Appendix C: Heat networks, including those with Combined Heat and Power (CHP) and those that use recovered heat

C1 Heat network definition

Heat networks are characterised as systems where heat is generated and supplied by a network and heat generator(s) that is located outside of the dwellings it serves. Various descriptive words may be assigned to such networks for categorisation purposes, such as “district”, “communal” and “community”. For SAP purposes, such network variations need not be considered.

CHP (Combined heat and Power) is defined as the simultaneous generation of heat and power in a single process.

There are two principal ways of producing heat for heat networks by a dedicated heat generator (but see also section C5):

- heat produced by boilers only (Figure C1);
- heat produced by a combination of boilers and CHP units (Figure C2).

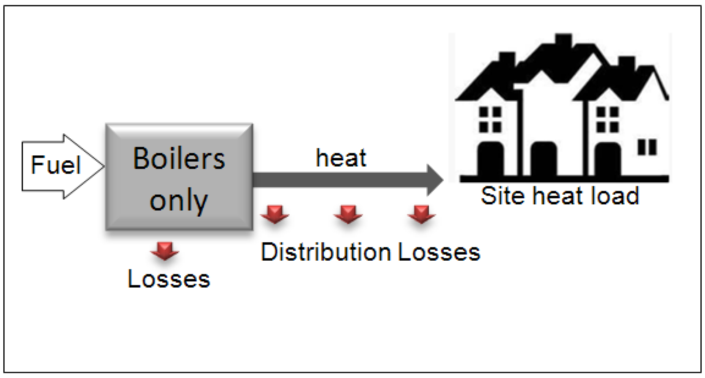

Figure C1: Heat networks with heat supplied by boilers only

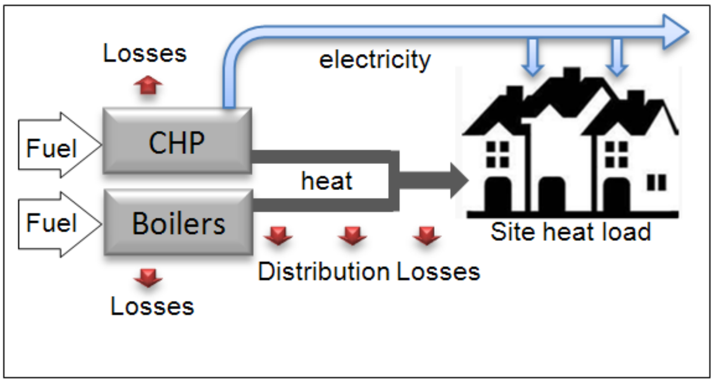

Figure C2: Heat networks with heat supplied by a combination of boilers and CHP

For heat networks with CHP, the CHP unit is the primary heat source, and back-up boilers of conventional design are used when the heat output of the CHP unit is insufficient to meet the instantaneous demand. The proportion of heat from CHP and from boilers varies from installation to installation.

The annual proportions of heat from the CHP and from conventional boilers, and the heat and electrical efficiencies of the CHP for the calculation of CO_2 emissions and Primary Energy are held in the PCDB for the heat network. If the network is not held in the database, these should be obtained either on the basis of operational records or in the case of a new network on the basis of its design specification. Heat efficiency is defined as the annual useful heat supplied by the CHP divided by the total annual fuel input, based on gross calorific value, and excluding any dumped heat (see Figure C3). The power efficiency is the total annual electrical power output divided by the total annual fuel input.

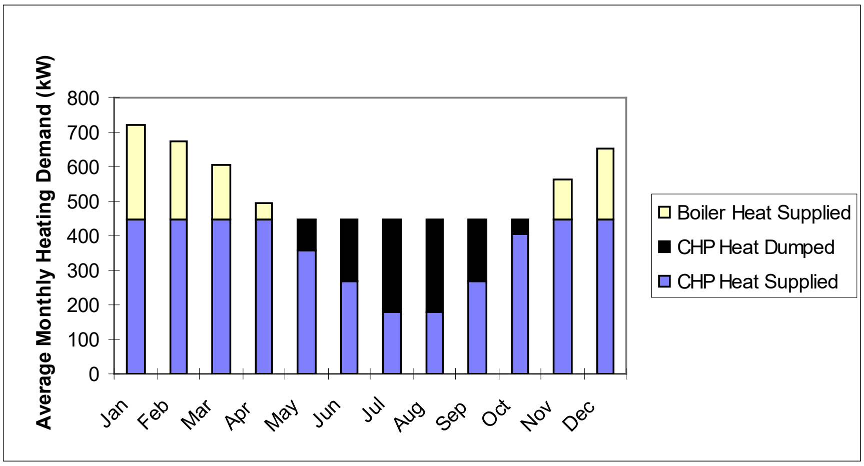

Figure C3: An example of a heat profile chart

The price of heat for heat networks is taken from Table 12. This price incorporates bulk rates for buying the fuel used in the heat generator, operating costs, energy used in pumping the hot water and, in the case of CHP, receipts from the sale of the electricity generated. The factor in Table 4c(3) allows for controls and charging method.

For the calculation of CO_2 emissions and Primary Energy, the efficiency to be used is that of the heat generator. A default figure is given in Table 4a for boilers connected to heat networks but, if known, the actual efficiency of the heat generators should be used instead (see C2). For CHP units, the efficiency can be specified as either (a) the heat efficiency and the power efficiency, or (b) the overall efficiency and the heat-to-power ratio.

Section 12b of the SAP worksheet includes provision for a credit of CO_2 emissions and Primary Energy for electricity generated by CHP. This credit is available whether or not the electricity is provided directly to the dwellings concerned; the only requirement is that the CHP provides heat to the dwelling via a heat main.

Performance data for specific heat networks is included in the Products Characteristics Database and should be used when available.

C2 Boiler efficiency

The gross efficiency of boilers from the PCDB connected to heat networks is assessed for SAP purposes in the same way as for domestic boilers. The efficiency is calculated according to the procedures referred to in Appendix D, except that the winter gross efficiency is used for all parts of the year (thus a separate summer gross efficiency need not be calculated or declared).

Where boilers of different efficiency are used in combination they are entered separately in worksheet (303b) to (303e) and corresponding subsequent lines. Alternatively, boilers using the same fuel may be treated as if they were a single boiler by assigning an average gross efficiency and total fraction calculated as follows:

$$\eta_{average} = \frac{\sum_{j=1}^{n} f_j}{\sum_{j=1}^{n} \frac{f_j}{\eta_j}} \quad \text{and} \quad f_{total} = \sum_{j=1}^{n} f_j$$

where
n is the number of boilers
f_j is the fraction of annual heat provided by boiler j
η_j is the winter gross efficiency of boiler j calculated as referred to in Appendix D

The gross efficiency of large/commercial boilers connected to heat networks is assessed following the procedure given in the Non-Domestic Building Services Compliance Guide.

C3 Heat distribution

C3.1 Distribution loss

Heat network distribution heat losses are accounted for by multiplying the heat to be delivered by the heat network by a 'distribution loss factor' (DLF), calculated as:
Distribution Loss Factor (DLF) = Heat generated ÷ Heat delivered

'Heat delivered' is defined as the amount of heat supplied to the buildings connected to the heat network. It is measured at the interface between the heat network and the connected building, whether domestic or non-domestic. Note: In the case of a block of flats, it is the heat supplied to individual flats (dwellings) within the block. For example, a heat network distribution loss of 40% represents a DLF of 1.67 (100 ÷ (100-40)).

Figure C4 displays the process for inputting heat network DLF values into SAP software. Default DLF values for networks compliant and not compliant with the CIBSE/ADE '*Heat Networks: Code of Practice for the UK'* are entered in the PCDB for selection by the SAP assessor. This will facilitate future amendment if sufficient evidence becomes available.

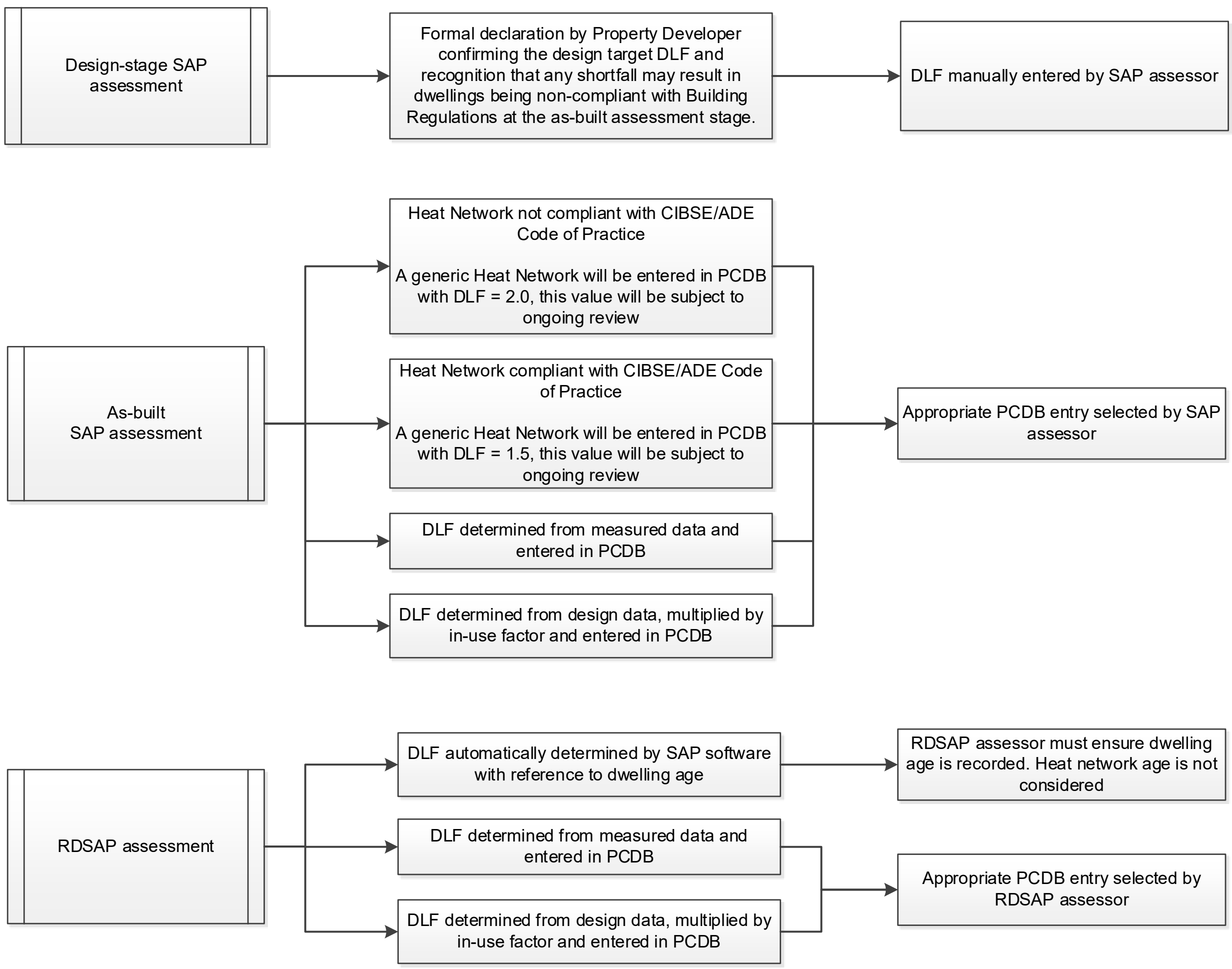

Figure C4: Distribution Loss Factor input process

For the purposes of SAP assessments, either design-stage or as-built, the network specific heat loss, expressed as a DLF, can be determined using actual consumption data and entered in the PCDB. Where network heat losses are estimated for the purpose of the PCDB entry, an IUF from the PCDB will be applied to the DLF.

For design-stage SAP assessments, a DLF of >= 1 can be manually entered by the SAP assessor. The entered DLF will require a suitable formal notification by the Property Developer to be supplied to the SAP assessor; this must confirm the design target DLF. Any shortfall in the DLF during construction may result in non-compliance with the Building Regulations at the as-built assessment stage.

For as-built SAP assessments, a default DLF of 1.5 is applied (where PCDB data is not available) if the heat network is designed and commissioned in accordance with the CIBSE/ADE '*Heat Networks: Code of Practice for the UK*'. This will require that the SAP assessor receives evidence via a certificate or headed letter from both the network designer and commissioning engineer, both of whom must have the necessary authority and competence to make such declarations.

For as-built SAP assessments for new dwellings supplied by heat networks, a default DLF of 2.0 is applied (where PCDB data is not available) if the network is not designed and commissioned in accordance with the CIBSE/ADE '*Heat Networks: Code of Practice for the UK'*.

For undertaking RdSAP assessments of existing buildings, Table 12c provides Distribution Loss Factors by dwelling age.

C3.2 Energy for pumping

CO_2 emissions and Primary Energy associated with the electricity used for pumping water through the distribution system are allowed for by adding electrical energy equal to 1% of the energy required for space and water heating. For heat networks that are recorded in the PCDB, actual electrical pumping energy will be included in the data record (though this may be an estimate).

C4 Heat networks that use recovered heat

For heat networks that use recovered heat, the recovered heat is the primary heat source, and secondary boilers of conventional design are used when the available recovered heat is insufficient to meet the instantaneous demand. Typically, high-grade recovered heat can be fed directly into a heat network, whereas low-grade recovered heat will need to be boosted/elevated (e.g. by a heat pump). The proportions of heat from the recovered heat source and from the conventional boilers will be held in the Product Characteristics Database for the heat network. Otherwise, these should be estimated, either on the basis of operational records or in the case of a new network on the basis of its design specification. In the case of recovered heat, a heat generation efficiency of 100% should be assigned.

C4.1 Heat recovered from waste combustion

Where a heat network recovers high-grade heat from a waste combustion plant, often referred to as 'energy from waste', or EfW, that heat can be considered to be free in terms of CO2 and Primary Energy (on the basis that the waste would have been burnt anyway) other than in its impact on reducing any electrical generation from the waste combustion process. Most EfW systems use the heat produced during incineration to generate electricity which is supplied to the grid. Where heat (usually in the form of steam) is drawn off from the turbine by a heat network, the electricity production will consequently fall, although the overall efficiency (heat plus electricity) will rise. Typically, electrical output will fall by around 1 unit for every 9 or 10 units of heat drawn off. Taking this reduction into account the net fuel factors will be similar to those for heat recovered from a waste power station (taking into account the pumping/auxiliary energy), so the CO2 and Primary Energy factors in Table 12 for heat networks using 'heat recovered from waste combustion' are used.

C4.2 Heat recovered from power stations

This includes high-grade heat recovered from power stations rated at more than 10 MW electrical output and with a gross power efficiency greater than 35%[1]

[1] General Electric research shows that the average efficiency of coal-fired power plants in the UK is 38%. Gas-fired power plants are typically more efficient than coal-fired power plants. (From 'GE

(otherwise the system should be considered as CHP). The CO2 emission and Primary Energy factors in Table 12 for heat networks using 'waste heat from power station' are used, which include an allowance for energy use associated with a reduction in power station electricity generation ('z-factor', as described in C4.1 above) and an allowance for the electricity used for pumping the water from the power station.

C4.3 Heat recovered from other industrial processes

Heat networks recovering high grade heat from industrial processes which would have happened regardless of the heat being recovered (i.e. while carrying some other necessary process), can be considered to be free in terms of CO2 and Primary Energy, subject to any additional energy required to facilitate the recovery of that heat (e.g. pumping energy). For this purpose, 'high grade heat' means heat which requires no additional energy input to elevate temperature before delivery to a heat network. The CO2 emission and Primary Energy factors in Table 12 for heat networks using 'heat recovered from industrial processes' are used, which include an allowance for the electricity used for pumping the water from industrial site.

C4.4 Heat recovered from other commercial processes

Heat networks recovering low grade heat from commercial processes which would have happened regardless of the heat being recovered (i.e. while carrying out some other necessary process), and which required additional energy input to elevate the temperature of the heat transfer medium, should determine CO2 and Primary Energy emissions based on either:

a) Where a centralised electrically driven heat pump utilises recovered heat, the CO2 emission and Primary Energy factors in Table 12 for heat networks with 'heat from electric heat pump' are used.
b) Where a system utilising recovered heat includes heat pumps at dwelling level with or without a centralised heat pump, a bespoke PCDB calculation is used, accounting for all heat pump electricity consumption and pumping energy.

For this purpose, 'low grade heat' means heat which requires additional energy input to elevate temperature. Examples of recovered heat sources in this category include heat from: data centre cooling; refrigeration processes; sewage treatment and wastewater processing; substation heat rejection.

C4.5 Heat recovered from geothermal or other natural source

Where a heat network recovers heat in a sustainable manner from a natural or ambient heat source, this heat can be assumed to be free of impact in terms of CO2 and Primary Energy, subject to any additional energy required to facilitate the recovery of that heat (e.g. pumping energy). An example of this would be the recovery of geothermal heat. The CO2 emission and Primary Energy factors in Table 12 for heat networks with 'geothermal heat source' are used, which include an

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Global Power Plant Efficiency Analysis, GE', available at: https://www.ge.com/reports/wp-content/themes/ge-reports/ge-power-plant/dist/pdf/GE%20Global%20Power%20Plant%20Efficiency%20Analysis.pdf) allowance for energy use associated with the electricity used for heat extraction (e.g. pumping).

C5 Permutations of heat generators

Possible heat network configurations include (and can be combinations of) the following:

1. A single boiler or set of boilers all using the same fuel. In the case of a set of boilers the average seasonal efficiency for the boilers is used for the calculation (see C2).

2. Two or more boilers or two or more sets of boilers, using different fuels such as mains gas and biomass. In this case the total heat requirement is divided between the boilers or sets of boilers according to the design specification of the overall system. Different average seasonal efficiencies apply to the sets of boilers and the CO_2 emissions and Primary Energy are calculated using the emission factors of the respective fuels.

3. CHP units and boiler(s), calculations according to section C1.

   If there are two or more boilers or two or more sets of boilers using different fuels (in addition to the CHP units) the heat requirement from boilers is divided between the boilers or sets of boilers according to the design specification of the overall system. Different average seasonal efficiencies apply to the sets of boilers and the CO_2 emissions are calculated using the emission factors of the respective fuels.

4. Utilisation of recovered high-grade heat from a waste combustion process, power station or industrial process (as per C4.1 – 4.3 above), topped up by boilers.

5. Geothermal heat or heat from another natural or ambient source topped up by boilers (as per C4.5 above).

6. A centralised electrically driven heat pump with various recovered (C4.4a, C4.5) or ambient (C4.5) heat sources. The calculation is essentially the same as that for boiler systems, with the Seasonal Coefficient of Performance (SCoP)[2] for the heat pump system being used in place of boiler efficiency. The SCoP should take account of winter and summer operation as appropriate and of the temperature of the heat source.

SAP software should allow for combinations of up to five of the above heat sources for a heat network.

Other permutations may be dealt with via a PCDB entry, including those described in C4.4b above, and where energy generating/boosting plant is either at dwelling level, or present in both an energy centre and a dwelling. Examples of this arrangement

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[2] To be determined using a method consistent with that for domestic heat pumps, see Appendix N.

could include ambient loop networks, and non-recovered / fossil fuel heat sources supplying dwelling-level heat pumps.

C6 Heat network providing DHW only

Some heat networks provide DHW only, with the space heating provided by heaters in each dwelling.

In this case the specification and calculation of space heating is the same as for a dwelling not connected to a heat network.

SAP software should allow for up to two heat sources for a DHW-only heat network.

Data required are:
- fuel used by heat network (same fuel options as for network providing space and water heating)
- efficiency of boilers, heat pump or CHP
- if CHP, the heat-to-power ratio
- distribution loss factor (Section C3.1)
- whether a Heat Interface Unit (HIU) is within the dwelling (see Section 4.3)
- whether a hot water cylinder is within the dwelling and if so its volume plus either its measured loss factor or its insulation type and insulation thickness (see Section 4.3)

Note: If the presence of a HIU is unknown, it should not be specified. If a hot water cylinder is present, but the specification is unknown, default cylinder details should be entered, see Section 4.3. If both HIU and cylinder are present, heat losses from both should be included. If neither are present, default cylinder details should be entered.

Allow for the control factor from Table 4c(3), for the distribution loss factor as in C3.1 and pumping energy as in C3.2. Include one-half of the normal heat network standing charge in the calculation of fuel costs unless the space heating is also a heat network (see next paragraph).

This also allows for the case where the heat network is different for space heating and for water heating. Separate heat network parameters apply to each system including heat distribution characteristics. In this case the total standing charge is the normal heat network standing charge.

C7 Biofuel CHP

For heat networks with biofuel CHP, it is possible for the total CO_2 emissions calculated at (373) to be negative. Once this quantity becomes negative, it becomes advantageous to increase the heating requirements of the dwellings, e.g. by removing insulation. Accordingly (373) should be set to zero unless the dwellings served by the heat network have a high standard of thermal insulation. That can be taken to be applicable if the dwelling has a Heat Loss Parameter (HLP) of less than 2 when averaged over the 12 months of the year.