Department for Energy Security & Net Zero

Combined Heat and Power statistics Data Sources and Methodologies

1. Introduction

CHP is the simultaneous generation of heat and power in a single process. The power generated is usually in the form of electricity, but sometimes the electricity generating step is by-passed and the power is used directly as mechanical power, for example in industrial processes utilising fans, pumps and compressors.

CHP is also known as “Cogeneration” in Europe and sometimes as “Total Power” in the United States.

CHP is a fuel efficient and, therefore, environmentally friendly technology for satisfying the demand for heat and power in industry, commerce and the domestic sector. It takes the waste heat inherent in the generation of power and uses this to satisfy a demand for heat local to the power generating plant or via a district heating network. This compares favourably with the more conventional means of satisfying local demand for heat and power, where power is imported from an extended network distributing power generated at large, usually remotely located power stations and heat is generated on-site using boilers. In the former case a significant proportion of the heat by-product of the power generating step is dumped to atmosphere, as there is no demand for it local to the power generating plant.

In considering the performance of CHP schemes, the concept of Good Quality CHP is observed. CHP schemes only provide fuel efficiency and environmental benefits if the heat generated during the power generating step is put to a good use. Where some of the generated heat is not put to a good use, some of the CHP output may not be deemed Good Quality CHP electricity. Good Quality outputs are those that are generated and used such that at least a 10% primary energy saving is realised, when compared against reference conventional power and heat generation efficiencies. It is only these Good Quality outputs, and the CHP generating capacity capable of generating these outputs, that are reported in Chapter 7 of DUKES (see section 4.2 for more details on Good quality CHP). The remaining electricity capacity and outputs are included under ‘other generation’ in chapter 5 of DUKES.

2. Data Collection

2.1 Source of Data

Data on the performance of CHP schemes in the UK is collected from a number of sources and is used to update a database of CHP schemes (known as the "CHPSTATS Database"), maintained by Ricardo Energy & Environment. These sources include:

- Annual performance returns made to the CHPQA programme. These returns are made by the scheme operator to allow an assessment of the scheme's qualification for certain fiscal incentives. For year of operation 2008 over 94% of the Good Quality CHP capacity in the CHPSTATS database was taken up by schemes reporting to CHPQA.

- Annual information from Ofgem ROCs database. This information is collected in respect of renewable fuel fired CHP schemes that do not submit annual performance returns to the CHPQA programme. For year of operation 2008 about 1.4% of the Good Quality CHP capacity in the CHPSTATS database was taken up by schemes reporting through this mechanism.

- Annual information from Iron and Steel Statistics Bureau (ISSB). This information is collected in respect of CHP schemes at the UK's two integrated steel sites that do not submit annual performance returns to the CHPQA programme. For year of operation 2008 about 1.2% of the Good Quality CHP capacity in the CHPSTATS database was taken up by schemes reporting through this mechanism.

- Annual carry forward of CHP schemes. For schemes that are held in the CHPSTATS database, but do not report annually through any of the above three mechanisms, performance data is carried forward to the next year. For year of operation 2008 about 3% of the Good Quality CHP capacity in the CHPSTATS database was carried forward in this manner. Schemes that do not report under the CHPQA programme tend to be those that are not eligible for fiscal incentives (e.g. the main inputs/outputs are not subject to the climate change levy). CHP plants serving residential schemes would fall into this category.

2.2 Data Items Collected

2.2.1 CHPQA Data

Data on the performance of CHP schemes is collected from the annual submission to the CHPQA programme. In these submissions, the scheme operator is obliged to report the following for the calendar year under consideration:

1. Total energy content of fuel consumed (Gross Calorific Value basis)

2. Energy content of each type of fuel consumed (Gross Calorific Value basis)

3. Total power generated

4. Total heat generated that was subsequently put to a good use (known as Qualifying Heat Output, QHO)

5. Information on the accuracy of meters used to measure the above quantities

2.2.2 Ofgem ROCs Database

The following information is extracted from the Ofgem Renewable database in respect of CHP schemes not reporting to CHPQA:

1. Electrical generating capacity

2. Number of ROCs issued. This is a proxy for electricity generated. Up until 31st March 2009 1 ROC was issued in respect of each MWh of electricity generated. From 1st April 2009 the number of ROCs issued per MWh is dependent upon the electricity generating technology employed. The Ofgem ROCs database now includes a factor to convert the number of ROCs issued into the number of MWh of electricity generated.

Note: As these schemes do not supply the quantity of fuel used and the heat generated, standard electricity generating efficiencies and heat to power ratios are used to calculate fuel consumption and heat generated, respectively. The CHP schemes included via this reporting mechanism are at sewage treatment works and an assumption is made that all of the fuel consumed is the renewable fuel "Sewage Gas", and that all of the heat that can be generated by the engine is put to a qualifying use. A consequence of this approach is that, when the CHPQA methodology is applied, all of the outputs are Good Quality.

2.2.3 Information from ISSB

The following information is submitted by ISSB for the CHP schemes at two UK integrated steel works :

1. Total energy content of fuel consumed (Gross Calorific Value basis)

2. Energy content of each type of fuel consumed (Gross Calorific Value basis)

3. Total electricity generated

4. Calculated mechanical power generated

5. Total steam consumed

Note: These energy inputs and outputs then have the CHPQA methodology applied for determining the proportion of outputs that are Good Quality, as it is only these that are reported in Chapter 7 of DUKES.

3. Data Quality

3.1 Dealing with Late Returns

Statistics relating to the operation of CHP in a particular year are reported in DUKES in July of the following year. This means that there is a relatively tight time frame for collecting, processing and publishing statistics.

In respect of data from the sources “Ofgem ROCs Database” and “Information from ISSB”, this is not an issue as real operating data for the calendar year in question becomes available in sufficient time for its processing and publication. However, as explained below, this is not always the case for data from CHPQA.

Operators of CHP schemes are incentivised to submit to CHPQA, as this is the mechanism by which they are assessed for fiscal benefits. However, the timetable of this assessment is such that schemes submit to CHPQA, in respect of the previous year, up to June of the following year.

Every submission to CHPQA is validated, that is a technical assessor examines the declared performance against the technical specification of the CHP scheme in order to assess whether the scheme is capable of attaining the performance declared in the submission. Only schemes that have submitted to CHPQA and have had these submissions validated have the performance for the year being reported entered into the CHPSTATS database.

As final figures for DUKES are supplied by Ricardo to DESNZ in May there is a proportion of schemes that either have not submitted to CHPQA or have submitted, but did not do so in time for the submission to be validated in time for the DUKES publication deadline. In such cases the previous year’s performance is carried forward in the database. This means that, in respect of such schemes, the statistics reported in DUKES for, say, 2008 will be the performance data for 2007. For DUKES 2009 (which contained data up to 2008), 28.5% of the CHPQA capacity was copied forward from the previous year.

3.2 Efforts to Identify Closed Schemes

Any scheme that operated in the calendar year under consideration will have its performance data included in the DUKES statistics for that year. This is because the scheme will have operated for part of the year under consideration. Schemes that are known to have ceased operation in the year before the calendar year under consideration will not have any performance data included in the DUKES statistics for the calendar year under consideration.

In the overwhelming majority of cases for schemes reporting to CHPQA, the programme Administrators are formally notified by a scheme operator if the scheme ceases to operate. If the scheme ceased to operate part way through the calendar year under consideration operational data for that scheme will be included for that year but not for subsequent years.

There are two possible ways of dealing with schemes operating for only part of the year under consideration. If the scheme submits to CHPQA for the year under consideration, this will be validated as normal and included in the statistics, but then marked as dead in the database for subsequent years. If the scheme does not submit to CHPQA for the year under consideration, then the previous full year’s operational data will be copied forward for that scheme and reported for the year under consideration. The scheme will be marked as dead in the data base for subsequent years.

If the scheme operator notifies the CHPQA Administrator that the scheme ceased to operate in a year earlier than the year under consideration the scheme is marked as dead for the year under consideration and for any previous years for which there was no operation, if this is necessary. If the scheme is marked as dead for previous years then this will lead to a revision of UK’s CHP operational statistics for these earlier years, when next reported in DUKES (see Revisions to Data).

The possibility of a scheme ceasing to operate, but the CHPQA Administrator not receiving formal notification, becomes apparent as the deadline for submission approaches and the scheme has not made a submission. For all cases where a scheme was certificated under CHPQA in the previous year, but has not made a submission for the year under consideration a specified amount of time before the submission deadline, the scheme operator is contacted to ascertain the scheme's status and the scheme operator's submission intentions. The same procedure, outlined above, for schemes that have formally notified CHPQA Administrator is then followed.

As stated above in relation to schemes reporting via the Ofgem ROCs database and ISSB - where actual operating data becomes available in time for the DUKES reporting deadline - the absence of operational data for a scheme is taken as an indication that the scheme in question may have ceased operation. Enquiries are made into the status of such schemes. If confirmation is obtained that the scheme in question has ceased operation it is removed from the database. If this confirmation is not obtained then the schemes operational data for the previous year is carried forward; a scheme is only removed from the CHPSTATS database if positive proof of its cessation of operation is received.

3.3 Checks to Ensure Correct Data on Forms

3.3.1 CHPQA Data

Every scheme submitting data to CHPQA, for the purpose of Certification, does so using a form known as a Form F4. All F4 forms are validated by a technical assessor. This validation takes the form of assessing whether the scheme performance stated in the F4 is consistent with the scheme's technical specification and operational configuration. Where there is a significant change in performance between years then a satisfactory explanation for this is sought before validation is considered complete. As already stated, only validated data is included in the statistics reported in DUKES.

Every year a proportion of CHP schemes are audited via a site-based evaluation of the operation of the scheme to check that the F4 submission is based on a correct interpretation of the CHPQA standard[1] and that site held data corroborates the data and calculations submitted via the F4. Every year about 100 schemes submitting to CHPQA are audited in this way and all schemes > 1MWe are audited at least once every three years. (These schemes represent >95% of the total certified Good Quality CHP capacity).

3.3.2 Ofgem ROCs Database

Data relating to electrical generating capacity and electricity generation are submitted by operators to Ofgem every month. As the quantity of electricity generated has a financial value in the form of ROCs, a minimum standard of electricity metering accuracy is stipulated by Ofgem. These standards are subject to audit by Ofgem at which time a check is also made that site held data corroborates the data and calculations submitted to Ofgem.

[1] CHPQA Standard: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/569406/CHPQAStandardIssue6.pdf

3.3.3 ISSB Data

There is no mechanism in place to routinely audit the information issued by ISSB relating to the two integrated steel works with CHP. The raw data supplied by ISSB is accepted and processed according to the CHPQA Standard. Were this processing to produce a performance outcome significantly different from the previous year, this would be followed-up up with ISSB. This has not been necessary over the last few years.

3.4 General Notes on Data Quality

3.4.1 Electricity and Heat Exports

Electricity and heat generated by a CHP is often exported for consumption by a 3rd Party(s). This is particularly the case for large CHP schemes. The quantity of exported electricity and heat is recorded in DUKES.

This information comes only from the F4 form submitted to CHPQA. However, supply of this information remains a voluntary part of the F4 form and until 2014 a robust check of the quantity of exported heat and power and numbers of customers was not undertaken. Since 2014, a check of export data has formed part of the validation process and so for this date the export data is more robust.

3.4.2 Revisions to Data

In DUKES data on CHP operation is reported for a number of years in order to give an historic time series perspective. It is normal practice for revisions to be made to the data for previous years. For example, it is normal for the electricity generation declared in DUKES 2009 for year of operation 2007 to be different from the value declared for year of operation 2007 in DUKES 2008.

The most common reason for this relates to the availability of validated CHPQA data at the time of statistics compilation, as mentioned above. If the F4 for year of operation 2007 for a particular scheme is submitted late, then the performance data for year of operation 2006 will be carried forward and reported as if it were the actual 2007 year of operation data. This would appear in DUKES 2008. However, the following year, when DUKES 2009 is prepared, the actual 2007 year of operation data for the scheme in question will have been received and validated and this actual data will be available for reporting in DUKES 2009, for year of operation 2007. Therefore, unless the actual power generated by the scheme in question was exactly the same in 2006 and 2007 then there would be a difference in the electricity generation reported for the same year (2007) in DUKES 2008 and DUKES 2009. Over the last 5 years revisions to the Qualifying Power output have average +/-3.3%, ranging from -4.8% to +3.2%.

There are other reasons for the revision of data for earlier years, including:

- Late notification that a CHP scheme ceased operation in an earlier year. Without positive proof that a scheme has ceased operation it is normal practice for the scheme to remain in the CHPSTATS database and for the most recent year's performance data to be carried forward. If, for example, the CHPQA Administrator receives notification in 2010, as DUKES 2010 is being prepared, that a scheme ceased operation in 2007, and consequently did not operate at all in 2008, then that scheme will be removed retrospectively for 2008. The consequence of this will

be a revision to the data for year of operation 2008, and the data reported for this year in DUKES 2009 and DUKES 2010 will be different.

- The results of an audit. If an audit reveals an error in the performance data for a particular year then the relevant entries in the database will be amended.

4. Methodology

4.1 Assigning Fuel to Heat and Power

In DUKES the heat and power performance of CHP schemes is reported separately. For example, an estimate of the fuel used to generate heat, only, is reported as is an estimate of the fuel used to generate power, only. Moreover, heat generating and power generating efficiencies are also reported separately.

For this to be possible it is necessary to assign a portion of the fuel input to the CHP scheme to heat generation and a portion of the same to the power generation. In order to do this a convention is adopted whereby it is assumed that it takes twice as many units of fuel to generate one unit of power than it takes to generate one unit of heat. The rationale behind this convention is that power only plant operate with power efficiencies ranging from 25%to more than 50%, whereas heat only boilers operate with heat efficiencies ranging from 50% to more than 90%, i.e. the separate generation of heat is approximately twice as efficient as the separate generation of electricity.

Apportioning the fuel input to the prime mover separately to the power output and heat outputs is achieved using the formulas below:

$$Fuel\ for\ Heat\ Output = \left(\frac{Total\ Fuel\ Input}{(2 \times Power\ Output) + Heat\ Output}\right) \times HeatOutput$$

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4.2 Determining heat capacity of CHP schemes

The heat capacity figures provided in the Digest are supplied by scheme operators, often based upon the capacity of boilers within the scheme. This means that the true capacity to generate heat has sometimes been overestimated as the output of some heat capacity is used to drive heat engines for the generation of power. Starting in the 2013 edition of the Digest, the heat capacity figures for new CHPQA schemes, existing CHPQA schemes undergoing changes to the plant contained within the scheme boundary and non CHPQA schemes have been determined in a way which better reflects the true capacity of the CHP to generate heat. This is as follows, where:

- THC = Total Heat Capacity of Scheme (as presented in DUKES)
- THC(FB) = Total Heat Capacity of Fired Boilers within the Scheme
- THC(HRB) = Total Heat Capacity of Heat Recovery Boilers within the Scheme
- $THC(FB)_{to\ ST}$ = Total Heat Capacity of Fired Boilers supplying steam to Scheme Steam Turbines
- $THC(HRB)_{to\ ST}$ = Total Heat Capacity of Heat Recovery Boilers supplying steam to Scheme Steam Turbines
- THC(GT or HRB) = Total Heat Capacity for the Gas Turbines or associated Heat Recovery Boilers within the Scheme
- THC(RE) = Total Heat Capacity for the engine cooling circuits of the Reciprocating Engines within the Scheme
- TPC = Total Power Capacity of the Scheme
- TPC_{ST} = Total Power Capacity of Steam Turbines within the Scheme

Back-pressure and Pass-out Condensing Steam Turbine Systems – For schemes certified under CHPQA, the Total Heat Capacity (THC) is given by:

$THC = THC(FB) + THC(HRB) – TPC_{ST}$

For schemes not certified under CHPQA, the THC is given by:

THC = TPC x 2.22

Where 2.22 is the standard heat to power ratio for steam turbines given in Annex I of the EU Directive on energy efficiency (2012/27/EU).

Combined Cycle Systems – For schemes certified under CHPQA, the Total Heat Capacity (THC) is given by:

$THC = THC(FB)_{to\ ST} + THC(HRB)_{to\ ST} - TPC_{ST}$

For schemes not certified under CHPQA, the THC is given by:

THC = TPC x 1.052

Where 1.052 is the standard heat to power ratio for combined cycle gas turbines given in Annex I of the EU Directive on energy efficiency (2012/27/EU).

Gas Turbine Systems - For schemes certified under CHPQA, the Total Heat Capacity (THC) is given by:

THC = THC(GT or HRB) + THC(FB)

For schemes not certified under CHPQA, the THC is given by:

THC = TPC x 1.81

Where 1.81 is the standard heat to power ratio for gas turbines given in Annex I of the EU Directive on energy efficiency (2012/27/EU).

Reciprocating Engine Systems – For schemes certified under CHPQA, the Total Heat Capacity (THC) is given by:

THC = THC(RE) + THC(FB) + THC(HRB)

For schemes not certified under CHPQA, the THC is given by:

THC = TPC x 1.33

Where 1.33 is the standard heat to power ratio for reciprocating engines given in Annex I of the EU Directive on energy efficiency (2012/27/EU).

4.3 Scaling-back Fuel Input and Power Outputs for Non-Good Quality CHP

As mentioned above, only the generating capacity, fuel inputs and power and heat outputs associated with Good Quality CHP are reported in Chapter 7 of DUKES. Where the performance of the CHP is such that, when all of the fuel inputs and heat and power outputs are taken into account, the primary energy saving is less than 10% compared with the separate, conventional generation of these heat and power outputs, then the CHP plant is not 100% Good Quality.

For such cases, there are established procedures for determining the amount of power output that in not Good Quality, and these are set out in the CHPQA Standard[2]. This power is known as non-qualifying power and when it is subtracted from the total power output of the CHP the result is the power that is reported in Chapter 7 of DUKES for that scheme.

The fuel used to generate this non-qualifying power needs to be determined as it should not be reported in Chapter 7. To calculate this fuel the non-qualifying power is divided by the design power efficiency of the prime mover for the particular scheme under consideration. (This information is provided in the F2). The result is the non-qualifying fuel which when subtracted from the total fuel input to the CHP scheme returns the fuel reported for that scheme in Chapter 7.

The non-qualifying power and fuel are included in the electricity figures published in chapter 5 of DUKES.

[2] CHPQA Standard: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/569406/CHPQAStandardIssue6.pdf

4.4 Categorisation of CHP Scheme According to Sector

Each scheme submitting to CHPQA chooses an Economic Sector in which it considers itself to operate. This choice is made from a list of Economic Sectors supplied in CHPQA Guidance Note 12[3], which are based on Standard Industrial Classification codes (SIC2003). The selected sector is then associated with the scheme in question in the CHPSTATS database. CHP data is reported in Chapter 7 segregated according to these Economic Sectors.

For the purposes of informing policy it is instructive to associate the CHP scheme with the economic sector in which the majority of the heat is consumed. If, for example, the CHP operator is only in the business of operating the CHP, exporting the electricity to the grid and the heat to 3rd Parties, then the economic sector associated with the CHP will be that of the 3rd Party heat consumer using the majority of the CHP heat output. As such, the economic sector that the CHP operator identifies itself with may be different with the economic sector assigned to the CHP for the statistics published in DUKES. This situation is more likely for very large CHP schemes and only applies to a small number of schemes.

For CHP schemes in the CHPSTATS database reporting via the Ofgem ROCs database, these schemes are identified with the sector "Sewage Treatment".

For CHP schemes in the CHPSTATS database reporting via ISSB, these schemes are identified with the sector "Iron and Steel".

5. Users of the data

DESNZ itself is one of the main users of the CHP statistics as these figures are included in some of the electricity and energy tables in DUKES to help provide the complete energy picture. In addition, the figures are also used to help inform DESNZ's heat policy and when DESNZ makes projections of energy demand, fuel mix and resulting CO2 emissions. Outside of DESNZ, the statistics are also used by HM Treasury, for example to feed in to budget advice, the Association for Decentralised Energy (ADE) and others. There is also an international interest in these statistics as we are required to submit CHP information to Eurostat on an annual basis.

[3] CHPQA Guidance Note 12 https://www.chpqa.com/guidance_notes/GUIDANCE_NOTE_12.pdf