GUIDANCE NOTE 12

CHP SCHEME DESCRIPTION

Refer to GN10 & GN11 for guidance on the influence of CHP Scheme boundaries on QI and Power Efficiency.

ECONOMIC SECTOR

GN12.1

Applicants should enter the name of the sector that best describes the activity served by the Scheme (i.e. the recipient of the heat, not necessarily the CHP operator's core business sector) from the following list of classifications:

Table GN12-1 Economic Sectors

Iron and steel	Non-ferrous metals
Chemical and pharmaceutical industry	Oil refineries
Paper, publishing and printing	Food, beverages and tobacco
Textiles, clothing & footwear	Electrical & instrument engineering
Vehicles	Mechanical engineering & metal products
Mineral products (e.g. glass, cement, bricks)	Extraction, mining & agglomeration
Construction	Other industrial branches
Transport	Sewage treatment
Public administration: Health Defence Education Public sector housing Post Office Local or National Government Other public administration	Commerce: Airports Hotels Sports and leisure Mixed Community Heating Offices Other commerce
Other: Horticulture Manufacturing and Retail Timber Scientific Research Private Hospitals Royal Household	

CHP SCHEME LINE DIAGRAM

GN12.2

A CHP Scheme Line Diagram (see Fig GN12-1) showing the CHP Scheme and its relationship to the site as a whole is required. The diagram should include all the main plant items that lie within the CHP Scheme boundary, their interconnections, and piping and cables carrying fuel and energy inputs, power and heat outputs (steam, hot water, or exhaust gas, as applicable). All lines should clearly indicate the fluid or service carried. In the case of steam and hot water, the notation should include the working pressure and temperature.

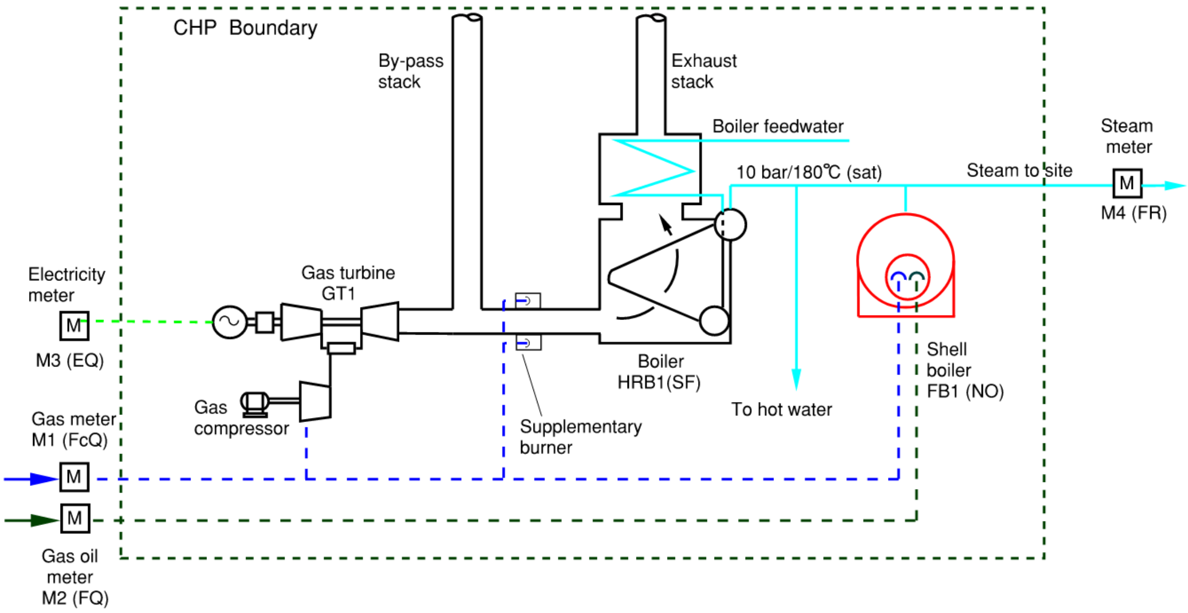


Fig GN12-1 CHP Scheme Line Diagram

TAG NOTATION

GN12.3

All main equipment items and metering stations should be identified on the CHP Scheme Line Diagram with simple Tag Numbers.

Equipment Tags should consist of a simple prefix (as indicated below) followed by a number, e.g. GT1, GT2, ST1, HRB1. Where appropriate a suffix indicating the sub-type of machine should be added, e.g. ST1 (CO), ST2 (PO/CO), RE1 (G), RE2 (DF).

Similarly, Meter Tags should be M1(FcQ), M2 (TR) etc.

Table GN12-2 Suggested Tag Notation

Prefix	Equipment type	Suffix	Sub-type
GT	Gas turbine		
RE	Reciprocating engine	(G)	Gas engine
		(D)	Diesel engine
		(DF)	Dual fuel

		(HFO)	Heavy fuel oil
ST	Steam turbine	(BP)	Back pressure
		(PO)	Pass-out
		(PI)	Pass-in
		(CO)	Condensing
HRB	Heat recovery boiler	(S)	Steam
		(W)	Hot water
		(SF)	Supplementary firing
		(AF)	Auxiliary firing
FB	Fired boiler	(NO)	Normally operating
		(HS)	Hot standby
		(CS)	Cold standby
FC	Fuel Cell		
RGT	Renewable Gas Turbine		
ORC	Organic Rankine Cycle		

Prefix	**Equipment type**	**Suffix**	**Sub-type**
M	Metering station	(F) / (Fc)	Flow / Flow (corrected)
		(E)	Electric Power
		(H)	Heat
		(T)	Temperature
		(P)	Pressure
		(An)	Analyser
		(I)	Indicator
		(R)	Recorder
		(W)	Weight
		(Q)	Totaliser
		(C)	Calculation

CHP SCHEME ENERGY FLOW DIAGRAM

GN12.4

A separate copy of the CHP Scheme Line Diagram (see Fig GN12-2) should be marked up to show typical flow rates, heat outputs, and electrical and mechanical power outputs. Where there are different operating modes or significant seasonal or daily load variations, state clearly the case for which the data apply (e.g. winter average conditions).

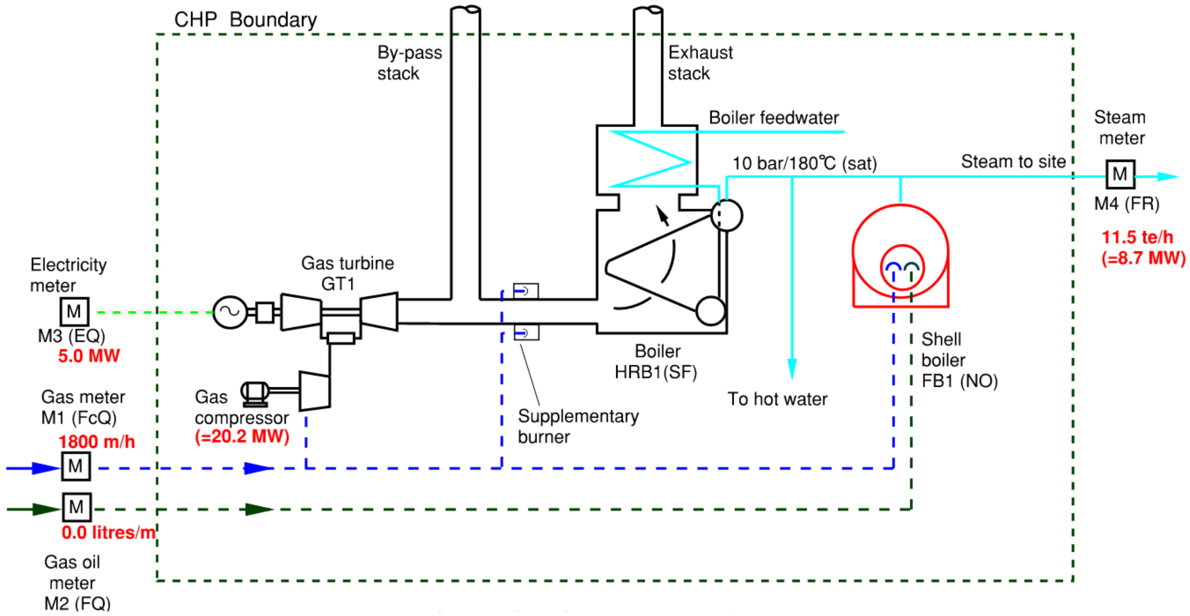


Fig GN12-2 CHP Scheme Energy Flow Diagram

HEAT PROFILES

GN12.5

To determine QI MaxHeat, all CHP Schemes with a heat rejection facility should provide three graphs to illustrate the CHP Scheme's annual and daily heat output profiles.

1. The annual profile (see Fig GN12-3) should illustrate any seasonal variations in heat output using weekly or monthly average figures.
2. The daily profile (see Fig GN12-4) should show any day/night variations, weekday and weekends, reflecting production patterns or occupancy over the 24-hour period.
3. The heat load duration curve (see Fig GN12-5) should indicate the cumulative hours of heat output over a year (by plotting the number of hours when the heat output from the CHP Scheme is at or above a particular value). In the present context this would be more appropriately called a heat output duration curve. If the data is not available an estimate of MaxHeat will be required.

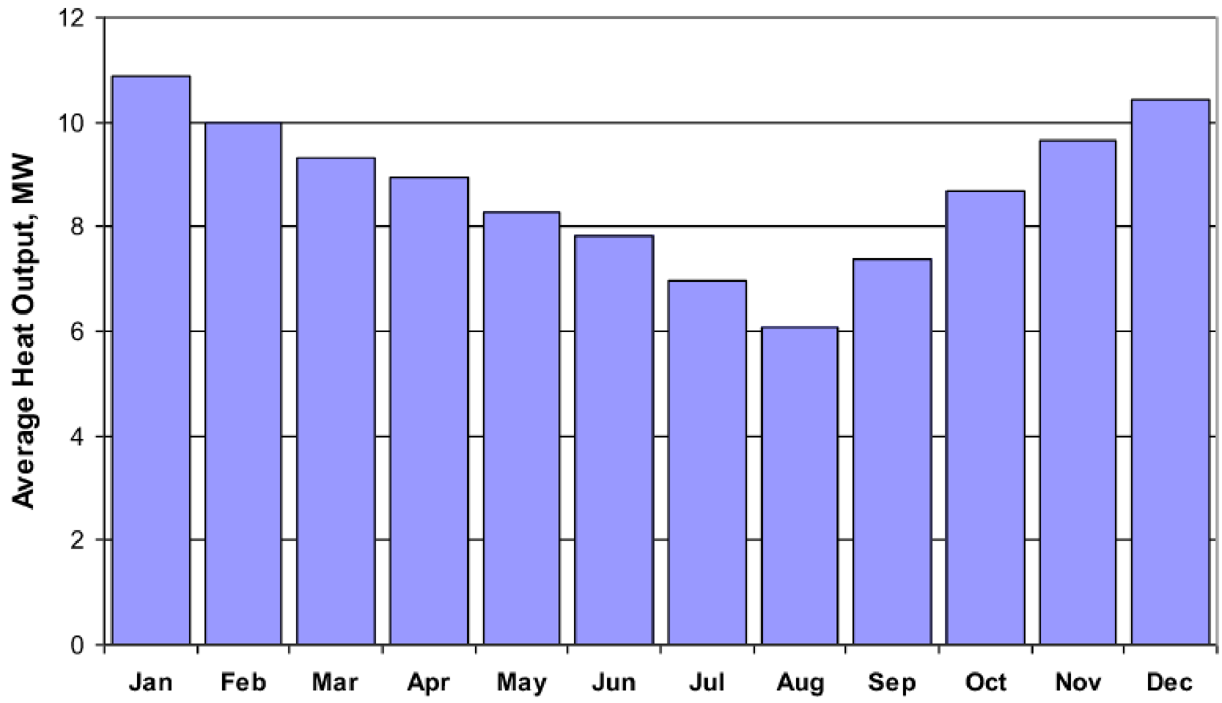


Fig GN12-3 Annual profile of CHP heat output

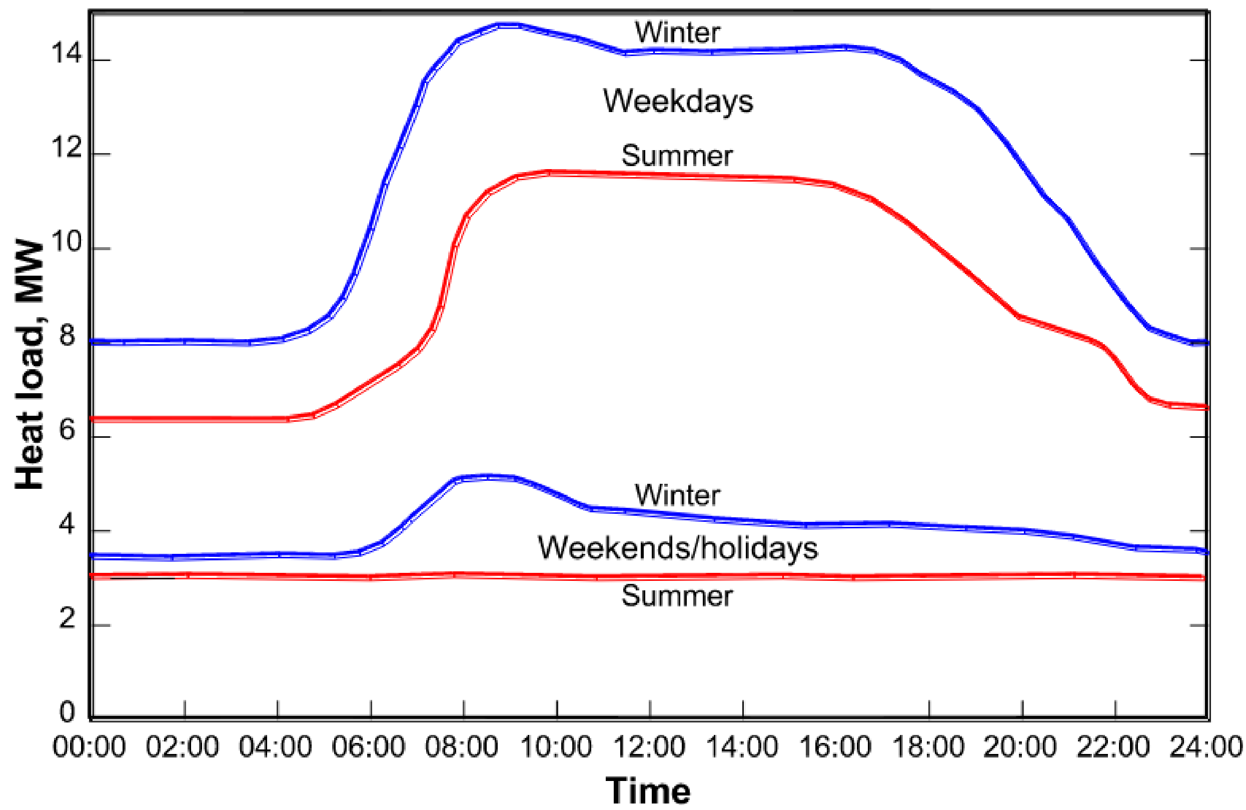


Fig GN12-4 Daily profile of CHP heat output

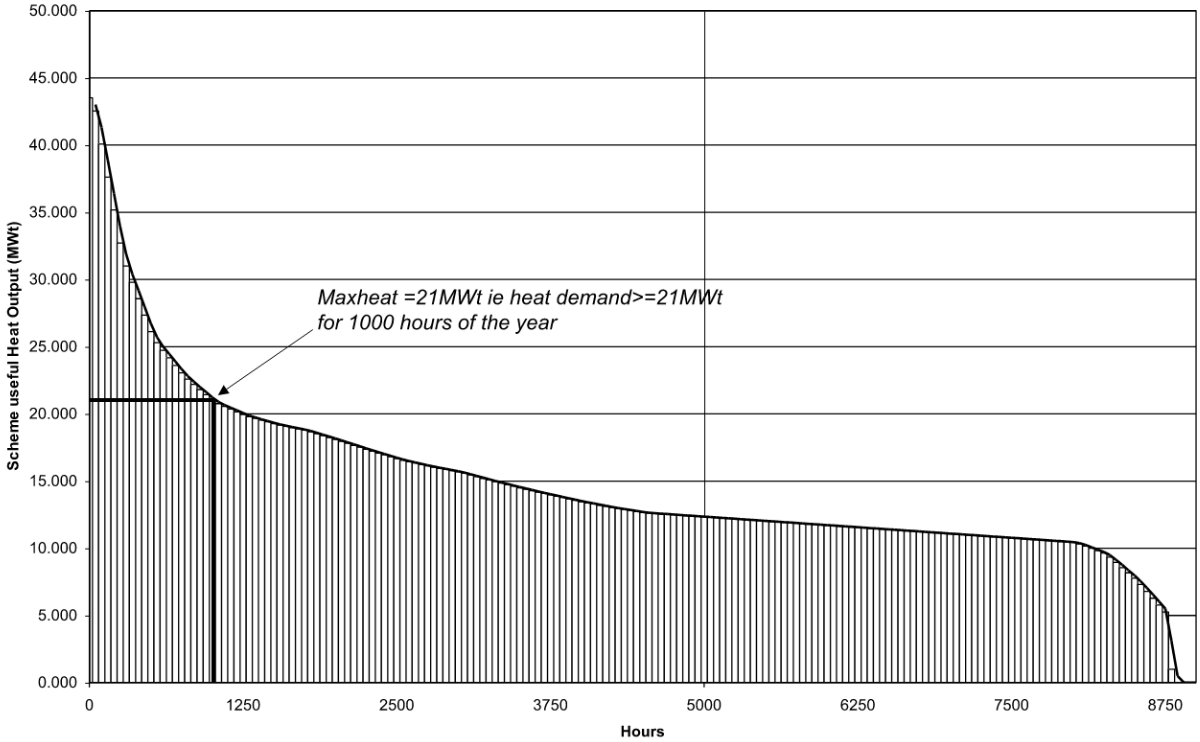


Fig GN12-5 Load duration graph (hourly data)

Developing a Heat Load Duration Curve and determination of MaxHeat

The heat load duration curve (Fig GN12-5) is required to accompany the submission and, more importantly, if in any particular Self-Assessment year the scheme fails to meet its Quality Index Threshold and the Qualifying Power Capacity (QPC) has to be scaled back from the Total Power Capacity (TPC) figure. It is used to derive the MaxHeat value for the scheme at Normal Operating Conditions (NOC), so that the Quality Index (QI) can be recalculated at MaxHeat conditions.

For some schemes, the heat load duration curve only needs to be produced **once**, as the MaxHeat value and the associated power and heat efficiencies may not change at NOC.

However, there are situations where it will be necessary to produce another heat load duration curve:

- Where the heat demand changes due to changes in process operation.
- Where a prime mover has been removed from the scheme boundary, or another has been added.
- Where a fully or partially condensing steam turbine is contained within the scheme boundary, there may be a trade off between heat and power and where this is the case the MaxHeat (and the associated scheme efficiencies) could change year on year.

The heat load duration curve may be derived without difficulty within a simple spreadsheet providing that heat output data, (determined at **regular** time intervals), are available, together with the associated fuel inputs and power outputs. Ideally, half-hourly or hourly data should be used, but if these are not available daily or even weekly data may be adequate.

Using the spreadsheet, sort the data into descending order of heat output (in MWth) and plot heat output against cumulative hours. MaxHeat (defined in the CHPQA Standard) is the heat output that is equaled or exceeded for a given number of hours in a year (1,000, 750 or 500 hours depending on the use of the heat outputs from the CHP scheme). MaxHeat value may then be determined from the graph.

To determine the power and heat efficiencies at MaxHeat conditions the fuel input and power output that best correspond to MaxHeat need to be estimated. For some schemes, particularly those that include steam turbines, there may be many combinations of fuel inputs and power outputs that can result in the MaxHeat heat output. The best strategy is to plot energy input (Y-axis) versus heat output (X-axis) and draw a smooth curve through the data points (e.g. a second order best-fit polynomial if doing this within the spreadsheet) and select the energy input that corresponds to the MaxHeat heat output. Similarly, a plot of power output versus heat output will reveal the power output that best represents MaxHeat operation.

- Refer to GN 27 for guidance on the application of the MaxHeat and related data for determining QPC.

CHP SCHEME EQUIPMENT

GN12.6

All prime movers (including secondary steam turbines, see GN16.9) and boilers within the CHP Scheme boundary, should be identified and details provided, including:

- Tag Number
- Manufacturer
- Model or type
- Maximum rated power and/or heat outputs at ISO conditions
- Year commissioned

Where a prime mover drives a mechanical load (e.g. a pump or a compressor) the mechanical power output should be converted to an equivalent electrical output using a multiplying factor of 1.05. Heat outputs for steam turbines should be based on the maximum pass-out and/or back-pressure steam flow rates.

CHP Scheme Monitoring Equipment Arrangements

GN12.7

Details of all metering equipment that will be used to monitor the performance of the CHP Scheme is required, including heat and electricity export meters. This should also include details (including the Meter Point Reference Numbers) of all gas supply billing meters, even if the CHP Scheme is supplied via a secondary meter. Meters should be identified by tag numbers, and details of each meter must be provided, including:

- Tag number
- Serial number (and, where applicable, meter point reference number or other unique billing identifier)

- Year of installation
- Manufacturer (of primary metering device), model and type
- Metered service and line conditions (fluid temperature and pressure, electricity voltage, e.g. steam (42 bar(a)/400˚C), electricity (3.3 kV))
- Meter output range (except for electricity meters which should be entered as N/A - not applicable), i.e. the minimum and maximum rate of flow (Qmin and Qmax) for fluid flow meters, not the maximum reading on a totaliser (e.g. 999999).
- Meter output units (state if corrected for temperature and pressure)
- Uncertainty as a percentage of reading or percentage of output range. What is required here is the basic meter/transmitter/computer uncertainty only, excluding any additional uncertainties for excessive intervals between calibrations (which may change each year).

➢ Refer to GN13 for guidance on Scheme monitoring

GN12.8

The assessment of the uncertainty of metering equipment is important, and where appropriate, supporting calculations shall be provided.

➢ Refer to GN17 for guidance on Uncertainty in Metered Inputs and Outputs.

GN12.9

Where a CHP Scheme's existing monitoring arrangements do not comply with the requirements set down in the CHPQA Standard (see GN14,15 and 16) applicants are required to provide information on the additional metering that applicants propose to install and, where applicable, details of any indirect methods to be used to derive unmetered inputs and outputs.

GN12.10

Where an indirect method is proposed, necessary to derive an unmetered input or output, details of the proposed method and an assessment of the resulting uncertainty are required. Details of any metering equipment upon which the indirect method relies should be included in the metering information.

➢ Refer to GN20, 21 & 22 for guidance on indirect determination of energy inputs and outputs.

➢ Refer to GN18 for guidance on Uncertainty in Calculated Energy Inputs and Outputs.

GN12.11

Where inadequate, or no metering is in place for measurement of steam or heat outputs, unmetered heat shall not be considered and should not be included in the Qualifying Heat Output.

GN12.12

Regarding Energy Inputs, metered or derived inputs (from metered values) that have uncertainties greater than the threshold shall have correction factors applied when calculating scheme efficiencies.

- Refer to GN13.10 & 14 for guidance on Energy Inputs.
- Refer to GN19 for guidance on Adjustment of Energy Inputs and Outputs for Excessive Uncertainty.

GN12.13

Regarding Energy Outputs, metered or derived outputs (from metered values) that have uncertainties greater than the threshold shall have correction factors applied when calculating scheme efficiencies.

- Refer to GN13.10, GN15 & GN16 for guidance on Energy Outputs.
- Refer to GN19 for guidance on Adjustment of Energy Inputs and Outputs for Excessive Uncertainty.

CHP SCHEME CAPACITY

GN12.14

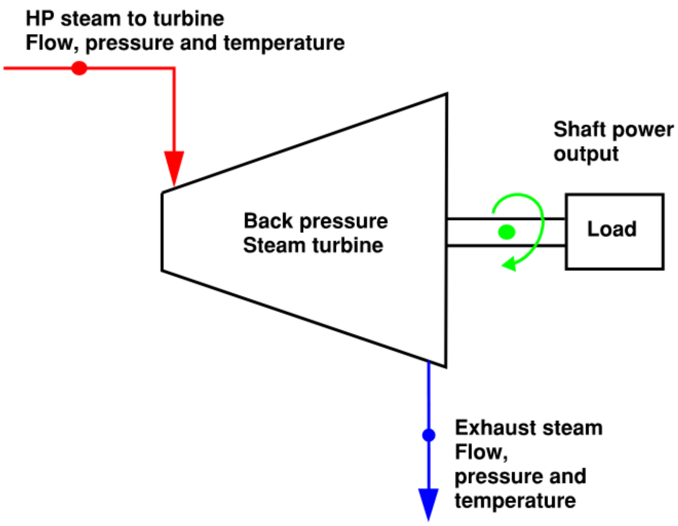
A CHP Scheme's capacity can be described in two ways:

CHP Total Power Capacity (CHP_{TPC}): This is the registered maximum power generation capacity of the CHP Scheme (MW_e), at ISO conditions. It defines the size of the CHP Scheme for the purpose of selecting the appropriate Quality Index formula.

Where there is more than one electrical generator in a Scheme, CHP_{TPC} shall include the total electrical capacity of all generators that can run together, i.e. the actual maximum generation capacity. Thus, for a CCGT CHP Scheme with a 42 MW_e GT and a pass-out condensing ST capable of producing a maximum 13 MW_e (when in fully condensing mode) the CHP_{TPC} = 42 + 13 = 55 MW_e

Where a Scheme includes mechanical power outputs, this shall be converted to an equivalent electrical output and included in CHP_{TPC}. An example is given below:

A site operates a CHP Scheme that includes a back-pressure steam turbine used to drive a process gas compressor. The steam flow and the turbine inlet and exhaust steam pressures and temperatures are all metered.



Since, for Schemes of the type including steam turbines, CHPQA requires reporting of monthly figures, this example is based on the operation over 1 month, but the same calculation may be carried out for other periods of time including instantaneous rates.	
Metered data	
Steam flow to/from steam turbine (mass)	*14,400 tonnes*
HP steam pressure (monthly average)	*41.4 bar(g)*
HP steam temperature (monthly average)	*410°C*
Exhaust steam pressure (monthly average)	*3.45 bar(g)*
Exhaust steam temperature (monthly average)	*190°C*
Assumption	
Turbine mechanical losses = 3%	
Calculation of mechanical power	
Specific enthalpy of inlet steam (41.4 bar(g), 410°C)	= 3,233.9 kJ/kg
Specific enthalpy of exhaust steam (3.45 bar(g), 190°C)	= 2,837.4 kJ/kg
Specific heat drop = 3,233.9 - 2,837.4 = 396.5 kJ/kg / 3.6	= 110.1 kWh/tonne
Total heat drop in period = 14,400 tonnes x 110.1 kWh/tonne / 1,000	= 1,585.4 MWh
Turbine shaft output allowing 3% mechanical losses	= 1,537.8 MWh
Equivalent electrical output *= 1.05 x 1,537.8* ***= 1,614.7 MWh (electrical)***	
The Total Fuel for Generating Mechanical Power =	
Equivalent Electrical Output/CHP Scheme's Power Efficiency *(from CHPQA certificate)*	

CHP Total Power Capacity MaxHeat conditions ($CHP_{TPCMaxHeat}$): This is the total power generation capacity of the CHP Scheme (MW_e) under MaxHeat conditions. It defines the CHP Scheme's capacity if delivering the maximum heat output under normal operating conditions.

- Refer to GN27.4 for guidance on calculating MaxHeat conditions (applicable to schemes that do not achieve the QI threshold under long term annual operation and new Schemes that (based on design data) failed to achieve the QI Threshold).