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SAP Technical Note for HHIC Hybrid Classes 1a and 1b

The Building Research Establishment Ltd (BRE) has prepared this Technical Note to define an interim treatment in the National Calculation Methodology for energy rating of dwellings (SAP) for the recognition of products that satisfy the Heating & Hotwater Industry Council (HHIC) Hybrid Working Group Class 1a or 1b definitions. These definitions are presented on pages 3 to 8.

The Standard Assessment Procedure (SAP) is the UK Government's methodology for calculating the energy performance of dwellings and is authored and managed by the Building Research Establishment Ltd (BRE) under contract from the Department for Business, Energy and Industrial Strategy (BEIS).

Members of the HHIC Hybrid Working Group are currently seeking formal recognition of their heat pump and boiler hybrid products in SAP. The purpose of this Technical Note is to provide an interim treatment for SAP calculations, based on BRE's understanding of the product's operation, but which has not been assessed in the field by BRE and cannot therefore be validated.

This interim treatment only applies to heat pump and boiler hybrid products that are specified, installed and commissioned in accordance with their Manufacturer's instructions. All installations must comply with the current Building Regulations.

This interim treatment is only applicable to SAP 2009 and SAP 2012 assessments, not SAP 2005 assessments or Reduced Data SAP assessments.

The interim treatment is only valid for products that satisfy the HHIC Hybrid Working Group Class 1a or 1b definitions (see below). Both boiler and heat pump components must be entered in the Product Characteristics Database (PCDB). The Hybrid Master Control must ensure that any direct-electric auxiliary back-up heater included within the heat pump package can never be used – see Class 1a and 1b definitions.

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SAP 2009/2012 assessor instructions:

1) SAP assessor assigns "two main heating systems " in SAP software
2) SAP assessor assigns first main heating system as the heat pump that comprises the hybrid system through selection in the Product Characteristics Database
3) SAP assessor assigns first main heating system as satisfying 100% of the space heating requirement.
4) SAP assessor assigns second main heating system as the boiler that comprises the hybrid system through selection in the Product Characteristics Database
5) SAP assessor assigns second main heating system as satisfying the hot water heating requirement
6) SAP assessor inputs all other variables as normal

For this Technical Note to be valid, documentation demonstrating how the above specification, installation and commissioning criteria have been satisfied must be presented to SAP assessors and Building Control officers on request.

This interim treatment will remain valid until further notice.

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Specification of Hybrid Heat Pump Systems for recognition by the UK's National Calculation Methodology for energy rating of dwellings (SAP)

HHIC Hybrids Working Group

Vaillant Group

Daikin

Viessmann

Ideal boilers

Sime

Background

A method is needed for assessing Hybrid Heat Pumps systems within the National Calculation Methodology for energy rating of dwellings (SAP) by utilising data, operational modes and profiles declared by the HHIC Hybrid Working Group.

At the meeting held with BRE on 12th June 2014, the HHIC Hybrid Working Group defined 'bivalent' systems as separate boiler and heat pump installations within a dwelling that may be controlled by separate control devices or a single integral control device, but where the control logic is undefined. The group had assumed that such systems can be recognised in SAP using the option to specify two main heating systems; however, they now recognise that this is not the case as the apportionment between the two heating systems does not follow the correct principles. Only where a procedure is defined using a suitable methodology and SAP conventions can a hybrid system be recognised satisfactorily.

Definitions

(1) Hybrid heat pump system - General definition (industry)

> *"A hybrid heat pump system consists of one electrically-driven heat pump and at least one non-electric heat generator. It is controlled by a 'Master Control' which determines the operation of both heat generators to satisfy the building heating and/or hot water load with reference to a defined control logic. The system may consist of a single box with modular technology sections, or of separate appliances, and may be connected in series or in parallel and may operate simultaneously for a proportion of time."*

(2) Hybrid heating system - General definition (BRE, for potential use in SAP)

> *"A hybrid hydronic heating system contains two heat generators that are capable of operating independently but are subject to a 'Master Control' that decides which of them is to run. The water circuit passes through a single shared set of heat emitters, and through the two heat generators connected either in series or parallel. The two heat generators and Master Control do not have to be co-located. However, they must be a coherent system, meaning that they are compatible and controlled in unison so as to respond to space heating and/or water heating demand in accordance with a well-defined control strategy."*

The term 'bivalent' is not used as it is ambiguous.

(3) Hybrid heat pump system – Class 1 definitions for recognition in SAP (the purpose of this specification)

As generally defined, a hybrid system may be configured in many ways and subject to a variety of control strategies. The actual configuration and control has a large influence on overall energy performance, running cost, and CO2 emissions. Consequently it is necessary to restrict definitions for the purpose of analysis, which is best done by classification.

In this project only hybrids in Class 1a and Class 1b will be analysed.

A Class 1a hybrid heat pump system is defined as:

> "A heat pump and regular or system boiler (not combi), connected in series or parallel, and a 'Master Control', all supplied as a single package by the applicant manufacturer. The heat pump is powered by electricity and the boiler fuelled by gas or LPG. The package is controlled by the Master Control, whose control logic must be based on the principle of minimising fuel and power costs for space heating. This is achieved by comparing the cost of useful heat output from the heat pump and boiler. The cost comparison takes into account:
>
> (i) external temperature (changing with time),
> (ii) heat emitter design temperature,
> (iii) flow temperature used to deliver space heating under current conditions,
> (iv) heat pump and boiler efficiencies at temperatures (i) and (iii),
> (v) the unit price of gas, LPG, and electricity.
>
> The Master Control must ensure that operation of the hybrid is subject to the restrictions applicable to Class 1a."

The following restrictions apply to Class 1a:

- The heat pump is an air-source heat pump, supplying heat to a hydronic domestic heating system.
- The boiler is a regular or system gas boiler of condensing type. The boiler must be declared as on/off or modulating, and if modulating the lower limit of modulation shall be declared.
- The Master Control decides whether the heat pump or the boiler provides the useful heat required for space heating. The control must determine the cost-optimal operation of the hybrid heat pump system by reference to the cost of electricity (in p/kWh) and gas or LPG (in p/kWh). The device must compare the cost of useful heat supplied by measuring or calculating the instantaneous efficiency of the heat pump taking into account source and sink temperatures, and measuring or calculating the instantaneous efficiency of the boiler.
- The prices of gas, LPG, and electricity will be taken from Table 12 of SAP. Only the standard tariff for electricity will be used (not separate low and high rates for off-peak tariffs). Fuel and power costs are not automatically updated (e.g. via network based protocols).
- Within a defined tolerance of ± 0.5°C of the crossover temperature, either the heat pump or the boiler may be utilised to provide useful heat for space heating, and for analysis it will be assumed that either will do so with equal probability.
- The Master Control ensures that the heat pump and boiler never run simultaneously.
- The hot water service is provided by the boiler only. The Master Control must ensure that:
  (i) water heating is provided by the boiler alone, and
  (ii) while the boiler is heating the hot water storage vessel, the heat pump is not operating.
- Space heating and water heating are never provided simultaneously, except when the circumstances are such that space heating would be provided by the boiler alone because the heat pump is currently the more expensive option.

- The design of the installed heating system is such that the space heating demand of the building can be satisfied by intermittent heating, using the SAP standard hours for heating demand. This implies sizing sufficient to meet space heating requirements (i) on the design day without recourse to continuous heating, and (ii) by the heat pump alone when the external temperature is above the crossover temperature[1].

- Control of the system includes weather compensation and/or load compensation; i.e. the Master Control controls the measured flow temperature with reference to the measured temperature outside and/or inside the building. The control strategy must ensure that the mean water circulation temperature for space heating falls as the demand for space heating reduces, and must be capable of limiting water temperature to achieve this.

A Class 1b hybrid heat pump system is defined as:

> "A heat pump and combi boiler, connected in series or parallel, and a 'Master Control', all supplied as a single package by the applicant manufacturer. The heat pump is powered by electricity and the boiler fuelled by gas or LPG. The boiler is designed such that the water circuit used for space heating is not heated while the boiler is providing hot water service. The package is controlled by the Master Control, whose control logic must be based on the principle of minimising fuel and power costs for space heating. This is achieved by comparing the cost of useful heat output from the heat pump and boiler. The cost comparison takes into account:
>
> (i) external temperature (changing with time),
> (ii) heat emitter design temperature,
> (iii) flow temperature used to deliver space heating under current conditions,
> (iv) heat pump and boiler efficiencies at temperatures (i) and (iii),
> (v) the unit price of gas, LPG, and electricity.
>
> The Master Control must ensure that operation of the hybrid is subject to the restrictions applicable to Class 1b."

The following restrictions apply to Class 1b:

- The heat pump is an air-source heat pump, supplying heat to a hydronic domestic heating system.

- The boiler is a condensing combination gas boiler, which may be either an instantaneous combi or storage combi. The boiler must be declared as on/off or modulating, and if modulating the lower limit of modulation shall be declared.

- The Master Control decides whether the heat pump or the boiler provides the useful heat required for space heating. The control must determine the cost-optimal operation of the hybrid heat pump system by reference to the user-input cost of electricity (in p/kWh) and gas or LPG (in p/kWh). The device must compare the cost of useful heat supplied by measuring or calculating the instantaneous efficiency of the heat pump taking into account source and sink temperatures, and measuring or calculating the instantaneous efficiency of the boiler.

- The prices of gas, LPG, and electricity will be taken from Table 12 of SAP. Only the standard tariff for electricity will be used (not separate low and high rates for off-peak tariffs). Fuel and power costs are not automatically updated (e.g. via network based protocols).

[1] If condition (ii) cannot be satisfied (i.e. the boiler must run simultaneously to supplement the heat output from the heat pump), then that does not comply with the definition of a Class 1a hybrid system. A separate class could be defined to allow simultaneous running for space heating, but that would require a more complicated performance analysis and BRE would have to understand and define the configuration assumptions, control strategy, and restrictions to be adopted.

- Within a defined tolerance of ± 0.5°C of the crossover temperature, either the heat pump or the boiler may be utilised to provide useful heat for space heating, and for analysis it will be assumed that either will do so with equal probability.
- The Master Control ensures that the heat pump and boiler never run simultaneously, except when space heating is being produced by the heat pump part alone and instantaneous hot water is being produced by the boiler part.
- The hot water service is provided by the boiler only. The Master Control ensures that water heating is provided by the boiler alone. The design of the system is such that, while producing hot water, no heat is supplied by the boiler to the water circuit used for space heating.
- The design of the installed heating system is such that the space heating demand of the building can be satisfied by intermittent heating, using the SAP standard hours for heating demand. This implies sizing sufficient to meet space heating requirements (i) on the design day without recourse to continuous heating, and (ii) by the heat pump alone when the external temperature is above the crossover temperature[2].
- Control of the system includes weather compensation and/or load compensation; i.e. the Master Control controls the measured flow temperature with reference to the measured temperature outside and/or inside the building. The control strategy must ensure that the mean water circulation temperature for space heating falls as the demand for space heating reduces, and must be capable of limiting water temperature to achieve this.

For performance analysis, meteorological data will be used to define the frequency of external temperatures throughout the year. At each temperature step the instantaneous heat pump and boiler efficiencies will be calculated to determine which will provide useful space heating more cheaply. The 'crossover temperature' is the external air temperature at which it has been calculated that the heat pump and boiler provide useful heat output for space heating at the same cost.

Sample calculations

The Working Group will develop three standard performance calculations for Class 1a and 1b hybrid product samples against which the method can be benchmarked. The group reserves the right not to proceed if the final method does not demonstrate a worthwhile performance enhancement for hybrids that can be recognised by SAP.

[2] If condition (ii) cannot be satisfied (i.e. the boiler must run simultaneously to supplement the heat output from the heat pump), then that does not comply with the definition of a Class 1b hybrid system. A separate class could be defined to allow simultaneous running for space heating, but that would require a more complicated performance analysis and BRE would have to understand and define the configuration assumptions, control strategy, and restrictions to be adopted.

Appendix A - SAP Seasonal Performance Method for heat pump performance

This appendix notes the method used to evaluate heat pump performance when the heat pump is the only or main device providing heat. It is anticipated that some amendments will be made to the methodology in order to reflect boiler/heat pump hybrids.

The principle of the current SAP 2009/2012 heat pump performance calculation procedure is to derive intermediate seasonal parameters for heat pumps using thermal performance measurements verified by independent laboratory tests following EN14511-2 and if required EN14825:2012 (50% load test). The seasonal parameters are:

a) Space heating Seasonal Performance Factor (SPF), which is highly dependent on the Plant Size Ratio (PSR).

b) Domestic hot water Seasonal Performance Factor (SPF)

To assess the overall thermal performance in terms of SAP, two other parameters need to be specified. These depend on the PSR and the designated hours of heating and are calculated according to Appendix N of SAP 2009. The parameters are:

a) Fraction of the space heating requirement not supplied by the heat pump

b) The number of days that the heat pump is expected to operate longer than the standard SAP heating times.

A range of Space Heating Seasonal Performance Factors (SPF) is calculated by following the EN15316 annual performance method for a range of PSR values. These are then stored in the Product Characteristics Database (PCDB). SAP software undertakes linear interpolation based on the plant size ratio for the specific heat pump and dwelling being assessed.

The principle of the annual performance method follows the bin method specified in EN15316-4-2:2008. This involves the outside air temperatures being subdivided into bins of a certain temperature range, for example, the number of hours with a temperature within the range of 2ºC to 5°C. For each temperature bin, the numerator and denominator of the Seasonal Performance Factor are calculated. These values are weighted by bin frequency and summed before dividing to give the Seasonal Performance Factor (SPF).

In certain conditions the heat pump might not satisfy the heating load or might be designed to provide only a proportion of the required heat. If this is the case, the fraction of heating required by a backup heating system is calculated according to Appendix N of SAP 2009. This means the space heating SPF must exclude any backup heating. In contrast, if the heat pump cannot satisfy the entire domestic hot water load, the backup energy required by an electric immersion heater is included in the domestic hot water SPF.

Heat pumps may operate more efficiently when running 24 hours/day or 16 hours/day as opposed to intermittently. The longer operation, however, has an energy penalty as it causes higher dwelling heat losses. This is accounted for by defining the designated hours of operation of a heat pump in the Product Characteristics Database (PCDB). The designated hours of heating are either a) 24 hours daily; b) 16 hours daily; c) 9 hours/day in the week and 16 hours/day at weekends (11 hours/day on average); or d) variable[3]. Appendix N of SAP 2009 indicates the number of days a heat pump is expected to operate for 24 hours instead of 16 hours, or the number of days it is expected to operate for 16 hours instead of 9 hours, and depends on its designated hours of operation.

[3] Variable is a special case where specific controls ensure that 16 hour operation or 24 hour operation is only required on certain days when the heat required cannot be met by operating for 9 hours/day or 16 hours respectively.

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Appendix B - SAP Seasonal Performance Method for boilers

The current method of evaluating boiler performance in SAP assumes that the boiler is used under all conditions. Some adjustment to the method will be necessary to reflect the restricted conditions of boiler usage in a hybrid heat pump system