GN39: Ene 01 Calculation Methodology for BREEAM UK New Construction 2018 and Version 6

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Introduction

This guidance note provides further information behind the calculation methodology for energy performance under the Ene 01 issue of BREEAM UK New Construction 2018 (UK NC 2018) and BREEAM UK New Construction Version 6 (UK NC V6).

For the purposes of completing an assessment the assessor only needs to upload the '_brukl.inp' file (or enter the relevant data points for shell only UK NC 2018 assessments) in the BREEAM Platform to automatically calculate the number of credits achieved. Due to the complexity of the calculation process it is not possible to calculate the credit score on a spreadsheet.

The calculation methodology is based on compliance modelling and uses a triple metric approach that addresses energy demand, energy consumption and CO_2 emissions. The aim of using this approach is to enhance the ability of BREEAM to recognise and promote designs that minimise energy demand and consumption in buildings and to reduce the carbon emissions resulting from that energy use.

The triple metric approach

The methodology considers three metrics of the modelled performance of a new building when determining the number of credits achieved for this issue, as follows:

- Heating and cooling energy demand.
- Primary energy consumption.
- Carbon dioxide (CO_2) emissions.

'Heating and cooling energy demand' is a measure of the annual heating and cooling energy demand, in MJ/m^2 year. It is influenced by factors including the building fabric performance and air permeability, and by heat gains from people, building servicing systems and energy using equipment.

'Primary energy consumption' is a measure of the building's primary energy use in kWh/m^2 year. Primary energy measures the total amount of raw energy inputs to an energy source i.e., before it has undergone any conversion and transformation process and includes both renewable and non-renewable sources. Delivered energy, measures the amount of energy that is consumed by the building and considers the demand for energy service and the efficiency of the plant and equipment, whereas primary energy consumption encompasses the demand for energy services, the efficiency of installed plant and equipment and the efficiency of the energy supply system.

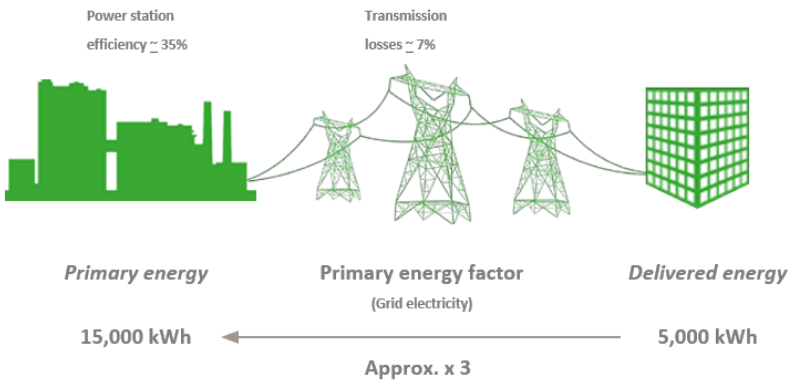

Figure 1: Delivered energy and primary energy

The CO_2 metric is a measure of the greenhouse gas emissions the building emits in meeting its predicted energy demands for heating, cooling, ventilation, domestic hot water, and lighting, in kg CO_2eq/m^2 year. It is influenced by the demand for building services, systems and distribution efficiency and fuel source. The specification of low or zero carbon forms of energy generation (on-site or near-site low carbon or renewable energy) are accounted for in this metric.

The triple metric approach ensures that standard practice for fabric and cannot be offset by high performance on the carbon metric scale through the specification of low or zero carbon, on-site (or near-site) solutions. Therefore, BREEAM seeks to encourage and reward a holistic approach to reducing energy demand, energy consumption and emissions, through a balance of good building design and systems specification.

Building regulations for the countries of the UK

The four countries of the UK (Wales, Scotland, Northern Ireland and England) have different building regulation standards for energy. The BREEAM credits for energy performance under Ene 01 are based on the building regulations baseline and methodology, so the credits for this issue are tailored to each UK country and use different numbers for the translation of energy performance into credits.

Using different baselines for different parts of the UK takes account of the divergence in country-specific energy regulations for new buildings across the UK and ensures that BREEAM reflects local building regulations. This means that any improvement over local regulations will be reflected in the scoring.

A consequence of this approach is that it means there is a loss of comparability between buildings across the UK. Therefore, the number of credits awarded for a building in one country may be different to those for a building in another country with an identical design. This could lead to a building scoring an Excellent rating in Scotland and an identical building scoring a Very Good rating in England.

Relevant building regulation versions

The versions of the building regulations that are used to define the baseline in **UK NC 2018** of the Ene 01 energy performance methodology for Northern Ireland, England, Wales and Scotland are as follows:

- Northern Ireland: Technical Booklet F2 2012 Conservation of fuel and power in buildings other than dwellings
- England: Approved Document Part L2A Conservation of fuel and power in new buildings other than dwellings, 2013 edition – for use in England.
- Wales: Approved Document Part L2A Conservation of fuel and power: New buildings other than dwellings – for use in Wales.
- Scotland: Technical Handbook 2015 Non-Domestic, Section 6 Energy.

The versions of the building regulations that are used to define the baseline in **UK NC V6** of the Ene 01 energy performance methodology for Northern Ireland, England, Wales and Scotland are as follows:

- *Northern Ireland: Technical Booklet F2 2012 Conservation of fuel and power in buildings other than dwellings
- England: Approved Document Part L2 Conservation of fuel and power in new buildings other than dwellings, 2021 edition – for use in England.
- *Wales: Approved Document Part L2A Conservation of fuel and power: New buildings other than dwellings – for use in Wales.
- *Scotland: Technical Handbook 2015 Non-Domestic, Section 6 Energy.

*As each country updates the corresponding building regulations the methodology will be updated as appropriate.

When entering and uploading building performance information into the BREEAM Platform, it is essential that the correct version of the building regulations is used in the tool, and that the building performance data is generated by the correct version of the approved software.

Translating building performance into BREEAM credits

The energy modelling data required to determine building performance is generated by National Calculation Method (NCM) compliant energy modelling software, used by the design team to demonstrate building regulation compliance. The NCM compliant energy modelling software produces a BRUKL input file ('_brukl.inp' file) and a standard output document, called the BRUKL Output Document: Compliance with Building Regulations. Details about the project the project, the '_brukl.inp' file or relevant data from the BRUKL output document is then entered into the BREEAM Platform to determine the EPR_{NC} and number of credits achieved.

The Target CO_2 Emission Rate (TER) is the minimum emissions performance required by building regulations for a new building for all four countries of the UK. The TER is based on the performance of a notional building, which is defined in the NCM modelling guide for each country.

For Wales, Northern Ireland and England and Scotland, the TER is set to equal the CO_2 emissions from the notional building, as the notional building is concurrent with the compliant building regulations standards for these countries. The notional building is used to generate 'Indicative Targets' for demand and consumption as well as the TER for CO_2, as shown in the Energy & CO_2 Emissions Summary table in the BRUKL Output Document (see example below).

The Target Primary Energy Rate (TPER) is the minimum energy consumption performance required by building regulation for a new building. The Target primary energy consumption is based on the performance of a notional building.

Energy Production by Technology [kWh/m²]

	Actual	Notional
Photovoltaic systems	1.43	0
Wind turbines	0	0
CHP generators	31.46	0
Solar thermal systems	0	0

Energy & CO_2 Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m²]	85.92	114.11
Primary energy* [kWh/m²]	265.5	322.67
Total emissions [kg/m²]	45.1	54.8

* Primary energy is net of any electrical energy displaced by CHP generators, if applicable.

Figure 2: Extract from a BRUKL Output Document

The BREEAM credits scale and minimum standards

The credit scale is listed in the technical manual in Table 6.1 (Ene 01 EPR_{NC} benchmark scale). There are up to 9 standard credits available.

The minimum EPR_{NC} required to achieve 1 credit is 0.1 and there is a linear scale up to an EPR_{NC} of 0.9 for 9 credits. This entry level serves to recognise buildings which achieve a moderate improvement over a Building Regulations compliant design. Table 1 describes the scheme's minimum standards for Ene 01.

In addition, the prediction of operational energy consumption criteria are an alternative means of achieving credits to gain an excellent rating - see GN32 (with the exception of shell only assessments).

Table 1: Ene 01 minimum standards

BREEAM credits	EPR_{NC}	Minimum standards
1	0.1	To achieve at least one Ene 01 credit
4	0.4	To achieve an Excellent rating
6	0.6	To achieve an Outstanding rating
9	0.9 AND zero net regulated CO_2 emissions	-

The BREEAM EPR_{NC} weightings

The Ene 01 methodology gives equal weighting to all three-energy metrics to ensure that each metric is given equal consideration when assessing the overall performance in terms of BREEAM credits.

Table 2: Weightings for each metric and country

Metric	All countries
Building energy heating and cooling demand	1/3
Primary energy consumption	1/3
Carbon dioxide (CO_2eq) emissions	1/3

Energy modelling input data required to translate building performance

The calculation is informed by the following performance data which is extracted from the '_brukl.inp' file. This should be uploaded to the online calculator, and any relevant additional input questions answered.

The performance data required below can be found in the Energy & CO_2 Emissions Summary table and the Energy Production by Technology table in the BRUKL Output Document shown in Figure 2:

- Building floor area (m^2)
- Actual building heating and cooling energy demand (MJ/m^2yr)
- Notional building heating and cooling energy demand (MJ/m^2yr)
- Actual building primary energy consumption (kWh/m^2yr)
- Target primary energy rate (TPER) (kWh/m^2yr)
- Building Emission Rate (BER) (kg CO_2/m^2yr)
- Target Emission Rate (TER) (kg CO_2/m^2yr)

Onsite renewable energy generation

- Actual Energy Production Photovoltaic systems (kWh/m^2)
- Notional Energy Production Photovoltaic systems (kWh/m^2)
- Actual Energy Production Wind turbines (kWh/m^2)
- Notional Energy Production Wind turbines (kWh/m^2)

Methodology for BREEAM UK New Construction Version 6.0

The UK NC V6 scheme is an update to UK NC 2018 to incorporate updated building regulations. Currently, only England has recently updated the building regulations. For Scotland, Wales, and Northern Ireland assessments the existing UK NC 2018 methodology is still used (see "Methodology for BREEAM UK New Construction 2018" below) but these will be updated when building regulations in these countries are updated. See "Relevant building regulation versions" on page 3 for the applicable building regulations for the country of assessment. To assess against this methodology the appropriate country of assessment must be selected and the '_brukl.inp' file should be uploaded to the online platform.

The BREEAM methodology defines all the heating systems in the notional building being defined as a gas boiler. For Building Regulations, the notional heating systems type is defined to be the same as the actual system type in most instances.

For England where the building is connecting to an existing district heating system the actual system data is used where this has better performance than the notional gas boiler. If the performance is worse than the notional gas boiler then the data of a notional gas boiler will be used for the actual performance. For new district heating systems, the actual system data must be used and will be compared against the notional gas boiler. In addition, UK NC V6 uses Part L 2021 carbon emission factors accounting for decarbonisation of the UK National Grid.

Defining the BREEAM translators for England

The translator of performance in England for each of the three metrics is derived from performance modelling of a stock of actual buildings, which reflect the expected distribution of performance against Part L 2021 regulations.

For shell only assessments separate building energy heating and cooling demand translators have been produced for different building types (Retail and Industrial) to reflect observed performance distribution based on UK NC 2018 assessments and expected distribution against Part L 2021 regulations.

Methodology for BREEAM UK New Construction 2018

There are two available methodologies to assess energy performance in Ene 01 in BREEAM UK New Construction 2018: the standard methodology and alternative methodology. To assess against these methodologies the '_brukl.inp' file should be uploaded to the online platform, and the additional questions required when applicable. The building score shows the maximum BREEAM credits achieved by both methods and the method used, along with EPR metrics and CO_2 percentage improvement over the notional building. The additional questions cover the electric generation of hot water (for Scotland only) and district heating (if applicable), this is shown in more detail below. If the '_brukl.inp' file is uploaded, the number of credits awarded is taken as the higher of that calculated by the standard and alternative methodologies.

If the '_brukl.inp' file is unavailable, you can still enter the data from the BRUKL output document, however credits are only awarded following the standard methodology.

In instances where the actual building performance values are worse than that of the notional building, or more than 15% worse than the notional building for the demand metric for shell only and fully fitted buildings, will result in an EPR of zero for that metric. Furthermore, no credits will be awarded if the CO_2 emissions for the actual building (BER) is higher than the notional (TER).

Defining the BREEAM translators for the standard methodology

The translator of performance for each of the three metrics is derived from performance modelling of a stock of actual buildings, which represent different building types, using an NCM compliant software package.

For England, a representative sample of buildings that underwent BREEAM assessment under the 2014 scheme were used to determine the 2018 translator curves. Using actual performance data to benchmark performance data means that the energy performance is directly comparable to other BREEAM assessed buildings. However, for Scotland, Wales and Northern Ireland sample sizes are currently insufficient to adopt this method and so the translator curves for these countries were based on the 2014 methodology using an updated energy performance specification.

England translators

For all three curves an Actual/Notional (A/N) of zero is defined as an unweighted EPR of 1.0. The mean A/N value for the sample defines an unweighted EPR 0.5, the policy decision point, which means that the unweighted EPR scores directly reflect where the performance sits within the distribution for assessed buildings. For the primary energy and CO_2eq metrics an unweighted EPR of 0 is defined as an A/N of 1, i.e., the actual performance is no better than the notional. For the energy demand metric, it is recognised that increased energy efficiency can lead to higher heating and cooling demands compared to the notional. For this reason, an unweighted EPR of 0 is defined by a value slightly greater than 1, where this value is determined based on the observed distribution of heating and cooling demands in the sample.

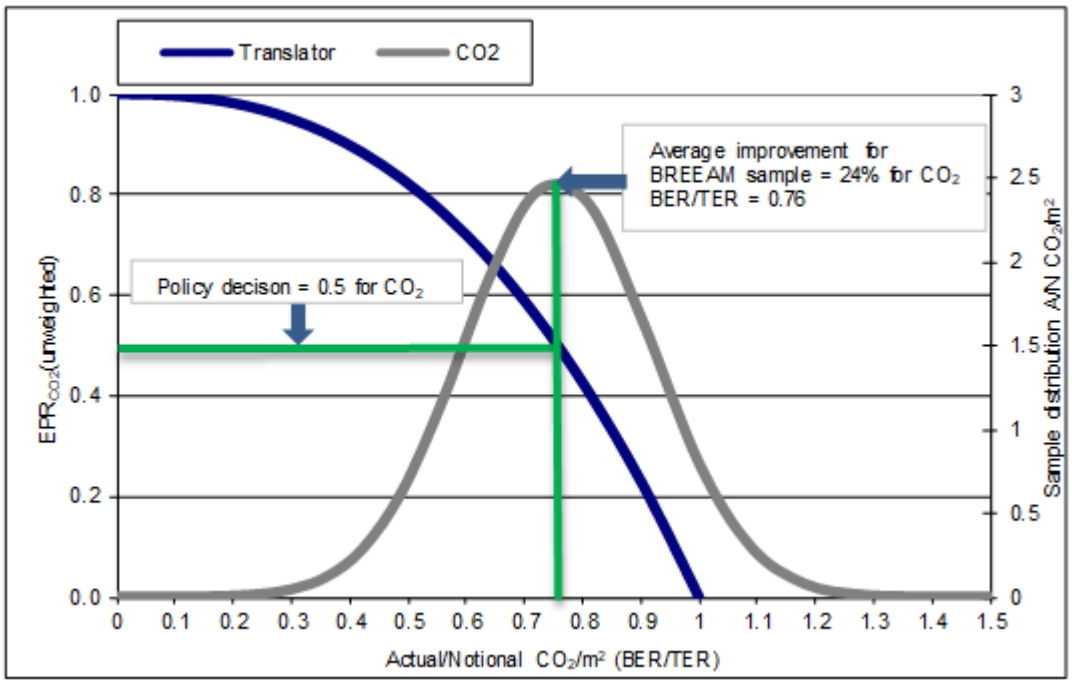

Figure 3: Example Ene 01 building performance translator England

Scotland, Wales, and Northern Ireland translators

For other countries it was not possible to use data from BREEAM assessed building to determine the translator curves as the sample sizes were insufficient. Therefore, instead of using a sample of real buildings, the sample of buildings used to determine the 2014 translators was used, but with a hypothetical high-performance specification updated to take account of improvements in plant and equipment efficiencies. These translators were devised based on a sample of building models converted to comply with the relevant building regulations for each country and then modified to a high-performance specification that comprises high thermal performance parameters, equipment, and system efficiencies, etc.

Data from this modelling was used to determine the distribution of performance improvement for each of the three metrics (graphically represented by the bell curve in the example below). This average performance improvement, coupled with several 'policy' decisions, described below, were then used to define a means of benchmarking actual building performance (graphically represented by the curve in the following example).

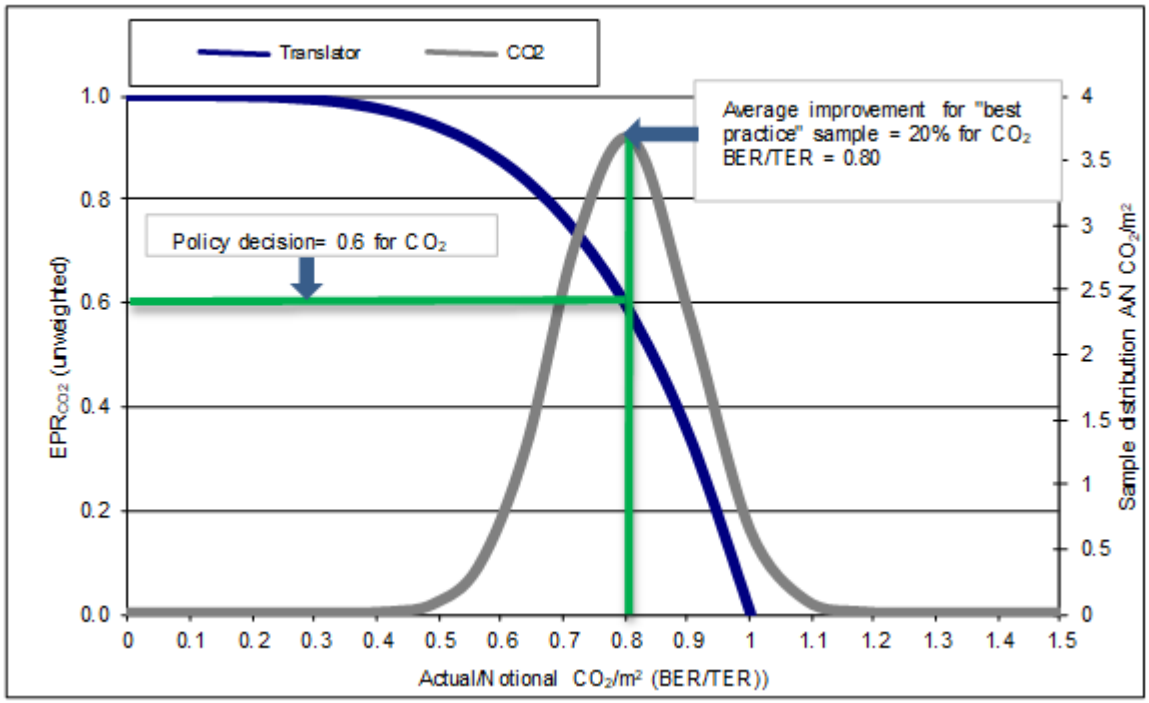

Figure 4: Example Ene 01 building performance translator Wales

Policy decisions

Each metric translator curve is defined from the modelled building stock, and the following 'policy' decisions.

A specific Energy Performance Ratio (unweighted) will be achieved where the assessed building achieves a defined percentage improvement on the notional building standard, where the defined percentage improvement is based on the average of the modelled building stock.

The policy decision points defined by the EPRs for each country are shown in Table 3.

Table 3: Policy decision points for each metric by country

Metric	England	Scotland, Wales, and Northern Ireland
Building energy heating and cooling demand	0.5	0.8
Primary energy consumption	0.5	0.8
Carbon dioxide (CO_2eq) emissions	0.5	0.6

The translator curves for each metric for Scotland, Wales, Northern Ireland and England are derived by generating a curve that connects three points:

1. Proportion A/N = 1, and:
    a. EPR = 0 for:
        — primary energy and CO_2 for all project types
        — energy demand for shell only projects
    b. Or EPR = 0.15 for:
        — energy demand for fully fitted and shell and core projects
2. Proportion A/N = average BREEAM (for England) or "high-performance" (for other countries), and EPR for 'policy decision'
3. Proportion A/N = 0, and EPR = 1

For energy demand translators for fully fitted and shell and core projects an adjustment factor (k) of 0.15 is applied to account for the negative impact that energy efficiency typically has on the energy demand ratio. This was determined based on the observed distribution of energy demand ratios for a sample of buildings assessed under BREEAM UK New Construction 2014.

For the demand EPR for shell only assessments and carbon and primary energy EPRs for all assessment types k=1

This curve is formed from the following equation:

$$EPR\ (unweighted) = 1 - (1 - k)(A/N)^n$$

where:

EPR = Energy Performance Ratio (unweighted)

A = actual building performance

N = notional building performance

n = 'n' value is a function of the EPR at the 'policy decision' and the average proportion of actual / notional building performance.

k = adjustment factor

k = 0 for the primary energy and for the demand EPR for shell only assessments and carbon and primary energy EPRs for all assessment types k=1

Alternative methodology

The alternative methodology is a similar approach to the "standard" methodology, but with all the heating systems in the notional building being defined as a gas boiler. For Building Regulations, the notional heating systems type is defined to be the same as the actual system type in most instances. The alternative method also uses more recent SAP 10 emission factors[1] accounting for decarbonisation of the UK National Grid compared to Part L 2013. This generates alternative carbon emissions and primary consumption energy metrics. The heating and cooling demand metric for the alternative methodology is the same as for the standard methodology.

In addition, for buildings where district heating has been installed as a condition for granting planning permission, this heating energy consumption is excluded from the carbon and primary energy metrics as the design team are not able to influence this decision. Where installation of district heating is a design choice additional information on the energy sources used to generate heat need to be provided. The system is currently unable to automatically calculate credits for these buildings. Please contact us for further details about how to submit a manual application.

Defining the BREEAM translators for the alternative methodology

Separate translator curves have been derived for use with the alternative energy metrics. Scenario modelling to simulate the energy performance improvements obtained using the alternative carbon and primary energy metrics was used to generate the policy decision points for the decision curves for the alternative methodology.

Monte Carlo analysis to simulate the distribution of A/N primary energy and carbon values that would be obtained using the alternative metrics was undertaken by varying four key input variables that affect how the actual metric will differ from the notional metric. Where the values chosen for these four input values reflect their stock distribution. The four key variables used are:

- Heating system efficiency – efficiency distribution of currently available heat pumps
- Proportion of energy used for heating – from the sample of buildings assessed using BREEAM UK New Construction 2014
- A/N heating energy use only – from the sample of buildings assessed using BREEAM UK New Construction 2014
- A/N other energy uses – from the sample of buildings assessed using BREEAM UK New Construction 2014

Heat pump efficiencies were used to determine the alternative translator curves because the current carbon and energy benefits associated with this technology are not recognised by the current NCM calculations. This is because the carbon and primary energy factors they use do not adequately reflect the level of grid decarbonisation that has occurred.

The simulation results provide the distribution of A/N values for the stock using the alternative metrics. The mean value for the distribution determines the policy decision point for the translator curves. To provide translator curves for buildings where connection to district heating is a condition of planning permission (and therefore the heating system is not a design choice) simulations were also run to generate A/N metrics excluding space heating and hot water.

[1]The Government's Standard Assessment Procedure for Energy Rating of Dwellings Version 10.0 available here.

Calculation process

Stage 1 - Defining the building's performance

The first stage of translating modelled building energy performance in to BREEAM credits is to calculate the 'building performance improvement'. For the standard and alternative metrics this is done by comparing the actual performance of the modelled building design specification to the notional performance of the modelled building design specification as a proportion for each of the three metrics on an annual basis: heating and cooling energy demand; primary energy consumption; and CO_2 emissions.

Building performance ratio = { actual building performance (A) / notional building performance (N) } for each metric

Building demand performance ratio = A/N demand

Building primary consumption performance ratio = (A-onsite energy)/(N-onsite energy) primary energy*

Building CO_2 performance improvement = BER/TER

*The primary energy performance ratio is adjusted to take account of grid supply electrical energy displaced by on site electricity generation from photovoltaic systems and wind turbines as the primary energy as the BRUKL outputs only take account of electrical energy displaced by CHP generators.

Stage 2 - Benchmarking the performance improvement against the modelled building stock

Each of the percentages from stage 1 is then 'translated' into an Energy Performance Ratio (EPR) for each metric expressed as a value.

To achieve an Energy Performance Ratio of less than one for any of the three metrics, the building's actual performance data must be better than the level achieved for the building notional performance data.

Stage 3 - Weighting the individual ratios for each metric

The Energy Performance Ratios for each metric from stage 2 is then multiplied by weightings.

These weightings reflect the maximum that each metric can contribute towards the overall Energy Performance Ratio, EPR_{NC} , and therefore BREEAM credits. UK NC 2018 uses a weighting factor in the stage 3 calculation to reflect equal importance of the three-energy metrics:

Weighted EPR_{dem} = Building energy heating and cooling demand weighting x unweighted EPR_{dem}

Weighted EPR_{PC} = Primary energy consumption weighting x unweighted EPR_{PC}

Weighted EPR_{CO2} = CO_2 weighting x unweighted EPR_{CO2}

Note: Different weightings are used for buildings/ building areas assessed using the domestic assessment method, e.g., Standard Assessment Procedure (SAP), i.e., residential areas. Please refer to the Methodology section of the Ene 01 issue for guidance on calculating the Ene 01 performance of buildings with residential areas modelled using the domestic assessment method.

Stage 4 - Awarding the BREEAM credits

The weighted Energy Performance Ratios for each metric from stage 3 are totalled to give an overall Energy Performance Ratio for New Construction, EPR_{NC} . This is then compared to the table of benchmarks to determine the number of BREEAM credits awarded. See the Ene 01 issue for the BREEAM credits benchmark scale and its relation to the building regulations compliant standard for each nation and BREEAM's minimum standards.

$EPR_{dem} + EPR_{PC} + EPR_{CO2} = EPR_{NC}$

Example calculation – standard methodology

The following provides an example calculation of each of the three stages of the methodology for a building located in England where the standard methodology gives the highest score.

Stage 1: Define the building's performance as a proportion of the UK NC 2018 notional building level

Demand (MJ/m^2 yr): 65/80 = 0.8125

Consumption (kWh/m^2 yr): 250/300 = 0.8333

Carbon dioxide (kg CO_2/m^2 yr): 40/50 = 0.8000

Stage 2: Benchmark the performance improvement against the modelled building stock i.e., the point that a building's performance as a proportion intersects with the translator curve

Unweighted demand ratio: 1 - (1 - 0.15)(0.8125 ^ 2.061) = 0.446

Unweighted consumption ratio: 1 - (0.8333 ^ 2.282) = 0.340

Unweighted carbon dioxide ratio: 1 - (0.8000 ^ 2.493) = 0.427

Stage 3: Apply the weightings

Weighted demand ratio: 0.446/3 = 0.149

Weighted consumption ratio: 0.340/3 = 0.113

Weighted carbon dioxide ratio: 0.427/3= 0.142

Stage 4: Determining the number of BREEAM credits

Overall EPR_{NC}: 0.149 + 0.113 + 0.142 = 0.404

Look up the number of credits and the minimum standards achieved from the credit table in the technical manual.

No. of BREEAM credits: 4 BREEAM credits

This meets the minimum standard for an Excellent rating.

Appendix A – Percentage improvement values for UK NC V6

BREEAM UK New Construction Version 6.0 percentage improvement values for each metric (England only).

Shell and Core/Fully fitted			
Heating and cooling energy demand	Primary energy consumption	Carbon dioxide (CO_2)	Unweighted EPR
-0.52	0	0	0
-0.3	0.24	0.25	0.1
-0.233	0.32	0.313	0.2
-0.187	0.38	0.358	0.3
-0.147	0.43	0.399	0.4
-0.11	0.475	0.435	0.5
-0.066	0.52	0.472	0.6
-0.033	0.572	0.512	0.7
0.015	0.63	0.56	0.8
0.08	0.713	0.623	0.9

Appendix B – 'n' values for standard methodology

BREEAM UK New Construction 2018 standard methodology 'n' value for each metric and country

Metric	Wales	Scotland	Northern Ireland	England
Building energy heating and cooling demand (fully fitted and shell and core)	7.667	7.230	5.431	2.061
Building energy heating and cooling demand (shell only)	9.078	8.230	5.882	2.674
Primary energy consumption	3.350	3.451	3.098	2.282
Carbon dioxide (CO_2) emissions	4.044	2.984	2.217	2.493

Appendix C – 'n' values for alternative methodology

BREEAM UK New Construction 2018 alternative methodology 'n' value for each metric and country excluding specified end uses

Excluded end use	Metric	Wales	Scotland	Northern Ireland	England
None	Building energy heating and cooling demand	7.667	7.230	5.431	2.061
	Primary energy consumption	3.138	3.243	2.894	2.144
	Carbon dioxide (CO_2) emissions	2.611	1.935	1.428	1.617
Space heating	Primary energy consumption	3.359	3.243	3.091	2.144
	Carbon dioxide (CO_2) emissions	2.506	2.561	1.372	2.140
Space heating and hot water	Primary energy consumption	2.529	2.189	2.388	1.448
	Carbon dioxide (CO_2) emissions	2.426	2.078	1.329	1.736
Hot water	Primary energy consumption	3.136	3.243	2.882	2.144
	Carbon dioxide (CO_2) emissions	2.584	1.983	1.403	1.582

Schedule of changes

Version	Release date	Description of change
0.0	Mar 2018	First issue. Describes methodology for BREEAM UK New Construction 2018 (SD5078).
0.1	May 2019	Refined methodology.
1.0	Nov 2019	Added guidance for alternative methodology.
2.0	Aug 2022	Updated to include BREEAM UK New Construction Version 6 (SD5079).

Find the latest version of this guidance note at: kb.breeam.com/knowledgebase/gn39