide a valid CHPQA GN44 certificate, confirming that the scheme either partially or fully qualifies as Good Quality under the CHPQA criteria. Support under the CfD will be paid only on the proportion of metered electrical output assessed by CHPQA to be Qualifying Power Output. This is applied in the CfD contract by applying a CHP Qualifying Multiplier (the ratio of Qualifying Power Output to the Total Power Output) to the total electrical output of the plant.

CfDs are also open to electricity generating stations using biogas from anaerobic digestion, other than landfill and sewage gas, where the capacity is greater than 5 MWe. If such a station was CHP then the heat would in principle be eligible for the RHI, but would not need to be certified under CHPQA. Similarly, new sewage gas CHP schemes are eligible in principle for CfDs and the RHI, though with no capacity limitations on either power or heat.

In the first CfD allocation round two EfW CHP projects totalling nearly 95 MWe of capacity were successful. The delivery year for these projects is 2018-2019.

The Renewable Heat Incentive

The Renewable Heat Incentive (RHI) was launched in November 2011 and provides support to renewable heat technologies in order to increase deployment and aid market development, with the ultimate aim of reducing the costs of installation. The RHI supports renewable heat where that heat is used in a building for 'eligible purposes', which are: heating a space, heating water, or for carrying out a process where the heat is used.

Dedicated solid biomass schemes are eligible for the higher solid biomass CHP tariff on their eligible heat output if:

- the installation/relevant combustion unit(s)/conversion from power only generation was commissioned on or after 4 December 2013;
- the relevant combustion unit(s) are new at the time of installation;
- the installation is certified under CHPQA. Applicants will have to provide evidence of current CHPQA certification as part of the accreditation process in order to be awarded this tariff;
- the relevant combustion unit(s) are designed and installed to burn solid biomass only (not including solid biomass contained in waste); and
- the relevant combustion unit(s) comply with air quality requirements

Thus to qualify for the solid biomass CHP tariff, a scheme has to have a CHPQA certificate but does not have to fully qualify as Good Quality CHP. However, the CHP tariff will be eligible only for heat generated by the engine or extracted from the turbine.

Energy from Waste CHP stations accredited under the RO are not eligible for support under the RHI.

Detailed statistics on the RHI are available at:
www.gov.uk/government/collections/renewable-heat-incentive-statistics

Feed-in Tariffs

The Feed-in Tariff (FiT) was introduced by the UK Government from 1 April 2010 in order to support renewable electricity generating technologies up to 5 MWe in capacity. The only enewable fuel CHP technology supported by the FiT scheme is power generation from anaerobic digestion (excluding sewage gas) and there is no distinction between CHP and power-only generators so no CHPQA certification is required.

Solid biomass, sewage gas and landfill gas generators were specifically excluded from the FiT scheme on the basis that there was adequate support available through the Renewables Obligation.

Detailed statistics on FiTs are available at: www.gov.uk/government/statistics/monthly-small-scale-renewable-deployment

Table 2 Summary of support to CHP schemes where certification under CHPQA is not required.

	Heat	Electricity	
	RHI	FiTs	CfDs
Biogas (AD – excl. sewage and landfill gases)	Yes	Yes, ≤ 5 MWe.	Yes, > 5 MWe.
Biogas (AD – sewage)	Yes	No	Yes
Biogas (gasification)	Yes	No	Yes
Biogas (pyrolysis)	Yes	No	Yes

Evolution of Renewable CHP capacity, outputs and technologies used over recent years

When reviewing the uptake of renewable CHP over the years in the context of policy developments, it is instructive to look at the available data both including and excluding CHP schemes at sewage treatment works. This is because, as discussed earlier, CHP at sewage treatment works have been largely unaffected by the policy environment. As such, while developments in renewable CHP including sewage treatment works are interesting in their own right, removing them from the analysis allows a clearer correlation to be made between renewable CHP development and policy development.

Presented below are the trends in renewable CHP deployment, firstly including sewage treatment works and then excluding them.

Analysis - Including CHP schemes at sewage treatment works

DUKES presents CHP statistics in Chapter 7, but largely provides only high level figures for plant using renewable fuels. The following tables and figures are based on the same data sets as used for DUKES 2015, but examine further some of the underlying details of renewable CHP.

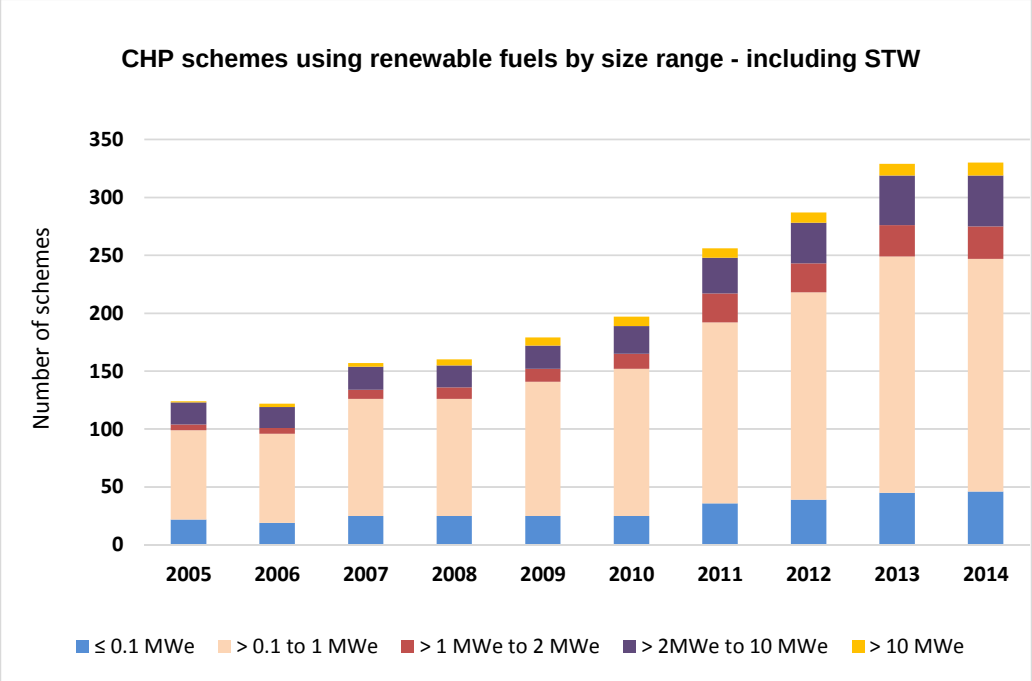
Table 3 and Chart 1 show the growth in the total number of UK CHP schemes that use, at least in part, renewable fuels over the last 10 years. Also presented is the breakdown of scheme numbers according Qualifying Power Capacity (QPC) range. Over the period 2005-2014 there has been a steady increase in the number of renewable CHP schemes.

Chart 1 shows the growth in the total number of UK CHP schemes that use, at least in part, renewable fuels over the last 10 years. Also presented is the breakdown of scheme numbers according Qualifying Power Capacity (QPC) range. Over the period 2005-2014 there has been a steady increase in the number of renewable CHP schemes.

Table 3: UK total number of CHP schemes using renewable fuels, 2005 to 2014, including STW

Size range	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
≤ 0.1 MWe	22	19	25	25	25	25	36	39	45	46
> 0.1 to 1 MWe	77	77	101	101	116	127	156	179	204	201
> 1 MWe to 2 MWe	5	5	8	10	11	13	25	25	27	28
> 2MWe to 10 MWe	19	18	20	19	20	24	31	35	43	44
> 10 MWe	1	3	3	5	7	8	8	9	10	11
Total	**124**	**122**	**157**	**160**	**179**	**197**	**256**	**287**	**329**	**330**

Chart 1 Number of UK CHP schemes using renewable fuels by size range – including sewage treatment works (STW)



Many schemes use both renewable and non-renewable (i.e. fossil) fuels. This may be because of the need to achieve a certain minimum calorific value of fuel sent to the CHP prime mover or due to considerations of fuel availability and cost. Chart 2 shows the qualifying CHP power capacity[1] of schemes, split on a pro-rata basis between that assigned to renewable and that to non-renewable fuels. The renewable CHP capacity by plant size range, by year is shown in Table 4 and the split for 2014 in Chart 3. Capacity is dominated by schemes over 2MWe, with 76 per cent of capacity > 2MWe, whilst the greatest numbers of schemes are in the 0.1 to 1 MWe range (Table 3).

[1] This is the capacity that qualifies, or would qualify, as 'Good Quality' CHP under the CHPQA programme where it is referred to as Qualifying Power Capacity (QPC). Any additional power capacity not qualifying is considered to be power-only generation. See www.gov.uk/guidance/combined-heat-power-quality-assurance-programme for further details.

Chart 2 Total Qualifying Power Capacity (QPC) of CHP schemes using renewable fuels, split by renewable and non-renewable fuel input

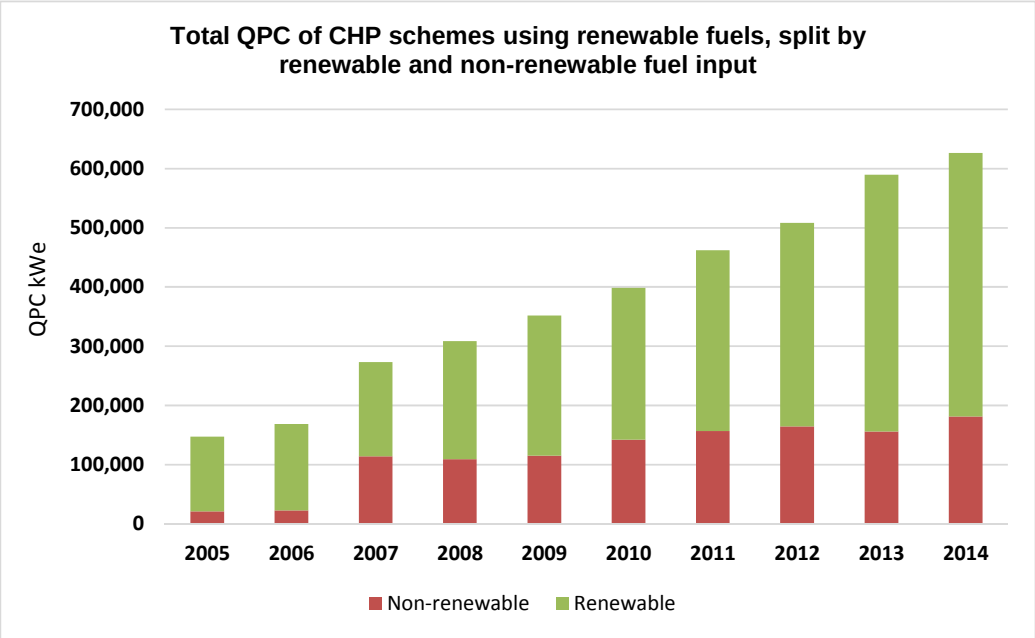


Table 4: Qualifying Power Capacity (kWe) of CHP schemes using renewable fuels scaled by renewable inputs, 2005 to 2014 - including STW

Size range	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
≤ 0.1 MWe	1,401	1,210	1,814	1,749	1,988	1,943	2,285	2,601	2,866	2,922
> 0.1 to 1 MWe	27,211	27,808	35,498	35,445	39,087	42,992	52,782	59,849	70,352	68,194
> 1 MWe to 2 MWe	6,610	8,319	11,895	14,995	15,288	18,781	33,071	34,164	38,005	37,641
> 2MWe to 10 MWe	78,586	76,190	77,489	72,517	81,050	91,000	115,307	130,795	169,464	181,150
>10 MWe	12,113	32,549	32,083	74,941	99,585	101,844	102,084	116,830	153,006	154,610
Total	**125,922**	**146,076**	**158,779**	**199,648**	**236,998**	**256,561**	**305,530**	**344,240**	**433,693**	**444,518**

Chart 3 Renewable CHP Qualifying Power Capacity (QPC) split by plant size range

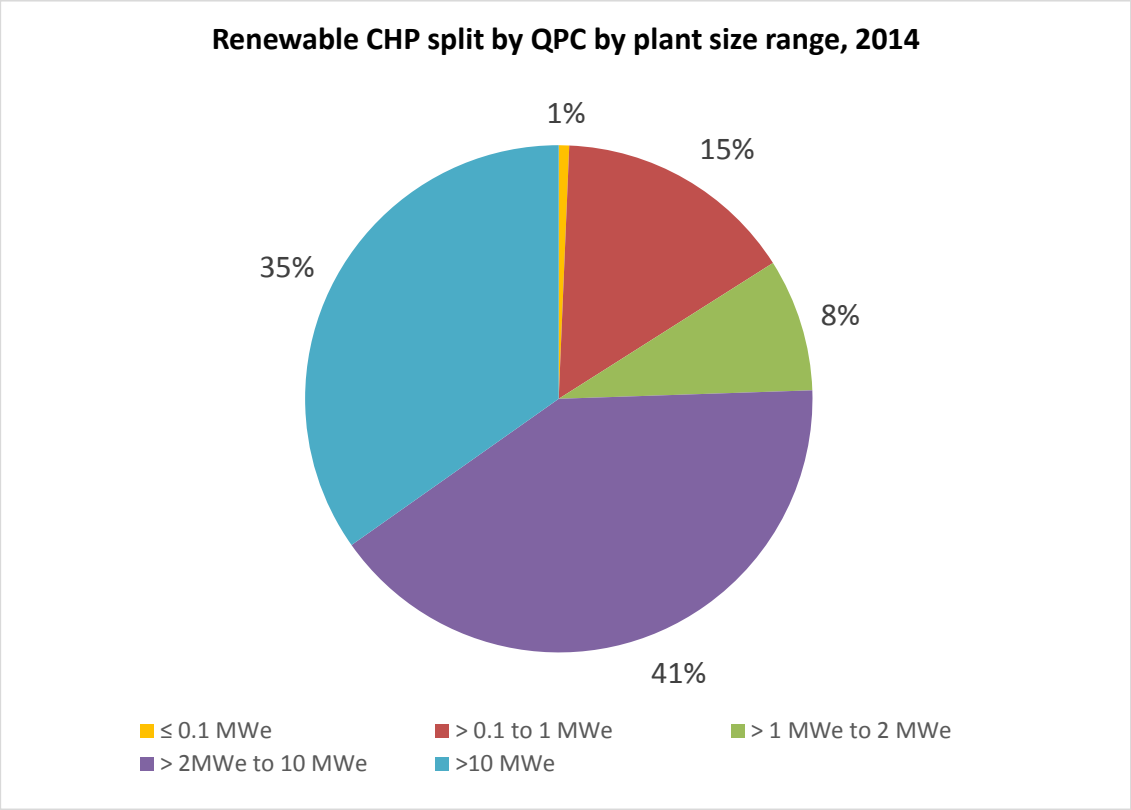


Table 5 shows the types of fuel consumed in renewable CHP schemes. In 2014 the most used fuel was solid biomass, followed by sewage gas and then biodiesel, bioethanol.

Table 5: Type of renewable fuel consumed

Fuel type	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Biodiesel, bioethanol etc	0	0	0	0	1,350	16,453	17,518	63,456	1,099,295	1,387,370
Biomass (energy crops, waste wood, chicken litter, etc.)	473,051	659,531	659,243	1,574,109	1,681,402	1,905,501	2,183,014	2,449,269	1,951,371	3,454,626
Domestic refuse (raw)	693,354	1,016,851	953,720	1,394,133	1,275,428	1,425,601	1,418,897	1,223,581	1,205,069	1,153,348
Other Biogas (e.g. gasified woodchips)	31,823	26,742	12,114	3,859	21,899	66,332	369,004	562,358	1,029,395	1,056,954
Other liquid waste (renewable)	0	0	0	0	0	0	0	0	11,170	2,564
Refuse-derived Fuels (RDF)	166,620	163,051	131,925	116,251	84,830	38,430	83,445	83,543	0	105,018
Sewage gas	1,482,770	1,316,635	1,442,780	1,505,171	1,708,920	2,044,806	2,239,097	2,222,790	2,212,425	2,399,895
Wood Fuels (woodchips, logs, wood pellets, etc.)	0	0	0	0	559,780	1,035,140	542,045	662,659	1,412,104	579,668
Total	**2,847,618**	**3,182,810**	**3,199,783**	**4,593,523**	**5,333,609**	**6,532,263**	**6,853,021**	**7,267,656**	**8,920,829**	**10,139,443**

Of the 330 renewable CHP schemes at the end of 2014, 194 serve sewage treatment works where CHP has been established practise for many years. In 2005 they comprised 116 of the 124 total renewables schemes (Chart 4) and around 77% of renewable CHP capacity in the UK. The growth in the number of CHP schemes at sewage treatment works is also shown in Chart 4.

Chart 4 Number of Sewage Treatment Works (STW) CHP schemes

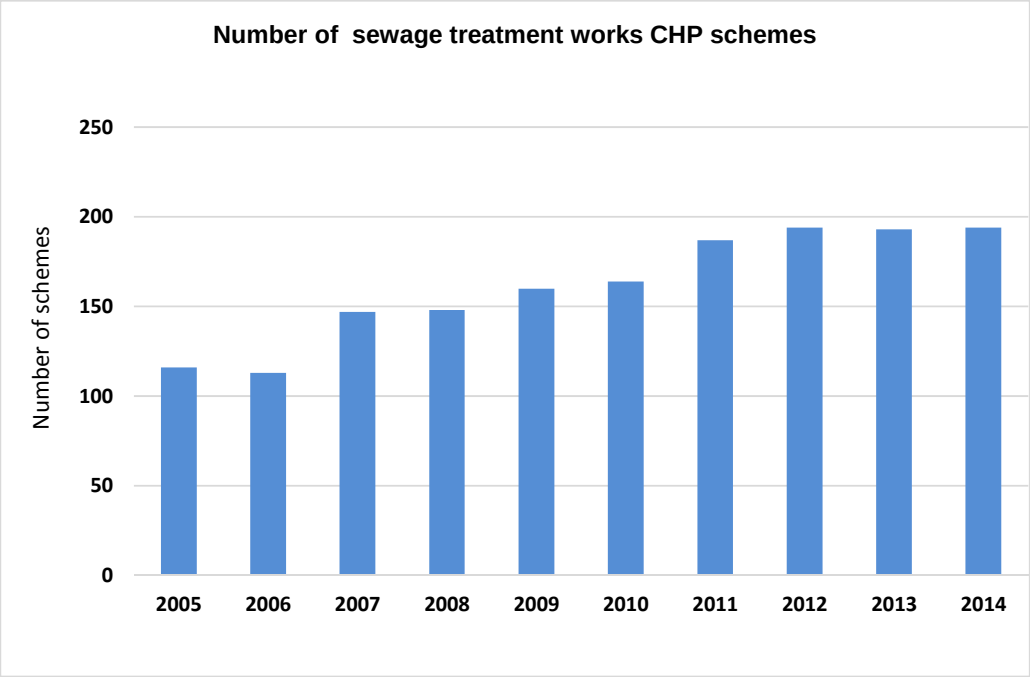


Figure 1 Number of CHP schemes at sewage treatment works

Given that CHP at sewage treatment works has been an established practice for some years and that they have been broadly unaffected by the policy landscape, means that, when trying to gain an appreciation of the effect that CHP policy has had on the take-up of renewable CHP, it is instructive to remove sewage treatment works CHP schemes from the analysis. The analysis in the next section is carried out on this basis.

Analysis - Excluding CHP Schemes at sewage treatment works

To see more clearly how other renewable CHP schemes have increased over the last ten years, the following tables and figures exclude all schemes at sewage treatment works. Table 6 shows the evolution in the number of such CHP schemes and how the Qualifying Power Capacity (QPC) is apportioned over the different size ranges.

Table 6: UK total number of CHP schemes using renewable fuels, 2005 to 2014 - excluding STW

Size range	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
≤ 0.1 MWe	1	0	0	1	1	1	8	8	15	16
> 0.1 to 1 MWe	1	2	2	2	6	16	35	56	81	78
> 1 MWe to 2 MWe	0	0	0	0	1	1	8	7	9	9
> 2MWe to 10 MWe	5	4	5	4	4	7	10	13	21	22
> 10 MWe	1	3	3	5	7	8	8	9	10	11
Total	**8**	**9**	**10**	**12**	**19**	**33**	**69**	**93**	**136**	**136**

Chart ***5*** shows the data in Table 6 graphically. These data show that there has been a rapid increase in the number of schemes, starting about 2010, after the introduction of the RO banding in 2009.

Chart 5 Number of UK CHP schemes using renewable fuels split by size range – excluding STW

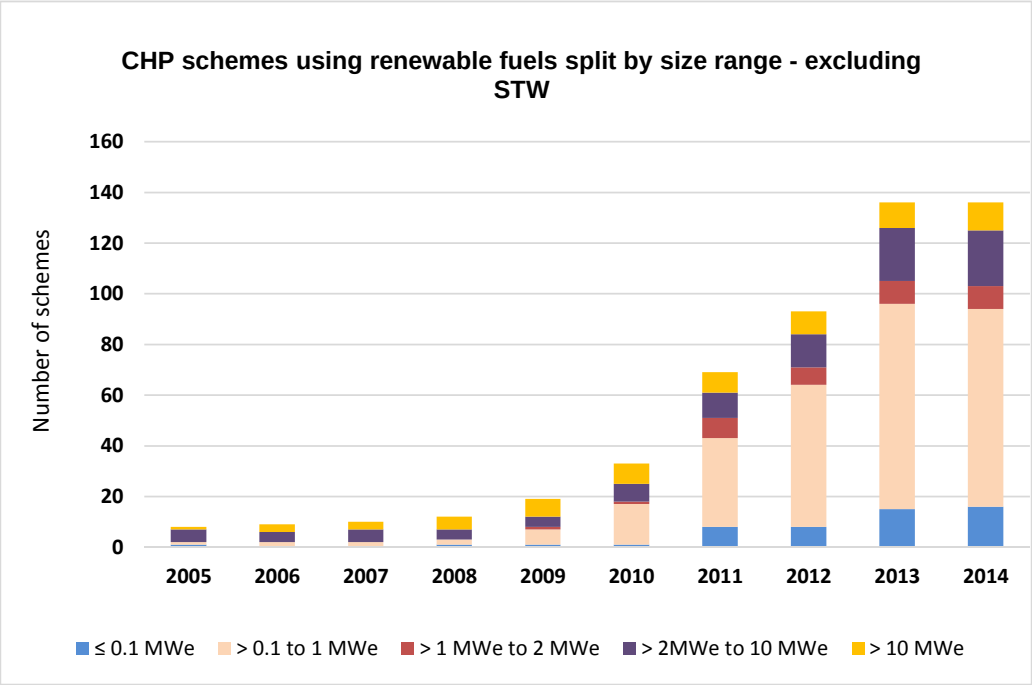
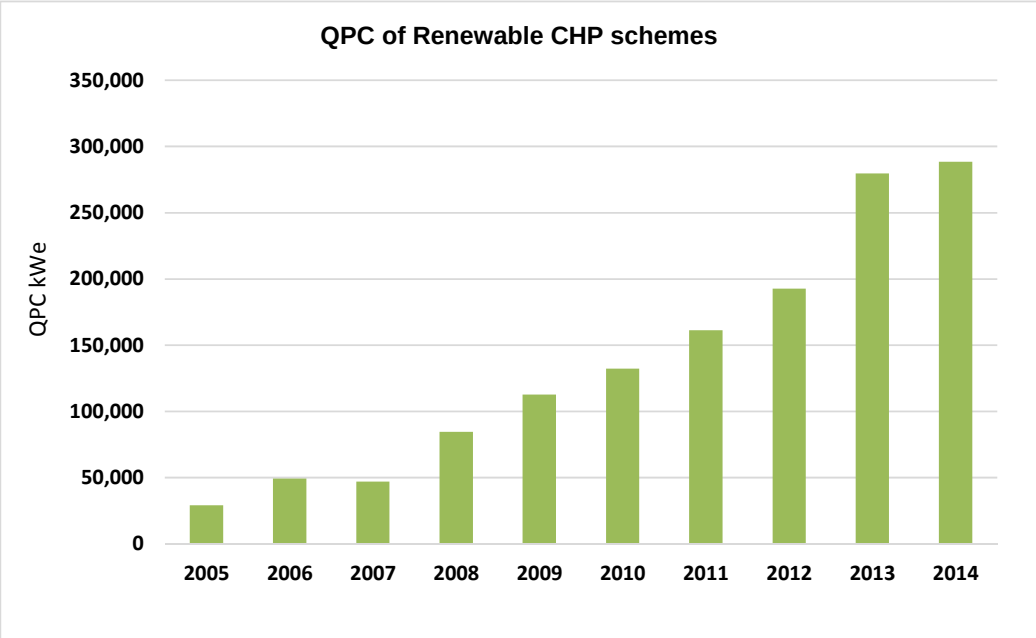


Chart 6 shows how the renewable CHP capacity has increased for the same schemes illustrated in Chart 5. While the number of renewable schemes has increased seven-fold since 2009 the power capacity has increased by about 2.5 times. This is explained by the large increase in the number of schemes in the relatively small capacity range of 100 kWe to 1 MWe.

Chart 6 Evolution of QPC of renewable CHP schemes – excluding schemes at sewage treatment works



The significant increase in the numbers of renewable schemes over the last 5 years or so may be largely attributed to the availability of the policy support mechanisms described earlier in this article, particularly the Renewables Obligation from April 2009. Access to this support continues to be principally through certification under CHPQA, which acts as a gate-keeper for ensuring that only genuine CHP is able to obtain additional support compared with that which might be available to power-only or heat-only installations.

CHPQA certification is not required where benefits can be gained separately for renewable heat and renewable electricity at the same rates that heat-only and power-only plants attract. The main circumstances where this is the case are where heat and power is generated from biogas (excluding sewage and landfill gases) produced from anaerobic digestion (AD) and are eligible for FiTs and the RHI. Of the 136 renewable CHP schemes in 2014 (excluding STW) 77 were certified under CHPQA). The remaining 59 are overwhelmingly schemes using biogas from AD and with an electrical capacity below 5 MWe. As of the end of 2014, there were 216 AD FiT commissioned installations (www.gov.uk/government/statistics/monthly-small-scale-renewable-deployment). The FiT statistics do not distinguish between power-only and CHP plant.

Therefore, the effect of the policy support mechanisms on the deployment of CHP is best understood by looking at the evolution of renewable CHP schemes certified under CHPQA, which are not schemes at sewage treatment works. Tables 7 and 8 present the number of such schemes and their aggregate capacity over the years.

Table 7: UK total number of CHP schemes using renewable fuels, 2005 to 2014 - CHPQA certified only, excluding STW

Size range	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
≤ 0.1 MWe	0	0	0	1	1	0	3	4	3	4
> 0.1 to 1 MWe	0	1	0	0	4	13	22	39	45	45
> 1 MWe to 2 MWe	0	0	0	0	1	1	2	2	1	1
> 2MWe to 10 MWe	4	4	5	4	4	7	9	11	14	17
> 10 MWe	1	2	2	4	5	6	6	8	9	10
Total	**5**	**7**	**7**	**9**	**15**	**27**	**42**	**64**	**72**	**77**

Table 8: Qualifying Power Capacity (kWe) of CHP schemes using renewable fuels scaled by renewable inputs, 2005 to 2014 - CHPQA certified only, excluding STW

Size range	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
≤ 0.1 MWe	2	26	30	17	256	194	32	253	256	312
> 0.1 to 1 MWe	682	1,428	640	337	733	4,174	7,902	13,769	15,766	15,242
> 1 MWe to 2 MWe	0	0	0	0	0	0	1,415	2,858	1,933	0
> 2MWe to 10 MWe	9,189	15,106	13,258	8,032	10,929	24,547	32,005	39,859	64,555	80,903
>10 MWe	12,113	13,049	12,583	55,441	58,436	60,695	60,935	97,330	133,506	135,110
Total	**21,987**	**29,610**	**26,510**	**63,828**	**70,354**	**89,611**	**102,289**	**154,070**	**216,016**	**231,567**

Chart 7 and Chart 8 show the evolution of the number of CHP schemes certified under CHPQA and their capacity. As discussed above, it is growth in these schemes that is the best barometer of the response to the evolving policy incentive environment, as certification under CHPQA is necessary for the benefits associated with policy to be accessed. It is clear that there has been a significant increase in the number of renewable CHP schemes and capacity, starting about 2010. This is significant as it was at this time that the new, beneficial ROCs banding for CHP came into effect. This clearly shows how changes to the RO in 2009 affected the uptake of Good Quality renewable CHP.

Chart 7 Number of CHPQA certified renewable CHP schemes, excluding STW

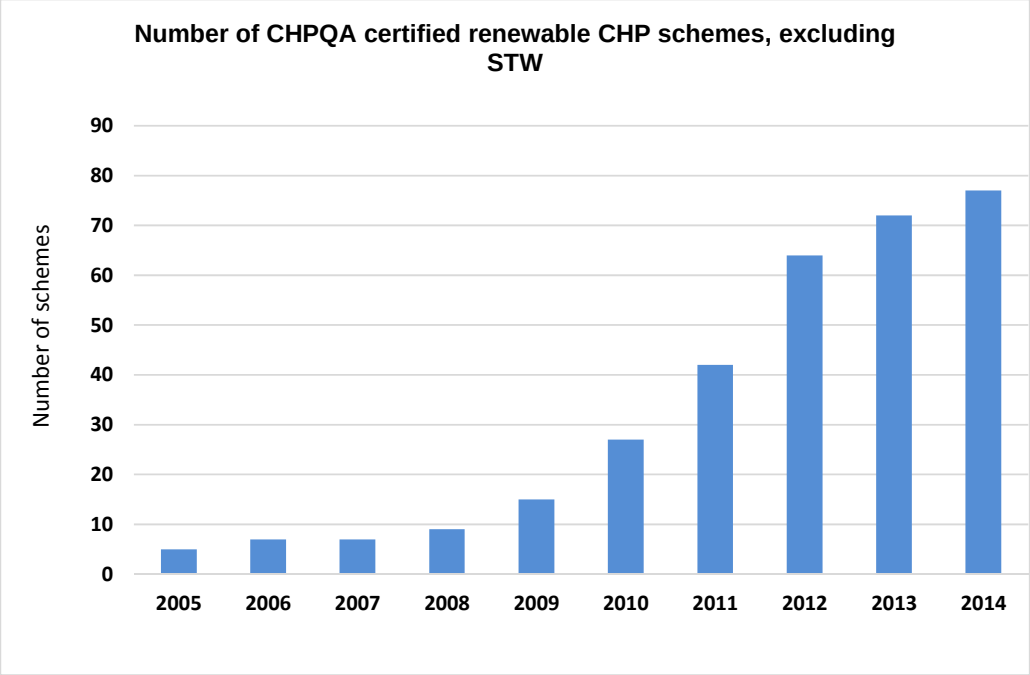
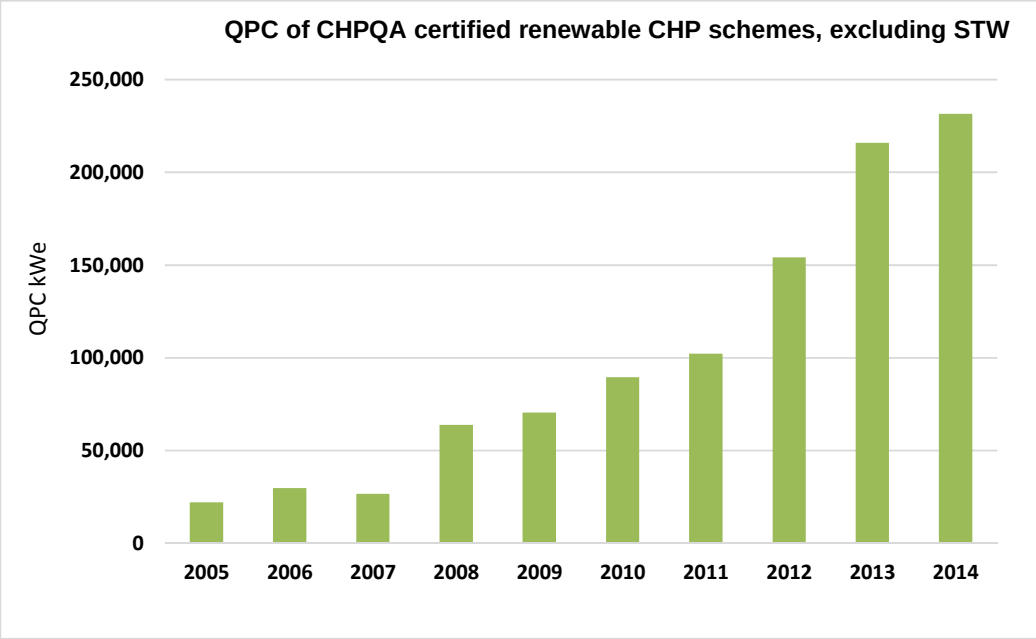


Chart 8 Capacity of CHPQA certified renewable schemes, excluding STW



Summary

The policy incentive landscape relating to renewable CHP has evolved appreciably over the past 10 years. The incentives offered to renewable CHP depend upon type of fuel consumed and capacity, with some types of renewable CHP being incentivised more than others, according to their perceived and actual need for support.

Including schemes at sewage treatment works, the number and total capacity of CHP schemes consuming renewable fuel has increased over the last 10 years by 166 per cent and 253 per cent, respectively.

CHP at STW is established practice over the long term and much less sensitive to policy incentives than other types of scheme. Removing STW from the analysis and concentrating on those schemes that need to be certified under CHPQA in order to access the policy incentives available, the number of renewable CHP schemes and capacity has increased 15-fold and 10-fold, respectively, between 2005 and 2014. There has been a significant increase in scheme numbers and capacity since 2010, following introduction of the beneficial ROC banding for renewable CHP in 2009.

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