GUIDANCE NOTE 19

ADJUSTMENT OF ENERGY INPUTS AND OUTPUTS FOR EXCESSIVE UNCERTAINTY

Scope

GN19.1

This GN gives detailed guidance to enable Responsible Persons to:

- determine the adjustment factor applicable to each measured or calculated energy input and output, so as to take account of any excessive uncertainty in that value,
- to combine these individual adjustment factors to determine overall weighted adjustment factors for energy inputs, power outputs and heat outputs required for the completion of a self-assessment submission.

It also contains three worked examples on how to combine individual adjustment factors for heat outputs. Similar approaches can be taken for fuel inputs and power outputs.

The examples show:

- how the computation of the overall weighted adjustment factor is adapted to handle cases where the heat output has to take account of heat losses (i.e. streams having negative values), and
- the simplified approach available for minor heat streams that can be shown to account for not more than 10% of the total useful heat output, i.e. not over 10% of the Scheme's Qualifying Heat Output (QHO).

The examples are based on heat outputs, but the same methods also apply to fuel inputs and power outputs.

Acceptable Levels of Uncertainty

GN19.2

The acceptable levels of uncertainty for energy data submitted as part of a CHPQA application, hereafter referred to as 'best practice', are set out in: GN14.8 - GN14.11 for energy inputs; GN15.6 for electrical outputs; and GN16.10 - GN16.13 for heat outputs. A detailed explanation is given in GN17.12 to GN17.14 and summarised in GN13.10. For convenience the summary is repeated below.

GN19.3

GN13.10 states that to be deemed to be best practice, the maximum uncertainties associated with the measurement of energy flows of different types are as follows:

Fuel Inputs, kWh	±2.0% of reading
Energy inputs as steam or hot water, kWh	As for steam or hot water as appropriate

Heat metering, of hot water, thermal fluid or other liquid heat circulating loops, kWh,	Metering to BS EN 1434-1:2022, metrological Class 3 (typically 4.5% of reading) or better, with concessions for Schemes with TPC ≤2 MWe), see GN16.15.
Metering of steam flows and derivation of energy content, kWh	±2.0% of full scale ±3.0% of reading
Electric power, kWh	Metering to applicable BS and metrological Class dependent on rating, see GN15.6
Indirect measurement or calculation of energy input or output, kWh	±2.0% of value, except for heat outputs from Schemes with TPC ≤2 MWe where ±5.0% of value applies.

GN19.4

Meters and calculations that meet the above requirements in terms of uncertainty (accuracy) are deemed to be 'best practice' and no adjustment of their output values is required to take account of uncertainties. See also GN19.23.

TREATMENT OF EXCESSIVE UNCERTAINTY

GN19.5

Excessive uncertainty is the amount, expressed as a percentage value, by which the uncertainty in a metered or calculated energy input or output, as assessed using the procedures in GN17 and GN18, exceeds the acceptable level of uncertainty i.e. 'best practice'. The procedure to calculate excessive uncertainty is shown in GN19.14.

GN19.6

GN13.12 sets out the underlying principles of the treatment of excessive uncertainty. Where the uncertainty associated with a metered value or indirect measurement of an input or output exceeds the uncertainty level that is deemed to be best practice for that type of variable, an adjustment of the value of that input or output is required. Non-complying **inputs shall be increased** by a factor based on the excessive uncertainty. Non-complying **outputs shall be reduced** by a factor based on the excessive uncertainty. The procedure to calculate these adjustment factors in shown in GN19.15.

GN19.7

For CHPQA self-assessment, the individual adjustment factors are combined to give overall weighted adjustment factors (**FOI for energy inputs, FOP for power outputs and FOH for heat outputs).** These are to be applied to the total energy inputs, total power outputs or total useful heat outputs in a submission to produce scheme power and heat efficiencies that have been corrected for the uncertainties associated with the scheme fuel input and useful energy outputs. The procedure to calculate these overall weighted adjustment factors is shown in GN19.17 – GN19.19.

GN19.8

Note that the values to be entered in the Energy Inputs, Power Outputs and Heat Outputs sections of a submission are values of energy inputs or outputs as metered or calculated. These must be **unadjusted** for the uncertainties. However, they may be adjusted for bias if this has been established, e.g. by recent calibration.

GN19.9

The method to be used in deriving and applying the overall weighted adjustment factors is prescribed below and pro-forma worksheets are provided to standardise these procedures.

INDIVIDUAL ADJUSTMENT FACTORS

GN19.10

Every individual **metered** energy input and output has an associated overall uncertainty**, Uo**, which may be determined by following the procedures set out in GN17.

GN19.11

Every individual **calculated** energy input and output has an associated overall uncertainty, **Uo**, which may be determined by following the full procedures set out in GN18. A calculated value (calculation output) may involve a number of metered values, each with its own uncertainty to be determined using GN17.

GN19.12

The **acceptable uncertainty for 'best practice'** for each individual metered or calculated value, **UBP**, is determined using the guidance given in GN19.2 and GN19.3, and other GNs referred to therein.

GN19.13

For CHPQA all uncertainties are to be expressed as percentage values to two decimal places e.g. 3.05%.

GN19.14

The **excess uncertainty, UX,** is given by:

If Uo > UBP, UX = U – UBP

If Uo ≤ UBP, UX = 0.00

GN19.15

The **individual adjustment factor, FI**, is given by:

For energy inputs **FI = 1 + (UX / 100)**

For power or heat outputs **FI = 1 - (UX / 100)**

e.g. If for an energy input UX = 1.50%, FI = 1 + (1.50 / 100) = 1.0150

e.g. If for a heat output UX = 1.50%, FI = 1 - (1.50 / 100) = 0.9850

GN19.16

For CHPQA all adjustment factors are to be expressed to **four** decimal places.

WEIGHTED ADJUSTMENT FACTORS

GN19.17

To derive the overall adjustment factor for energy inputs, power outputs or heat outputs, each individual adjustment factor is weighted in proportion to the annual contribution of that individual input or output to the corresponding total annual scheme energy input or useful energy output.

e.g. From Submission journey:

An individual annual energy input stream	= 100,000MWh
The total annual energy inputs, TFI	= 400,000MWh
Fraction of TFI for the individual input stream **(F)**	= 100,000/400,000 = 0.2500
If the individual stream adjustment factor, **FI**	= 1.0150 (as in GN19.15)
Then, **Weighted Adjustment Factor, FW = F x FI**	**= 0.2500 x 1.0150 = 0.2538** (four decimal places)

GN19.18

The **overall adjustment factor, FO**, is the sum of all the relevant weighted adjustment factors:

$$F_O = \sum F_W$$

GN19.19

The values of **FO** have to be determined separately for Energy Inputs, (**FOI)**, Power Outputs **(FOP)**, and Heat Outputs, (**FOH)**. Pro-forma worksheets are given below, and several worked examples are provided.

PRO-FORMA WORKSHEETS AND WORKED EXAMPLES

GN19.20

The Worksheets provided at the end of this Guidance Note are:

Worksheet FOI - Energy Inputs - Uncertainty Adjustment Factor

Worksheet FOP - Power Outputs - Uncertainty Adjustment Factor

Worksheet FOH - Heat Outputs - Uncertainty Adjustment Factor

GN19.21

The first worked example **(Example GN19-1)** is a calculation of FOH for a site that supplies useful heat (steam) to site via a number of steam flow meters (M8 for LP steam and M9 for MP steam).

The second example **(Example GN19-2)** deals with the treatment of negative energy streams, which is a special, though not uncommon case. Here, some of the metered low pressure (LP) steam passing through the main LP steam meter M8 is diverted and used for heating the feedwater for the boilers that are included within the Scheme, (for example in a hot well or deaerator). This steam take-off, which does not qualify as a CHP heat output, may be either metered or determined by calculation. In either case, its uncertainty must be determined unless it is to be treated as a minor stream.

In order for the uncertainty adjustment calculation to work, negative heat outputs are not permitted, so for CHPQA a simplifying approximation has been adopted. This requires the heat outputs of negative energy flows to be entered as absolute (positive) quantities in the heat output column and to enter the sum of all the positive values in the total cell. This allows the fraction of the heat associated with the various output streams to be computed with respect to a normalised annual total, rather than the actual annual total of useful heat sent to the site.

The third example (**Example GN19-3)** is similar to Example GN19-2 above, except that the LP steam used within the Scheme for heating boiler feedwater (meter M10) has been shown to be less than 5% of the total useful heat to process. It was therefore decided to take advantage of the treatment available for minor streams (see GN13.20).

The procedures permitted for minor streams can also be used for fuel inputs or power outputs, including where several metered or calculated streams are involved, as long as the sum of these streams is no more than 5% of the Total Fuel Input (TFI), or the Total Power Output (TPO) or Qualifying Heat Output (QHO), as appropriate.

COMPLETING A SUBMISSION

GN19.22

The values of the **overall adjustment factors, F_{OI}, F_{OP} and F_{OH}** are used in the submission journey to determine the power efficiency and heat efficiency.

GN19.23

Where **all values of energy inputs** are within the acceptable level of uncertainty

F_{OI} = 1.0000.

Where **all values of power or heat outputs** are within the acceptable level of uncertainty

F_{OP} and/or F_{OH} = 1.0000.

WORKSHEET FOI ENERGY INPUTS – UNCERTAINTY ADJUSTMENT FACTOR

Record below the individual annual fuel inputs to the CHP Scheme and determine the individual and overall uncertainty adjustment factors.
See GN19

Meter or Calc. No.	Description of Input (e.g. HP gas to GT1)	Annual Energy Input (from submission) **(Absolute values)**	Fraction of TFI **F**	Acceptable Uncertainty for Best Practice **U_{BP}**	Actual Uncertainty **Uo**	Excess Uncertainty **Ux= Uo – U_{BP}** **(if Uo < U_{BP}, Ux = 0.00)**	Individual Adjustment Factor **F_I = 1+(Ux/100)**	Weighed Adjustment Factor **Fw = F x F_I**
		MWh	(4 decimal places)	% (2 decimal places)	% (2 decimal places)	% (2 decimal places)	(4 decimal places)	(4 decimal places)
The line below is to be completed only where the concessions offered for minor energy steams is to be used								
	Minor energy inputs			N/A	N/A	N/A	**1.1000**	
	Total		**1.0000**		**Overall Adjustment Factor FOI** (= sum of **Fw** Factors)			

WORKSHEET FOP POWER OUTPUTS – UNCERTAINTY ADJUSTMENT FACTOR

Record below the individual annual power outputs from the CHP Scheme and determine the individual and overall uncertainty adjustment factors. See GN19

Meter or Calc. No.	Description of Output (e.g. GT1 power gen.)	Annual Power Output(From submission) **(Absolute values)** MWh	Fraction of TPO **F** (4 decimal places)	Acceptable Uncertainty for Best Practice **UBP** % (2 decimal places)	Actual Uncertainty **Uo** % (2 decimal places)	Excess Uncertainty **Ux= Uo – UBP (if Uo < UBP, Ux = 0.00)** % (2 decimal places)	Individual Adjustment Factor **FI = 1 – (Ux/100)** (4 decimal places)	Weighed Adjustment Factor **FW = F x FI** (4 decimal places)
The line below is to be completed only where the concessions offered for minor energy steams is to be used								
	Minor power outputs			N/A	N/A	N/A	**0.9500**	
	Total		**1.0000**		**Overall Adjustment Factor FOP** (= sum of **Fw** Factors)			

WORKSHEET FOH HEAT OUTPUTS – UNCERTAINTY ADJUSTMENT FACTOR

Record below the individual annual heat outputs from the CHP Scheme and determine the individual and overall uncertainty adjustment factors. See GN19

Meter or Calc. No.	Description of Output (e.g. MP steam to site)	Annual Heat Output(From submission) **(Absolute values)** MWh	Fraction of QHO **F** (4 decimal places)	Acceptable Uncertainty for Best Practice **U_{BP}** % (2 decimal places)	Actual Uncertainty **U_o** % (2 decimal places)	Excess Uncertainty **$U_x = U_o - U_{BP}$** **(if $U_o < U_{BP}$, $U_x = 0.00$)** % (2 decimal places)	Individual Adjustment Factor **F_I** **= 1 – (Ux/100)** (4 decimal places)	Weighed Adjustment Factor **F_W** **= F x F_I** (4 decimal places)
The line below is to be completed only where the concessions offered for minor energy steams is to be used								
	Minor heat outputs			N/A	N/A	N/A	**0.9000**	
	Total		**1.0000**		**Overall Adjustment Factor FOH** (= sum of **Fw** Factors)			

EXAMPLE GN19-1 – DETERMINATION OF UNCERTAINTY ADJUSTMENT FACTOR

This example is based on a Scheme that provides two metered supplies of steam to site.

MP steam totaling 100,000 tonnes/year is supplied to site at a typical pressure of 10 bar(g) and a temperature of 200°C. The flow measurement through meter M9 has been shown to have an overall uncertainty (Uo) of 4.85% and the acceptable uncertainty for best practice is 3.00% of reading (**see Example GN17-1**). Steam tables show the specific enthalpy of steam at 11 bar(a) and 200°C to be 2,822 kJ/kg = MJ/tonne, so, for CHPQA, the energy equivalent of MP steam is (2,822 - 42)/3,600 = 0.772 MWh/tonne. Annual heat output from 100,000 tonnes of MP steam is therefore 77,220 MWh.

LP steam (metered on M8) totaling 50,000 tonnes/year is supplied to site at a typical pressure of 2.5 bar(g), nominally in a dry-saturated condition. The steam flow meter is an orifice plate without pressure compensation, its transmitter was last calibrated 30 months ago and the orifice plate was last inspected 8 years ago. Using the default values given in GN17 the uncertainty associated with this measurement is 7.68% and the acceptable uncertainty for best practice is 3.00% of reading (GN17.14). Steam tables show the specific enthalpy of saturated steam at 3.5 bar(a) to be 2,732kJ/kg = 2,732 MJ/tonne, so for CHPQA the energy equivalent of LP steam is (2,732 - 42)/3,600 = 0.747 MWh/tonne. Annual heat output as LP steam is therefore 37,350 MWh.

WORKSHEET FOH HEAT OUTPUTS – UNCERTAINTY ADJUSTMENT FACTOR

Meter or Calc. No.	Description of Output (e.g. MP steam to site)	Annual Heat Output (From submission **(Absolute values)** MWh	Fraction of QHO **F** (4 decimal places)	Acceptable Uncertainty for Best Practice **U_{BP}** % (2 decimal places)	Actual Uncertainty **Uo** % (2 decimal places)	Excess Uncertainty **$Ux = Uo - U_{BP}$** **(if $Uo < U_{BP}$, $Ux = 0.00$)** % (2 decimal places)	Individual Adjustment Factor **F_I** **= 1 – (Ux/100)** (4 decimal places)	Weighed Adjustment Factor **F_W** **= F x F_I** (4 decimal places)
M8(FQ)	LP steam to site	37,350	0.3260	3.000	7.68	4.68	0.95328	0.3107
M9(FQ)	MP steam to site	77,220	0.6740	3.00	4.85	1.85	0.9815	0.6615
The line below is to be completed only where the concessions offered for minor energy steams is to be used								
	Minor heat outputs			N/A	N/A	N/A	**0.9000**	
	Total	114,570	**1.0000**		**Overall Adjustment Factor F_{OH}** (= sum of **F_W** Factors)			**0.9722**

EXAMPLE GN19-2 – DETERMINATION OF UNCERTAINTY ADJUSTMENT FACTOR

This example is similar to Example GN19-1 above, except that some of the LP steam metered by M8 (FQ) is used within the Scheme for heating boiler feedwater and so does not qualify as a CHP heat output. This flow of steam to the hot well is metered by steam meter M10 and shown to be 10,000 tonnes/year (7,470 MWh). The uncertainty associated with this metered steam flow is 14.35%, applying the procedures set out in GN17.

In order for the uncertainty adjustment calculation to work, negative heat outputs are not permitted, so for CHPQA the simplifying approximation adopted is to enter the heat outputs of negative energy flows as absolute (positive) quantities in the heat output column and to enter the sum of all the positive values in the total cell. This allows the fraction of the heat associated with the various output streams to be computed with respect to a normalised annual total, rather than the actual annual total of useful heat sent to the site. The normalised total used for determining the individual heat stream fractions then becomes 122,040 MWh, rather than the actual QHO value of 107,100 MWh.

WORKSHEET FOH HEAT OUTPUTS – UNCERTAINTY ADJUSTMENT FACTOR

Meter or Calc. No.	Description of Output (e.g. MP steam to site)	Annual Heat Output (From submission) **(Absolute values)** MWh	Fraction of QHO **F** (4 decimal places)	Acceptable Uncertainty for Best Practice **U_{BP}** % (2 decimal places)	Actual Uncertainty **Uo** % (2 decimal places)	Excess Uncertainty **$U_x = U_o - U_{BP}$** **(if $U_o < U_{BP}$, $U_x = 0.00$)** % (2 decimal places)	Individual Adjustment Factor **F_I** **= 1 – (Ux/100)** (4 decimal places)	Weighed Adjustment Factor **F_W** **= F x F_I** (4 decimal places)
M9(FQ)	MP steam to site	77,220	0.6328	3.00	4.85	1.85	0.9815	0.6211
M8(FQ)	LP steam to site and hot well	37,350	0.3060	3.00	7.68	4.68	0.9532	0.2917
M10(FQ)	Deduct LP steam to hot well	7,470	0.0612	3.00	14.35	11.35	0.8865	0.0543
The line below is to be completed only where the concessions offered for minor energy steams is to be used								
	Minor heat outputs			N/A	N/A	N/A	**0.9000**	
	Total	122,040	**1.0000**		**Overall Adjustment Factor F_{OH}** (= sum of **Fw** Factors)			**0.9671**

EXAMPLE GN19-3 – DETERMINATION OF UNCERTAINTY ADJUSTMENT FACTOR (SIMPLIFIED APPROACH)

This example is similar to **Example GN19-2** above, except that the LP steam used within the Scheme for heating boiler feedwater (meter M10) constitutes less than 5% of the total useful heat to process and it has been decided to take advantage of the treatment available for minor streams.

WORKSHEET FOH HEAT OUTPUTS – UNCERTAINTY ADJUSTMENT FACTOR

Meter or Calc. No.	Description of Output (e.g. MP steam to site)	Annual Heat Output (From submission) **(Absolute values)** MWh	Fraction of QHO **F** (4 decimal places)	Acceptable Uncertainty for Best Practice **U_{BP}** % (2 decimal places)	Actual Uncertainty **Uo** % (2 decimal places)	Excess Uncertainty **Ux= Uo – U_{BP}** **(if Uo < U_{BP}, Ux = 0.00)** % (2 decimal places)	Individual Adjustment Factor **F_I** **= 1 – (Ux/100)** (4 decimal places)	Weighed Adjustment Factor **Fw** **= F x F_I** (4 decimal places)
M8(FQ)	LP steam to site and hot well	37,350	0.3112	3.00	7.68	4.69	0.9531	0.2966
M9(FQ)	MP steam to site	77,220	0.6434	3.00	4.85	1.85	0.9815	0.6315
The line below is to be completed only where the concessions offered for minor energy steams is to be used								
	Minor heat outputs	5,450	0.0454	N/A	N/A	N/A	**0.9000**	0.0409
	Total	120,020	**1.0000**		**Overall Adjustment Factor FOH** (= sum of **Fw** Factors)			**0.9690**