Department for Business, Energy & Industrial Strategy

chp QA

CHPQA – Understanding Uncertainty

Joe McQuillen

CHPQA

November 2019

Talk Coverage

- Applicability to CHPQA
- What is uncertainty? % reading vs full-scale
- Relevance to CHPQA
- CHPQA best practice
- Determining uncertainty
- Excessive uncertainty
- Uncertainty adjustment factors (F_{OI}, F_{OP}, F_{OH})
- Management (and reduction) of uncertainty

Applicability to CHPQA

- The uncertainty of your monitoring arrangement must be reported to CHPQA when applying via the complex form route: F3 or F2+F4
- The overall uncertainty (U_o) of each metered or calculated energy input/output is required in forms: F3 or F2
- Uncertainty adjustment factors (F_{OI}, F_{OP} and F_{OH}) are required on Form F4. These are used to correct for excess uncertainties.

Department for Business, Energy & Industrial Strategy

Applicability to CHPQA

- Guidance on uncertainty (and bias) is provided in the following detailed CHPQA guidance notes:

GN13 – CHP Scheme Monitoring Information

GN17 – Uncertainty in Metered Inputs and Outputs

GN18 – Uncertainty in Calculated Energy Inputs and Outputs

GN19 – Adjustment of Energy Inputs and Outputs for Excessive Uncertainty

GN23 – Correction of Bias in Inputs and Outputs Information

- Found online at: https://www.gov.uk/guidance/chpqa-guidance-notes

Department for Business, Energy & Industrial Strategy

CHP QA

What is uncertainty?

- Any measurement is subject to imperfections, uncertainty is a quantitative indication of the quality of a measured value.

- Uncertainty is expressed as a range ±n% of the measured value.

- For the purposes of CHPQA, this is defined as:

the range of values, within which there is a high probability (usually >95%) that the true value of a measured (or calculated) variable is estimated to lie.

Department for
Business, Energy
& Industrial Strategy

What is uncertainty?

Example

A manufacturer of a flow meter state that the uncertainty of their device is ±2%.

The flow meter records a water flowrate of 10l/s through a pipe.

The true flowrate through the pipe is therefore likely (greater than 95% probability) to lie within the range of 9.8l/s and 10.2l/s (an error band of ±0.2l/s).

What is uncertainty?

- The overall uncertainty (U_o) of a meter must include for all of its components

- A heat meter has three components: a flowmeter and two thermocouples

- Overall uncertainty is determined by the root-sum-square (RSS) method as set out in GN17.24-17.25

- The overall uncertainty (U_o) of such a heat meter becomes:

$$U_o = \sqrt{U1^2 + U2^2 + U3^2}$$

% of Reading vs Full-scale

- Uncertainty of metered values can be quoted in two ways: % of reading and % of full-scale reading
- Full-scale reading is the maximum value that the meter can record.
- An uncertainty of ±1% of full-scale reading becomes an uncertainty of ±2% of the actual reading at 50% output.
- GN13.11 sets out uncertainty requirements of steam flows in terms of % reading and % full-scale

Relevance to CHPQA

- Monitoring of values (fuel, heat and power) determines a CHP Scheme’s performance
- The fiscal benefits available to a CHP Scheme are dependant on its performance
- Low uncertainty in monitored values gives confidence that a Scheme’s performance is being correctly determined and hence correct benefits received
- Conversely, high uncertainty casts doubt on measured values

Relevance to CHPQA

- CHPQA must therefore correct a CHP Scheme's performance for any excess uncertainty
- CHPQA have developed what it considers 'best practice' limits to uncertainty.
- Where uncertainty exceeds 'best practice', Uncertainty Adjustment Factors (F_{OI}, F_{OP} and F_{OH}) must be applied.

F_{OI} – Energy Inputs

F_{OP} – Power Outputs

F_{OH} – Heat Outputs

Department for Business, Energy & Industrial Strategy

chp QA

CHPQA best practice

- CHPQA have set out what it deems as best practice limits to uncertainty for all energy inputs and outputs.

- See table in GN13.11

• Fuel Inputs, kWh	±2.0% of reading
• Energy inputs as steam or hot water, kWh	As for steam or hot water as appropriate (see below)
• Heat metering, of hot water, thermal fluid or other liquid heat circulating loops, kWh,	Metering to BS EN 1434-1:2007, metrological Class 3 (typically 4.5% of reading) or better, with concessions for Schemes with TPC <2MWe), see GN16.15 – 16.16. The Measuring Instrument Directive MID 2004/22/EC Annex MI-004 is based on BS EN 1434-1:2007.
• 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 Class dependant on rating, see GN15.7
• Indirect measurement or calculation of energy input or output, kWh	±2.0% of value, except for heat outputs from Schemes with TPC <2MWe where ±5.0% of value applies.

Department for Business, Energy & Industrial Strategy

chp QA

CHPQA best practice - electricity

- Uncertainty (or class) requirements specific to power meters are detailed separately in Table GN15-1.

Table GN15-1 – Classification of Electricity Metering Equipment

Rated Capacity	Watt-Hour Meter Standard and Accuracy Class	Current Transformer Accuracy Class (Note 1)	Voltage Transformer Accuracy Class (Note 2)	Nominal Overall Uncertainty for CHPQA (Note 3)
>100 MVA	BS EN 62053 (2003) Class 0.2S	0.2S	0.2	±0.5%
<100 MVA	BS EN 62053 (2003) Class 0.5S	0.2S	0.5	±1.0%
<10 MVA	BS EN 62053 (2003) Class 1	0.5	1	±1.5%
≤1 MW	BS EN 62053 (2003) Class 2	0.5	1	±2.5%

Notes

(1) CTs to IEC 60044-1 (2002)

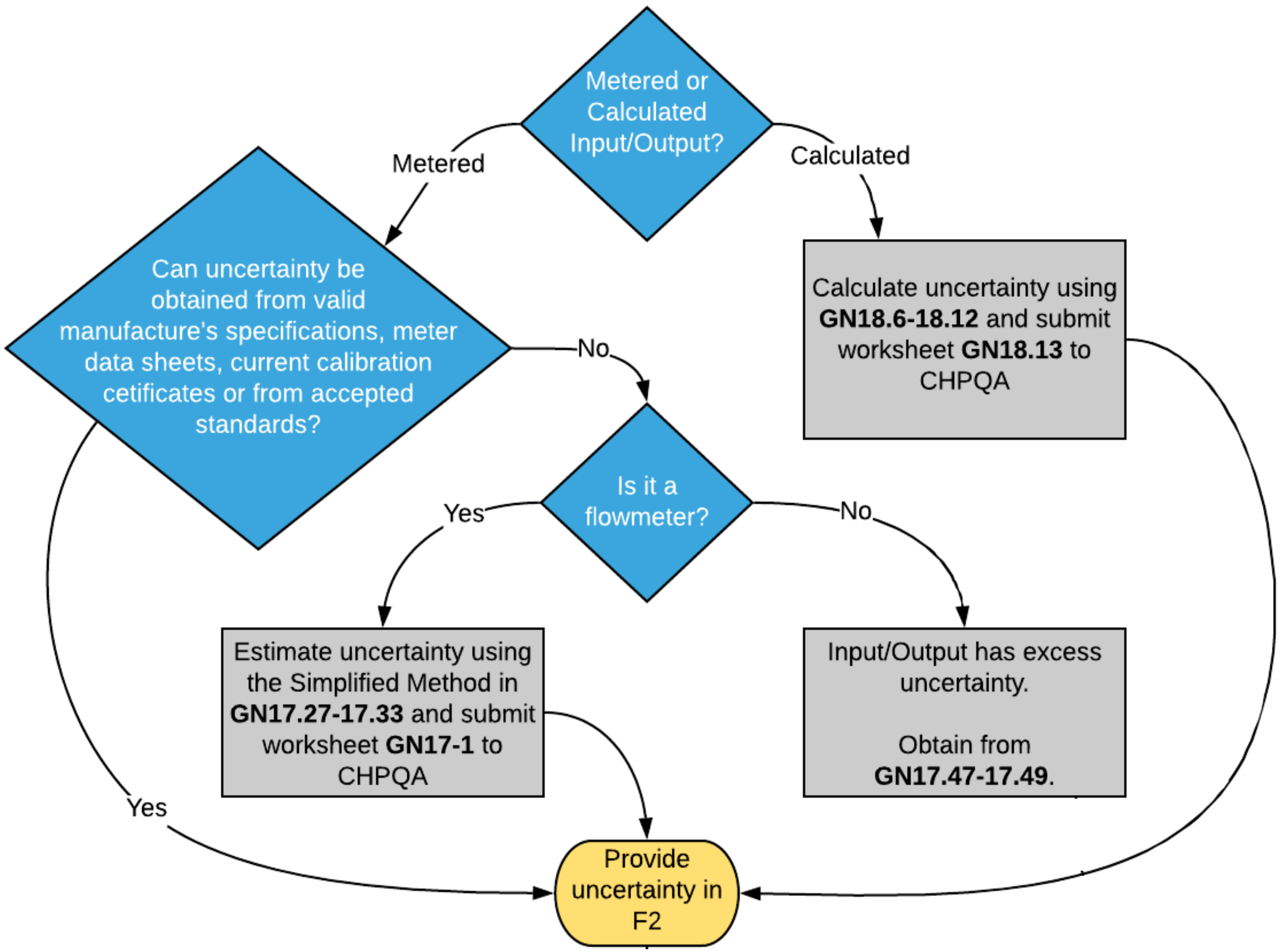
(2) VTs to IEC 61869-3 (2011) and 61869-5 (additional requirement)

(3) The actual uncertainty is influenced by power factor and metered load (percent of rated measuring current). The nominal values tabulated shall be used to assess the excess uncertainty of metering systems (meters, current and voltage transformers) that do not meet the applicable standard for their rated capacity.

Department for Business, Energy & Industrial Strategy

CHP QA

Determining uncertainty



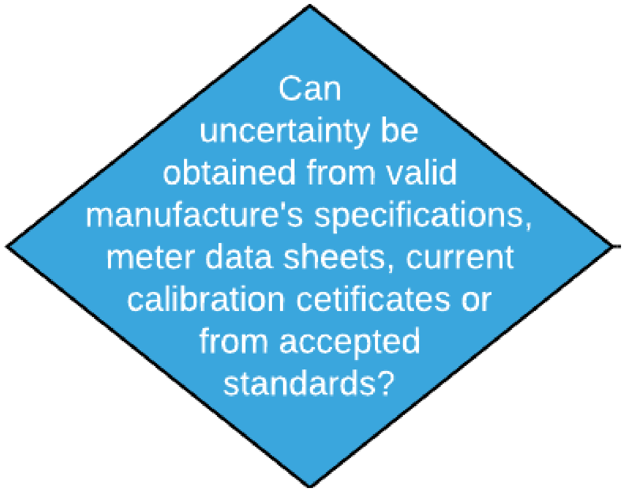
Department for Business, Energy & Industrial Strategy

CHP QA

Determining uncertainty

- In majority of cases, it should be possible to determine uncertainty at this point.

- Accepted sources:
  - Confirmation from manufacturer
  - Meter data sheets
  - Current calibration certificates
  - Fiscal meters should be within best practice – though you must have confirmation from your supplier

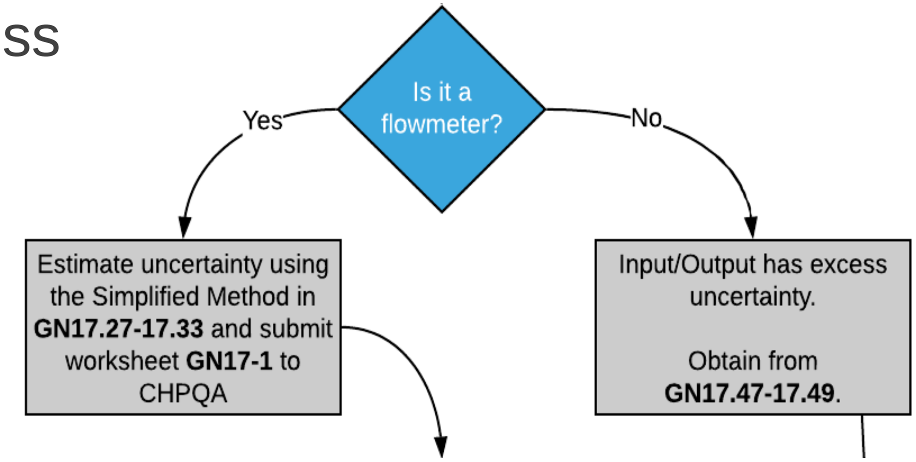


Department for Business, Energy & Industrial Strategy

CHPQA

Determining uncertainty

- Calculated energy inputs/outputs must determine uncertainty using GN18.6-18.12
- CHPQA have developed a Simplified Method of determining uncertainty for flow meters – see GN17.27-17.33.
- For other meter types, excess uncertainty is automatically imposed – see GN17.47-GN17.49.



Determining uncertainty

- Simplified Method set out in GN17.27-17.33
- Note the effect of lack of calibration on uncertainty in table GN17-4

Table GN17-4 – Default values of additional uncertainty due to time elapsed since calibration or inspection of primary device

Time elapsed since calibration or inspection	Effective Uncertainty Ue
≤ 5 years	0.0
> 5 – 7 years	3.0
> 7 – 10 years	7.0
> 10 years	10.0

Department for Business, Energy & Industrial Strategy

CHP QA

Determining uncertainty

- The uncertainty of each energy input or output of your monitoring arrangement is requested in Question 5 of form F2 (or Q6 of F3).

Provide uncertainty in F2

Q5 : Scheme Details (Monitoring Arrangements)

See: GN13 , 14, 15, 16, 17, 18, 20 & 22

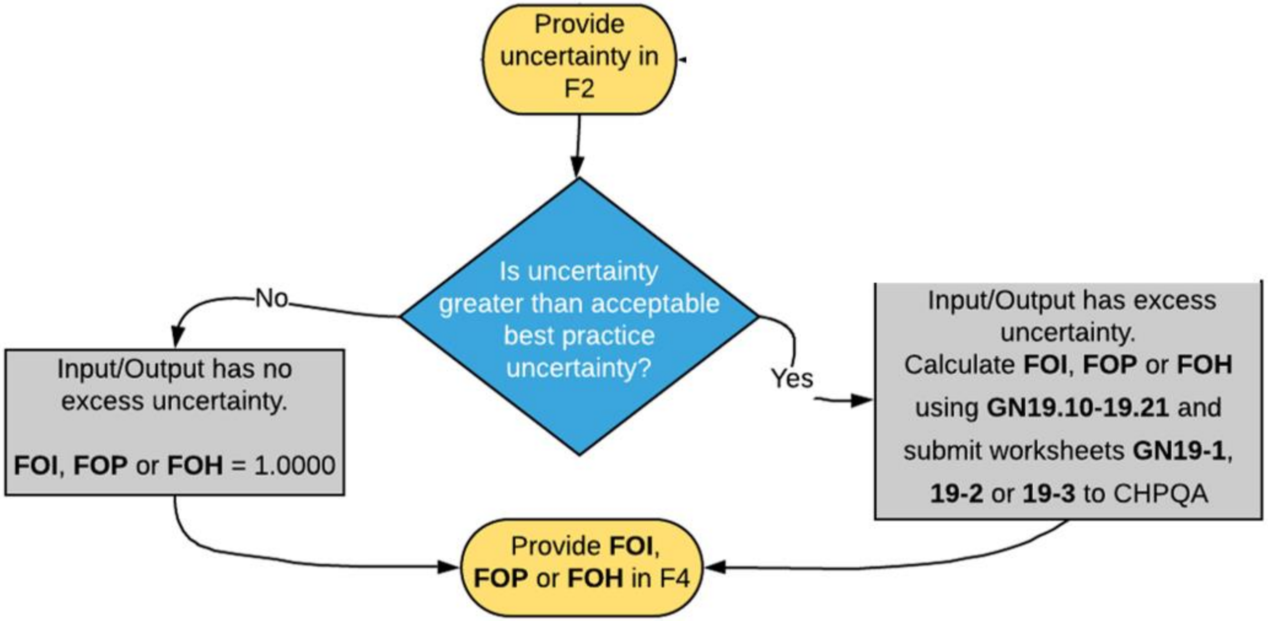
- Use this table to list all existing and proposed metering stations (including. the meters by which you are billed) for your Scheme inputs and outputs. See GN12.7 to GN12.13
- Identify each meter by tag number using the notation in the Guidance Notes. (Each meter should be identified on your Scheme line and energy flow diagrams). See GN12.3
- Provide details of all export metering (heat and electricity). See GN15.10 to GN15.14 & GN16.5 & GN16.7
- Attach details of any indirect methods used to derive unmetered inputs or outputs (include below the monitoring upon which these rely). See GN20 to GN22
- Identify the meter uncertainty % (= 100 - accuracy of reading %), attach supporting calculations. See GN17 & GN18

Tag prefix	Tag no.	User tag	Year installed	Metered service	Outputs Range	Outputs Units	Uncertainty +/-	
M	1	M1(FcQ)	2018	Fuel	80-1600	m3/hr	% 1.55	delete
Model type: Example Gas Turbine Meter			MPR meter: Yes	MPR no.: 9339232669		Serial no.: 1509112935		
M	2	M2(EQ)	2018	Electricity	N/A	MWh	% 1.55	delete
Model type: Example Power Meter - Class 2			MPR meter: No	MPR no.: N/A		Serial no.: 6243972		
M	3	M3(HQ)	2018	Heat	0.6-30000	m3/hr	% 1.05	delete
Model type: Example Heat Meter			MPR meter: No	MPR no.: N/A		Serial no.: 5351234		

Report to two decimal places

Excessive uncertainty

- Compare uncertainty against best practice stated in GN13.11 and GN15-1.
- If the uncertainty of an energy input/output exceeds best practice, it is deemed to have excessive uncertainty (UX).



Department for Business, Energy & Industrial Strategy

CHP QA

Excessive uncertainty

- Excess uncertainty is simply the difference between the overall uncertainty of the energy input/output (U_o) and the best practice uncertainty (UBP).

If $\mathbf{U_o > UBP}$, then $\mathbf{UX = U_o - UBP}$

If $\mathbf{U_o \leq UBP}$, then $\mathbf{UX = 0.00}$

Where $\mathbf{U_o}$ = Uncertainty of value, **UBP** = Best practice uncertainty and **UX** = Excess uncertainty.

Uncertainty Adjustment Factors F_{OI}, F_{OP} and F_{OH}

- If an energy stream (fuel, heat or power) has no excessive uncertainty, we essentially apply no uncertainty adjustment factor:
  F_{OI}, F_{OP} and F_{OH} = 1.0000

- This must include for all inputs/outputs of that energy stream!

- Where there is excessive uncertainty associated with energy input/output, F_{OI}, F_{OP} and F_{OH} must be determined using GN19.10-19.21.

Input/Output has no excess uncertainty.

FOI, **FOP** or **FOH** = 1.0000

Input/Output has excess uncertainty.
Calculate **FOI**, **FOP** or **FOH** using **GN19.10-19.21** and submit worksheets **GN19-1**, **19-2** or **19-3** to CHPQA

Uncertainty Adjustment Factors F_{OI}, F_{OP} and F_{OH}

- Uncertainty adjustment factors are requested in Question 6 of the F4 form.
- Note that they act to reduce heat and power efficiencies – hence reducing QI.

Provide **FOI**, **FOP** or **FOH** in F4

Q6 : CHP Scheme Efficiency

See GN24.2.

UNCERTAINTY ADJUSTMENT FACTORS

Please enter the uncertainty adjustment factors derived in accordance with GN19.

Fuel Uncertainty Adjustment Factor FOI:	1.0921
Power Uncertainty Adjustment Factor FOP:	1
Heat Uncertainty Adjustment Factor FOH:	0.9012

Power Efficiency = $100 \times (CHP_{TPO} \times F_{OP}) / (CHP_{TFI} \times F_{OI})$

η POWER = $100 \times (18285 \times 1) / (104055 \times 1.0921) = 16.09$ %

Heat Efficiency = $100 \times (CHP_{QHO} \times F_{OH}) / (CHP_{TFI} \times F_{OI})$

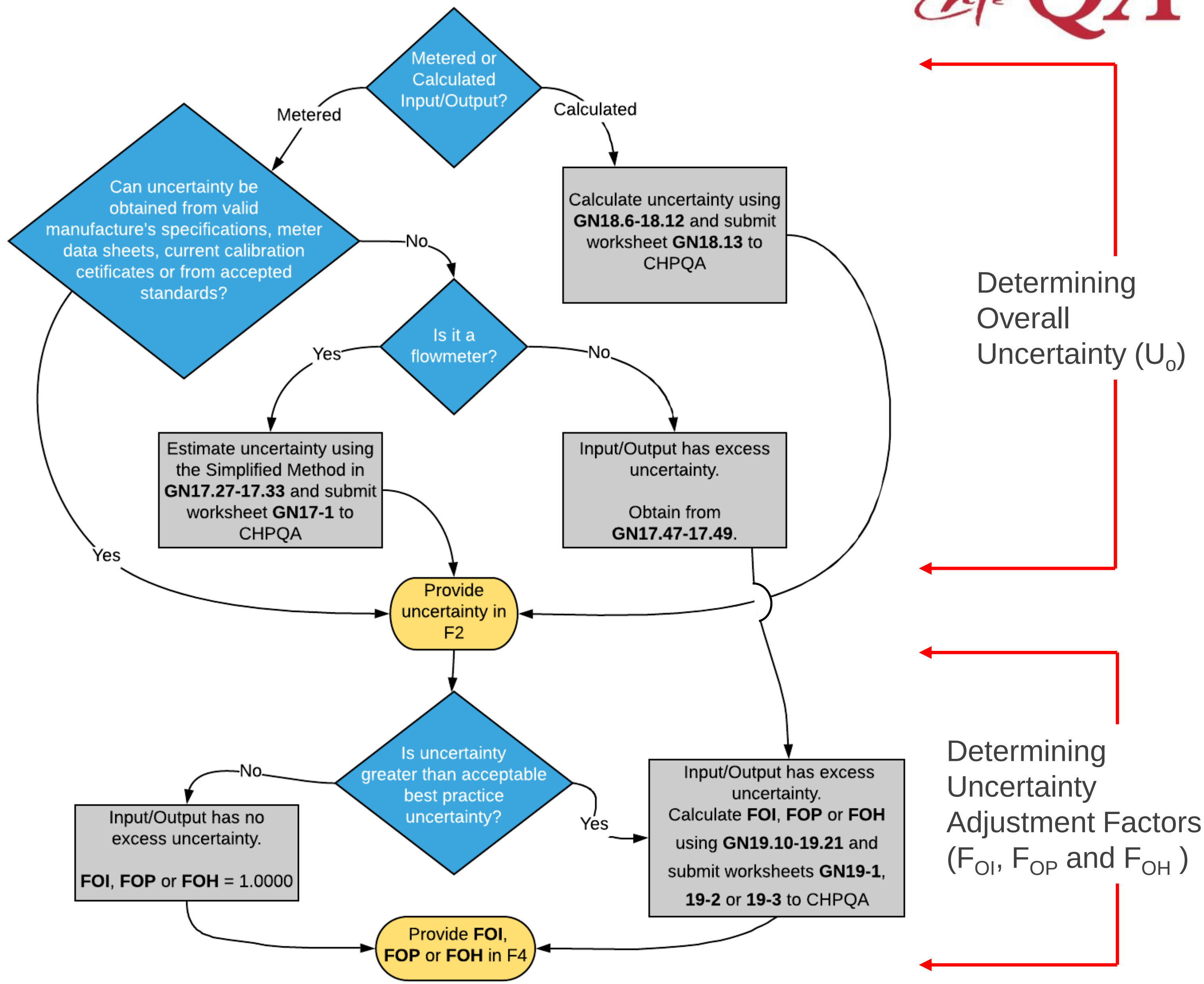
η HEAT = $100 \times (61258 \times 0.9012) / (104055 \times 1.0921) = 48.58$ %

Report to four decimal places

Adjustment factors reduce power and heat efficiencies ☹

Department for Business, Energy & Industrial Strategy

CHPQA



Management of uncertainty

- Uncertainty adjustment factors act to reduce the performance of a scheme. It is therefore in your best interests to minimise uncertainty.

- Optimise your CHPQA performance – keep calibrated! Develop an appropriate calibration schedule.

- Alternatively, meters may be replaced for new if this works out to be more economical.

- Evidence of current calibration certificates and a calibration schedule will be requested on site audit.

Department for Business, Energy & Industrial Strategy

CHPQA Contact Details

CHPQA Administrator

The Gemini Building
Fermi Avenue
Harwell
Didcot
OX11 0QR

E-mail: **chpqainfo@chpqa.com**

Tel: 01235 75 3004

Web: **https://www.gov.uk/combined-heat-power-quality-assurance-programme**

Thank You