BRE Technical Note – No: 1 – V1.1 – 21.05.2021

Title: Recognition of the GDC Group Ltd - Zeroth Energy System 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 which must be followed for assessment validity.

This document allows for recognition of the GDC Group Ltd "Zeroth Energy System", a type of heat network, specifically in SAP 2009 and 2012 specification versions. 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 Zeroth Energy System components has not yet been developed. In due course, a mechanism will be developed for implementation within the next SAP specification update (SAP 10); it will utilise the Product Characteristics Database (PCDB).

SAP assessors seeking instructions on how to enter this system into SAP software may wish to skip the background material and go directly to the final page of this document.

Background to development of guidance:

The GDC Group Ltd's Zeroth Energy System comprises two elements:

1) A heat network design, installation and commissioning specification (see: GDC Group document – *"Basic Design Requirements for a Zeroth Energy System"* - Issue 03) for heat networks within buildings containing dwellings (flats). This includes specifying communal heat generator requirements.

2) A Dimplex-branded water-to-water combination heat pump installed within individual dwellings 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 of 25°C (and design return temperature of 15°C). The valid Dimplex heat pump models for the purpose of this document are ZHP6-180C, ZHP6-180H, ZHP4-180C and ZHP4-180H.

    Note: Whilst alternative Dimplex 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

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[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.

(dwellings) within the block. For example, a heat network distribution loss of 40% represents a DLF of 1.67 (100 ÷ (100-40)).

The latest SAP specification, SAP 10.0, 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 Zeroth Energy System 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 fixed network flow temperature of 25°C 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 175 Litre cylinder for hot water heating.

It is anticipated that distribution heat losses for a heat network compliant with the requirements of a Zeroth Energy System 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 of *"Basic Design Requirements for a Zeroth Energy System"* – Issue 03) are satisfied. This includes a requirement that *Zeroth Energy System* 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. If multiple building blocks need to be connected to one heat network system, the sum of all losses of the external pipework should be below 2% of the total annual demand of dwellings served by the heat network. Alternative arrangements are not valid.

The Zeroth Energy System 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.

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

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.

For SAP 2012, the development of special convention rules was reviewed, but it was considered that such rules would be unreasonable, since the Zeroth Energy System 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, since the value of default DLFs will increase.

To resolve this problem and enable SAP recognition of the Zeroth Energy System, GDC Group Ltd requested that BRE consider whether there is a technical basis for SAP 2009 and 2012 assessments to utilise the default DLF of 1.05, given that a typical heat network system (installed to new-build dwellings) may have a higher DLF in practice. To that end, BRE undertook the following tasks:

1) Reviewed *"Basic Design Requirements for a Zeroth Energy System"* - Issue 03) to confirm whether minimum requirements were sufficient for analysis purposes.

2) Undertook SPF_H4 (annual efficiency) calculations for the Zeroth Energy System ZHP6-180C[3] heat pump (a water-to-water unit with integral hot water cylinder) using the SAP heat pump annual performance method[4] at 35°C and 55°C design flow temperatures. The following technical data was supplied by GDC Group Ltd (EN14825 test data at 35°C and 55°C):

   a. DRL10.2.1, Rev 1.2 – Engineer's Test Report - EN14825 test report for Dimplex Zeroth Energy System Water-to-Water combination heat pump [Model name: ZHP6-180C], tested with variable outlet temperature conditions, dated 15/01/2018

   b. RD01008-1 - EN12897 Standing Heat Loss Measurement Test Report, dated 20/12/2017

   c. GDC Group Ltd – Drawing No. 9250360, dated 06/12/2017

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 (ZHP6-180C compressor) 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 ZHP6-180C 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 ZHP6-180C heat pump's performance, known as the Seasonal Performance Factor (SPF_H4)[5]. Higher (better) values of SPF_H4 means that less electrical energy input is required to satisfy the heating requirement, with a greater proportion

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[3] Models: ZHP6-180H, ZHP4-180C and ZHP4-180H were declared as identical by GDC Group Ltd

[4] 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)

[5] 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

supplied by the communal boiler. For a Zeroth Energy System incorporating a communal boiler, the delivered energy requirement is defined as:

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

This equation accounts for the electricity required by the ZHP6-180C heat pump, which is installed within each dwelling. These upgrade heat distributed by the heat network at a water temperature of 25°C to water temperatures of 35°C to 55°C for space heating services, depending on the dwelling's heat emitter 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 Zeroth Energy System. In practice, the Building Regulations require a minimum annual efficiency of 91%, but the Zeroth Energy System 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:

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

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

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

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

Therefore, determining the minimum required SPF_H4 for the ZHP6-180C 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[6] 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'[7] and published within the SAP 10.0 specification.

SPF_H4 values were calculated for the ZHP6-180C heat pump based on SAP's annual performance method for heat pumps[4] at 35°C and 55°C design flow temperatures (for space heating; hot water service is taken at 55°C). The only modification to standard method assumptions was that the hot water cylinder thermostat was taken as halfway up the cylinder, as opposed to 1/3; based on the supplied drawing. The following table presents SPF_H4 results for the ZHP6-180C heat pump:

SPF_H4 Values based on EN14825 variable outlet test conditions and weather compensation active								
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	6.08	5.93	5.85	5.79	5.93	5.51	5.43	5.20

SPF_H4 Values based on EN14825 variable outlet test conditions and weather compensation disabled								
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	5.50	5.33	5.27	5.31	5.48	5.17	5.14	4.97

SPF_H4 Values based on EN14825 variable outlet test conditions and weather compensation active								
Design flow temperature[8] (°C)	55							
Plant Size Ratio[9]	0.5	0.8	1.0	1.2	1.5	2.0	2.5	3.0
SPF_H4	5.02	4.25	4.28	4.32	4.42	4.31	4.26	4.01

SPF_H4 Values based on EN14825 variable outlet test conditions and weather compensation disabled								
Design flow temperature[8] (°C)	55							
Plant Size Ratio[9]	0.5	0.8	1.0	1.2	1.5	2.0	2.5	3.0
SPF_H4	3.65	3.67	3.70	3.76	3.87	3.83	3.85	3.67

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 GDC Group/Dimplex heat pump models: ZHP6-180C, ZHP6-180H, ZHP4-180C and ZHP4-180H within dwellings (for these installation scenarios) when installed as part of a Zeroth Energy System. This treatment equally applies to other types of communal heat generators that supply heat to the Zeroth Energy System, namely communal heat pumps and Combined Heat & Power (CHP) units.

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

[7] 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).

[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 Zeroth Energy System in SAP 2009 and 2012 assessments):

1) SAP assessor must confirm that the Zeroth Energy System complies with the requirements of *"Basic Design Requirements for a Zeroth Energy System"* - Issue 03). 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 any of the following Dimplex models are installed in the dwelling: ZHP6-180C, ZHP6-180H, ZHP4-180C and ZHP4-180H. 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.

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