BRE Technical Note
Recognition of the Mitsubishi Electric - Ecodan Hydrodan within SAP 2009 and 2012 assessments

This document has been authored by BRE in support of SAP assessor conventions. It incorporates a background and technical justification and concludes with instructions for assessors which must be followed for assessment validity.

This document allows for recognition of the Mitsubishi Electric "Ecodan Hydrodan", a type of heat network, specifically in SAP 2009 and 2012. It is not applicable to Reduced Data SAP assessments and will not be applicable in versions of SAP beyond SAP 2012.

This process could be applied to any equivalent heat network type supplied by others, subject to it satisfying the same requirements[1].

These instructions use default values because an accepted method for evaluating all Ecodan Hydrodan components has not yet been developed. In due course, a mechanism will be developed for implementation within the next SAP specification update (SAP 10) utilising the Product Characteristics Database (PCDB).

Background to development of guidance:

The Ecodan Hydrodan comprises two elements:

1) A heat network design, installation and commissioning specification for heat networks within buildings containing dwellings, authored by Mitsubishi Electric. This includes specifying communal heat generator requirements.

2) A Mitsubishi Electric water-to-water heat pump installed within each individual dwelling and providing space and hot water heating services. The heat pump's heat source is provided by the heat network, which circulates primary water at a constant temperature. The valid Mitsubishi Electric heat pump model for the purpose of this document is: Ecodan Hydrodan EHWT17D-MHEDW.

   Note: Whilst alternative Mitsubishi Electric heat pump model variants may be permissible for the purpose of this document in future, this can only be advised by BRE.

Heat networks incur distribution heat losses whilst transferring heat energy from communal heat generators to individual dwellings. For new-build dwellings connected to heat networks (and compliant with current Building Regulations), the proportion of heat losses compared to delivered heat energy can be significant. Whilst this may be reduced through optimised network design and use of pipework insulation, these losses cannot be avoided entirely.

SAP calculations account for heat network distribution heat losses by increasing the heat to be delivered by the heat network by a 'distribution loss factor' (DLF). The quantity of heat delivered to buildings connected to a heat network 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)).

[1] There are two criteria: 1) An equivalent heat network design, installation and commissioning specification must exist, including minimum performance requirements for communal heat generators. A mechanism for declaring compliance with these requirements must also be provided; 2) The minimum Seasonal Performance Factor for the water-to-water heat pump installation must exceed 2.76 when calculated in accordance with the DAHPSE method and providing both space and water heating services.

The latest SAP specification, SAP 10, specifies that the following default DLFs should be applied (multiplied) by the dwelling heat requirement (calculated by SAP):

- DLF = 1.5 for heat networks compliant with the design, installation and commissioning guidance: *'Heat Network: Code of Practice for the UK'*, which was jointly published by the Chartered Institute of Building Services Engineers (CIBSE) and the Association for Decentralised Energy (ADE)
- DLF = 2.0 for heat networks not compliant with the design, installation and commissioning guidance: *'Heat Network: Code of Practice for the UK'*

At the present time, Building Regulation compliance throughout the UK may be demonstrated by either SAP 2009 or 2012 specification versions. This depends upon the version of Building Regulations in force at the time planning permission was granted. Both of these SAP versions provide two default DLF options for new-build dwellings connected to heat networks:

- *'Modern higher temperature system (up to 120ºC), using pre-insulated mains installed in 1991 or later, variable flow system'*
- *'Modern pre-insulated piping system operating at 100ºC or below, full control system installed in 1991 or later, variable flow system'*

The selection of these options respectively assigns a DLF of 1.1 and 1.05 within SAP assessments. It is understood that DLF = 1.05 is used in the majority of SAP assessments for new-build dwellings.

For SAP 2012, and as an alternative to default DLF data options, there is provision for recording actual or design heat network performance data via the Product Characteristics Database (PCDB).

The Ecodan Hydrodan reduces distribution losses by utilising a lower than normal flow temperature within the heat network. A water-to-water heat pump is used to upgrade the low (e.g. 20°C) fixed network flow temperature to an acceptable temperature for space and hot water heating services within each dwelling. A separate water circuit is used to distribute heat within each dwelling, whilst the heat pump package, being a combination heat pump, incorporates a 180 litre cylinder for hot water heating.

It is anticipated that distribution heat losses for a heat network compliant with the requirements of an Ecodan Hydrodan will be lower than a typical heat network system[2]. The exact extent depends upon the location of distribution pipework, heat generator and buffer vessels, the specification of the plant room building fabric, and the specification of pipe insulation used. However, the basis of this document is that the minimum requirements specified by Mitsubishi Electric are satisfied. This includes a requirement that Ecodan Hydrodan components, including distribution pipework, are located exclusively within the building heated envelope. In the case of communal heat pumps, these may be located outside, but must be positioned as close to the building as practicable. Alternative arrangements are not valid.

The Ecodan Hydrodan requires electrical energy to be consumed within the dwelling to operate the water-to-water heat pump. The heat pump upgrades heat supplied by the heat network to a higher temperature for domestic purposes. Unfortunately, this electrical consumption cannot be recognised in SAP 2009 or 2012 assessments for two reasons:

1) When a dwelling is connected to a heat network, and this is specified in a SAP 2009 or 2012 assessment, a 2nd main heating system cannot be specified. The heat network is assumed to provide the entire heating service, meaning there is no scope to specify additional electrical consumption.
2) SAP defines a heat network system boundary as the interface between the heat network and the connected building or dwelling. In the case of SAP 2012, this means that the electrical power cannot be counted within the heat network's performance record, and held in the PCDB, without defining special convention rules.

[2] In practice this may mean a DLF lower than 1.05

For the recognition of the Ecodan Hydrodan within SAP 2012, the development of special convention rule was reviewed, but it was considered that such rules would be unreasonable, since Ecodan Hydrodan would be shown to require more energy (in Primary Energy terms) than the default case for a typical heat network, where a default DLF = 1.05 is applied, despite this not being the case in practice. For SAP 10 and future versions it is considered appropriate for such special convention rules to be developed and implemented in the PCDB, since the value of default DLFs will increase.

To resolve this problem and enable SAP recognition of the Ecodan Hydrodan System, Mitsubishi Electric requested that BRE consider whether there is a technical basis for SAP 2009 and 2012 assessments to utilise the default DLF of 1.05, whilst ignoring the presence of the Mitsubishi Electric branded water-to-water combination heat pump, on the basis that the reduction in distribution losses, compared to a typical heat network system installed to new-build dwellings, more than offsets the CO_2 emissions associated with this energy use. To that end, BRE undertook the following tasks:

1) Reviewed design requirements to confirm whether minimum requirements were sufficient for analysis purposes.

2) Undertook SPF_H4 (annual efficiency) calculations for the Ecodan Hydrodan heat pump (a water-to-water unit with integral hot water cylinder) using the SAP heat pump annual performance method[3] at 35°C and 55°C design flow temperatures. EN14825 test data at 35°C and 55°C was supplied by Mitsubishi Electric.

3) Evaluated whether the calculated SPF_H4 at design flow (heat emitter) temperatures of 35°C and 55°C is sufficiently high to justify ignoring direct electric (Ecodan Hydrodan compressors) heat input that occurs outside of the heat network system boundary and cannot therefore be accounted in SAP assessments.

To consider the minimum SPF_H4 requirement for the Ecodan Hydrodan heat pump, it is first necessary to consider the heating energy requirements for a typical heat network incorporating a communal boiler. The delivered energy requirement can be defined as:

$$Q_{req'd} = Q_{Space\ \&\ DHW} \times \frac{DLF_{Standard}}{\eta_{boiler}}$$

Heat energy transferred by the heat network will vary in accordance with the Ecodan Hydrodan heat pump's performance, known as the Seasonal Performance Factor (SPF_H4)[4]. Higher (better) values of SPF_H4 means that less electrical energy input is required to satisfy the heating requirement, with a greater proportion supplied by the communal boiler. For an Ecodan Hydrodan incorporating a communal boiler, the delivered energy requirement is defined as:

$$Q_{req'd} = Q_{Space\ \&\ DHW} \times \left[\left(\frac{DLF_{Ecodan\ Hydrodan}}{\eta_{boiler}} \times \left(1 - \frac{1}{SPF}\right)\right) + \left(\frac{1}{SPF} \times \frac{PE_{elec}}{PE_{gas}}\right)\right]$$

This equation accounts for the electricity required by the Ecodan Hydrodan heat pump, which is installed within each dwelling. These upgrade heat distributed by the heat network at a water temperature of 20°C to water temperatures of 35°C to 55°C for space heating services, depending on the dwelling's heat emitter

[3] http://www.ncm-pcdb.org.uk/sap/filelibrary/pdf/Calculation_Methodology/SAP_2012/CALCM-01---SAP-REVISED-HEAT-PUMP-PERFORMANCE-METHOD---V1.2.pdf, known as DAHPSE (Domestic Annual Heat Pump System Efficiency)

[4] The SEPEMO SPF H4 definition combines both space and hot water heating performance into a single value, accounting for all electrical energy inputs required to deliver the space and hot water heating service – see: https://www.ncm-pcdb.org.uk/sap/filelibrary/pdf/Calculation_Methodology/SAP_2012/CALCM-01---SAP-REVISED-HEAT-PUMP-PERFORMANCE-METHOD---V1.2.pdf

system design. A temperature of 55°C is required for the hot water service. Primary energy factors are used to equate electrical energy in gas energy terms.

For the purpose of the below equation, communal boiler efficiency (η_{boiler}) is assumed equal for both a typical heat network and the Ecodan Hydrodan System. In practice, the Building Regulations require a minimum annual efficiency of 91%, but the Ecodan Hydrodan will operate with a return water temperature of 15°C (± 5°C) which, depending on the hydronic configuration of the boiler, should result in a higher efficiency; this effect has not been considered.

Removing $Q_{Space\ \&\ DHW}$ and rearranging to make SPF the subject:

$$\frac{DLF_{Standard}}{\eta_{boiler}} = \left[\left(\frac{DLF_{Ecodan\ Hydrodan}}{\eta_{boiler}} \times \left(1 - \frac{1}{SPF}\right)\right) + \left(\frac{1}{SPF} \times \frac{PE_{elec}}{PE_{gas}}\right)\right]$$

$$\frac{DLF_{Standard} \times SPF}{\eta_{boiler}} = \left[\left(\frac{DLF_{Ecodan\ Hydrodan}}{\eta_{boiler}} \times (SPF - 1)\right) + \left(1 \times \frac{PE_{elec}}{PE_{gas}}\right)\right]$$

$$\frac{DLF_{Standard} \times SPF}{\eta_{boiler}} - \frac{SPF \times DLF_{Ecodan\ Hydrodan}}{\eta_{boiler}} = \frac{PE_{elec}}{PE_{gas}} - \frac{DLF_{Ecodan\ Hydrodan}}{\eta_{boiler}}$$

$$SPF = \frac{\left(\frac{PE_{elec}}{PE_{gas}} \times \eta_{boiler}\right) - DLF_{Ecodan\ Hydrodan}}{DLF_{Standard} - DLF_{Ecodan\ Hydrodan}}$$

Therefore, determining the minimum required SPF_H4 for the Ecodan Hydrodan heat pump to achieve energy consumption parity with a typical heat network gives a minimum value of 2.76:

$$SPF_{Min} = \frac{\left(\frac{3.07}{1.22} \times 0.91\right) - 1.05}{1.5 - 1.05} = 2.76$$

The above calculation uses Primary Energy factors published within the SAP 2012 specification[5] and a $DLF_{Standard}$ of 1.5, as found to be the best case within 'CONSP:04 - Distribution loss factors for heat networks supplying dwellings in SAP - Issue 1.0'[6] and published within the SAP 10 specification.

SPF_H4 values were calculated for the Ecodan Hydrodan heat pumps based on SAP's annual performance method for heat pumps[3] at 35°C and 55°C design flow temperatures (for space heating; hot water service is

[5] See Table 12 of SAP 2012 - https://www.bre.co.uk/filelibrary/SAP/2012/SAP-2012_9-92.pdf

[6] https://www.bre.co.uk/filelibrary/SAP/2016/CONSP-04---Distribution-loss-factors-for-heat-networks---V1_0.pdf. For heat networks compliant with the design, installation and commissioning guidance: 'Heat Network: Code of Practice for the UK', which was jointly published by the Chartered Institute of Building Services Engineers (CIBSE) and the Association for Decentralised Energy (ADE).

taken at 55°C). The following table presents SPF_H4 results for the Ecodan Hydrodan EHWT17D-MHEDW heat pump[7]:

Weather compensation off								
Ecodan Hydrodan EHWT17D-MHEDW SPF_H4 Values based on EN14825								
Design flow temperature[8] (°C)	35							
Plant Size Ratio[9]	0.5	0.8	1.0	1.2	1.5	2.0	2.5	3.0
SPF_H4	3.3	3.4	3.4	3.5	3.6	3.6	3.6	3.6
Design flow temperature8 (°C)	55							
Plant Size Ratio9	0.5	0.8	1.0	1.2	1.5	2.0	2.5	3.0
SPF_H4	4.7	4.8	4.8	4.9	5.0	4.9	4.8	4.7
Ecodan Hydrodan EHWT17D-MHEDW SPF_H4 Values based on EN14825								
Design flow temperature8 (°C)	35							
Plant Size Ratio9	0.5	0.8	1.0	1.2	1.5	2.0	2.5	3.0
SPF_H4	3.8	4	4.1	4	4.1	4.1	4.0	4.0
Design flow temperature8 (°C)	55							
Plant Size Ratio9	0.5	0.8	1.0	1.2	1.5	2.0	2.5	3.0
SPF_H4	2.9	2.5	3.2	3.7	3.8	3.8	3.8	3.7

The calculated values exceed the minimum requirement for all the analysed installation scenarios, and it is therefore reasonable for SAP 2009 and 2012 assessments to ignore the presence of the following Mitsubishi Electric heat pump model: Ecodan Hydrodan EHWT17D-MHEDW within dwellings (for these installation scenarios) when installed as part of an Ecodan Hydrodan System. This treatment equally applies to other types of communal heat generators that supply heat to the Ecodan Hydrodan System, namely communal heat pumps and Combined Heat & Power (CHP) units.

[7] Weather compensation was set to off in all cases to simulate a worst-case scenario.

[8] See Section 9.3 of SAP 2012 for certification requirements and visit: https://www.ncm-pcdb.org.uk/sap/lowtemperatureheating

[9] Heat pump design capacity divided by the design heat loss of a dwelling, both derived at -4.7°C.

SAP assessor instructions (for recognition of Ecodan Hydrodan in SAP 2009 and 2012 assessments):

1) SAP assessor must confirm that the Ecodan Hydrodan complies with the requirements of Mitsubishi Electric guidance. Documentation confirming this requirement has been satisfied must be available for the SAP assessor and Building Control officers on request. Documentation must be provided in a suitable declaration certificate confirming the person responsible for this compliance and the date this determination was made.

2) SAP assessor must enter all necessary technical details relating to communal heat generators within SAP software as normal, and as advised by the declaration provided.

3) This document is only valid if the following Mitsubishi Electric EHWT17D-MHEDW model is installed in the dwelling: Ecodan Hydrodan. Their presence should be checked by the SAP assessor, but not entered in software.
4) SAP assessor must confirm that the design flow temperature for the dwelling's heat emitter system does not exceed 55°C for validity of this document – See footnote 8 for certification requirements.

5) SAP assessor selects *'Modern pre-insulated piping system operating at 100ºC or below, full control system installed in 1991 or later, variable flow system'* as the heat network distribution system type. This means a Distribution Loss Factor of 1.05 is assigned.

This document is only applicable to SAP 2009 and 2012 assessments, not RdSAP assessments (any version). It has no validity expiration date but may be updated from time to time. Updates may include transferring the SAP assessor instructions to the SAP convention document[10]. SAP assessors should ensure they are using the latest version.

[10] The SAP convention document is available here: https://www.bregroup.com/sap/standard-assessment-procedure-sap-2012/