



Education & Skills  
Funding Agency

**Building Bulletin 101**

# **Guidelines on ventilation, thermal comfort and indoor air quality in schools**

**Government response to public  
consultation**

**August 2018**

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## Introduction

Building Bulletin 101 (BB101): guidelines on ventilation, thermal comfort and indoor air quality in Schools, sets out regulations, standards and guidance on ventilation, thermal comfort and indoor air quality for school buildings. It replaces BB101 'Ventilation of School Buildings', 2006. This document is the government's response to its recent consultation on BB101.

A draft of BB101 was open for public consultation from 30 June 2016 to 6 September 2016. There were 27 written responses to the consultation. Due to the technical nature of BB101, officials then held detailed follow-up discussions with an editorial group of impartial experts and advisors from September 2016 to February 2016. These conversations and written comments informed detailed technical changes to the guidance.

ESFA would like to thank the following members of the editorial group:

Laura Mansel-Thomas, Ingleton Wood, Engineering Consultant

Malcolm Orme, Aecom, Engineering Consultant

Mike Entwistle, Buro Happold, Engineering Consultant

Andrew Spencer, ESFA Engineering Design Adviser

Paul Vorster Van Zyl de Villiers, Engineering Consultant

Paul Cooper, Hoare Lea, Engineering Consultant

Keeran Jugdoyal, Tim Taylor, Dane Virk, Alastair Rowe, Stephen McLoughlin,  
WS Atkins, Engineering Consultants

Robin Pritchett, Cundall, Engineering Consultant

Benjamin Jones, University of Nottingham

Hershil Patel, Jacobs, Engineering Consultant

## Summary of responses received and the government's response

There were 27 written responses to this consultation. The department held extensive follow-up meetings with an editorial group of impartial experts as part of the consultation process. The intention of this was to make sure the technical subject matter of the document and the responses were considered.

### Main findings from the consultation

Within BB101, a summary table was asked for to act as a quick reference guide that shows which sections are: regulatory; contractual requirements for ESFA funded projects; and further information and guidance. This is now in Section 3 to help technical designers navigate the document.

The document was reformatted to provide greater clarity. The previous section 3 was split into two sections; Section 6 on Indoor and outdoor air quality; and Section 7 on Thermal Comfort.

More guidance was asked for on specialist teaching and practical spaces. This has been added as Section 5: Ventilation for particular areas and activities.

Section 7 on thermal comfort criteria was considered too theoretical, difficult to interpret and use as practical design criteria on current school projects with limited design time.. The expert designers on the editorial group all wanted simpler criteria for designers to follow. We have simplified the design criteria as far as possible, specifying clearly what the design criteria are in all cases and producing look-up tables in BB101, eg for sizing radiant panels and some simple spreadsheet tools for use with BB101.

Some aspects of the design criteria were revised to make them affordable within ESFA funding. ESFA technical requirements have been cost checked. The standards in BB101 have been aligned with ESFA design standards published in the ESFA Output Specification: Generic Design Brief and Technical Annexes.

The new method to prevent summertime overheating is in line with the established CIBSE Technical Memorandum 52 adaptive thermal comfort method based on BS EN 15251 that has been quoted in ESFA Output Specification since 2013 as the design method to use. The previous 2006 edition of BB101 used a fixed temperature threshold of 28°C and the Test Reference Weather Year for summertime overheating assessment. This means that designs built to the revised BB101 will perform much better in summertime than those designed to the current BB101 2006 overheating standards.

Use of this adaptive thermal comfort Overheating Risk Assessment (ORA) method has been simplified from the three criteria used in the 2013 ESFA Output Specification. This

was as a result of detailed thermal modelling which proved that a single criteria is adequate for compliance and that the DSY 2020 (50<sup>th</sup> percentile range) is the Design Summer Weather Year that should be used for ORA modelling.

## Question Analysis

Questions 1 to 4 and questions 20 to 23 of the consultation addressed contact information of respondents. This response addresses questions 5 to 19.

### Question 5

**Is Section 1 of BB101 “Introduction to indoor environmental quality and ventilation strategies” adequate and useful? If not please suggest changes/amendments with reasons.**

Section 1 is the introduction to BB101 and provides a summary of the department’s approach to ventilation, thermal comfort and indoor air quality in schools.

Respondents felt that Section 1 of BB101 gave a good, accessible introduction to the subject and defined the scope of the guidance well.

They felt that definitions should be set out in a glossary with more detail. A particular point raised was the definition of hybrid ventilation should specify that, when the system is operating in mechanical mode, the air is driven mechanically.

Consultation responses	Total	Percent
Yes	20	74%
No	6	22%
Not sure	1	4%

### Government response

Reference to cooling systems was removed at the suggestion of the editorial group. Diagrams were clarified. Reference was added to the ESFA’s Output Specification: Generic Design Brief for ESFA funded projects and its Technical Annexes. Reference was added to the ESFA’s Building Performance Evaluation (BPE) Methodology for schools.

## Question 6

**Section 2: Regulatory Framework provides an overview of all the statutory and regulatory requirements that apply to schools which relate to indoor air quality, thermal comfort and ventilation. Is the summary of regulations adequate and useful? If not please suggest changes/amendments with reasons.**

Section 2 is a summary of the regulatory framework relevant to BB101.

Like the responses to Question 5, respondents felt that definitions should be clarified more consistently.

Respondents said that a summary table or list of regulations and guidance would be very useful and would make the document more accessible.

Respondents also pointed out that references to other documents may go out of date.

Consultation responses	Total	Percent
Yes	19	70%
No	5	19%
Not sure	3	11%

## Government response

DCLG Building Regulations Division have updated the information in Section 1 related to Building Regulations and Public Health England have revised the references to Radon remediation.

The decision was taken to include the most up to date version of a reference rather than to remove all dates of references.

A summary section 3 has been produced.

More comprehensive guidance on compliance with the Gas Safety Installation and Use Regulations has been included at Section 2.9. This is to align BB101 with the revised IGEM UP/11 2018 standard for gas safety in schools and other educational establishments. It includes more comprehensive guidance on gas safety interlocking and types of CO, CO<sub>2</sub> and flammable gas detectors for use in schools.

## Question 7

**Section 2.4 and Sections 3.1 to 3.5 provide standards for indoor air quality in teaching and learning spaces. Do you think that the revised standards for indoor air quality in teaching spaces adequately cover the requirements and are reasonable? If not please suggest changes/amendments with reasons.**

Section 2.4 details specific DfE performance standards for ventilation, thermal comfort and indoor air quality in teaching and learning spaces. These performance standards are in addition to the regulations summarised in Section 2.

Respondents felt that these sections are reasonable.

Respondents felt that the CO<sub>2</sub> levels for mechanical, natural and hybrid ventilation systems should be clarified. They also felt that more detail should be included on pollution guidance.

Consultation responses	Total	Percent
Yes	16	59%
No	7	26%
Not sure	4	15%

## Government response

Regulation on air quality standards is dealt with as Local Planning Authority requirements.

The higher 1500ppm daily average CO<sub>2</sub> level, allowed in teaching spaces that are naturally ventilated, than the 1000ppm allowed for mechanically ventilated spaces, was supplemented by a new clause applying to natural ventilation and hybrid systems acting in natural mode. The new clause at Section 2.4 paragraph 2.b takes into account differences between natural and mechanical ventilation but aims to provide a similar level of indoor air quality by either method of ventilation. The additional requirement in Section 2.4 2.b is that a CO<sub>2</sub> level of less than 1200ppm in new build (and 1750ppm in refurbishment) should be achieved for the majority of the occupied period.

The CO<sub>2</sub> levels remain as they were in the 2006 edition but clarification has been added in an Appendix, which explains why slightly higher maximum levels of CO<sub>2</sub> are acceptable in the case of natural and hybrid ventilation than in the case of mechanical ventilation. Manufacturers of mechanical ventilation systems had complained about this. In addition, a third CO<sub>2</sub> criteria has been added that requires the same average level of



CO2 concentration to be achieved for the majority of the occupied period by all types of ventilation systems.

We have added references to the European Sinphonie project reports for more guidance on pollution.

## Question 8

**Do you agree with the changes to standards for ventilation practices in practical spaces given in Section 2.5? If not, please suggest changes and amendments with reasons.**

As with other questions, respondents felt that the guidance in this section could be improved with clearer guidance.

Consultation responses	Total	Percent
Yes	17	63%
No	2	7%
Not sure	8	30%

## Government response

More detailed guidance has been added on the range of specialist spaces found in schools and also on specialist equipment that requires local exhaust ventilation.

Guidance from the Health and Safety Executive (HSE) and CLEAPSS has been included on pollutants from laser cutters and 3D printers.

## Question 9

**Sections 3.5.3 to 3.5.6 provide guidance on the location of air intakes, chimneys and exhausts. Is the guidance on air intakes, chimneys and exhausts reasonable? If not, please suggest changes/amendments with reasons.**

Respondents commented that this section needed to be reviewed as there were some formatting errors.

It was also pointed out that guidance on air permeability is covered in other documents and may not be directly relevant to BB101.

Consultation responses	Total	Percent
Yes	17	63%
No	3	11.0%
Not sure	7	26%

## Government response

Guidance on air permeability was removed from BB101. This is covered in the Building Regulations Approved Document L.

Guidance has been updated and included in Section 4.4 'Location of ventilation air intakes and exhausts'.

## Question 10

**Sections 3.1 to 3.5 of BB101 provide an overview of all indoor and outdoor air quality guidelines. Do you think the guidance on air quality is adequate and reasonable. If not, please suggest changes/amendments with reasons.**

Respondents said that these sections should be clarified. Others said the sections were too long and complicated. Respondents also felt that the performance standards for air quality especially could be more detailed by giving specific standards to be achieved. They said that the differences in performance standards between new and refurbished buildings should be detailed.

Consultation responses	Total	Percent
Yes	19	70%
No	4	15%
Not sure	4	15%

## Government response

A new Section 6: 'Indoor and outdoor air quality' has been separated from the previous content of Section 3. This included thermal comfort and ventilation guidance.

Some respondents did not realise that performance standards for indoor air quality due to external air pollution are a matter for Local Planning Authority requirements and not a matter for BB101.

## Question 11

**Do you think the criteria given in Section 3.7.1 and Table 3.9 to overcome problems of draughts in teaching spaces are adequate and reasonable? If not please suggest changes/amendments with reasons.**

Some respondents felt that the additional criteria given in these sections made the guidance more complex and onerous. Their concerns related to the way that the guidance was drafted. They believed it would lead to them having to perform costly and complicated thermal modelling.

Respondents suggested that the difference between recirculated and mixed air should be clarified.

They also highlighted formatting issues and inaccurate references.

Consultation responses	Total	Percent
Yes	16	59%
No	5	19%
Not sure	6	22%

## Government response

The format has been improved. Various parts of the of the previous section 3 were split into separate sections including a separate section 7 on Thermal comfort.

Section 7.3 includes the previous section 3.7.1 on local thermal discomfort caused by cold draughts. The criteria for cold draughts was made less onerous to allow the wider use of natural ventilation systems. A spreadsheet tool called the window and damper draught - line plume - calculator will be published on the ESFA pages on GOV.UK at the same time as BB101. This is to test whether window design is acceptable for natural ventilation to prevent cold draughts.

## Question 12

**Changes have been made to the thermal comfort criteria given in ISO 7730 to make them more applicable to schools. Do you think the criteria given are adequate and reasonable? Please comment on Sections 3.6 to 3.10 and the criteria given in Table 3.9 and 3.10.**

Respondents felt that the formatting and captioning of tables would help make the guidance more accessible.

Some respondents said that maximum temperatures should be detailed. They proposed that a fabric-first approach should be taken in designing ventilation. Respondents also suggested that the distinction between operative and air temperature should be made clearer.

It was also pointed out that, in places, the guidance did not align with the technical requirements in ESFA's Output Specification.

Consultation responses	Total	Percent
Yes	17	63%
No	3	11%
Not sure	7	26%

## Government response

Tables on thermal comfort have been simplified as have the design criteria and the section and Tables have been reformatted.

The redraft now aligns relevant parts of BB101 with the ESFA's 2017 Output Specification: Generic Design Brief and its Technical Annexes.

## Question 13

**Do you think the changes in Sections 3.11 and 3.12 to move from a fixed temperature threshold to adaptive thermal comfort criteria to control summertime overheating are adequate and reasonable?**

Consultees welcomed the move away from fixed temperatures in the guidance.

Respondents felt that the use of TM 49 is too London-centric and that TM52 is more stringent in preventing overheating.

Consultees also said that guidance on calculations should be improved by simplifying the calculations.

Respondents said that there should be more detailed guidance on the use of weather files included in BB101. DSY weather files give different types of summer and BB101 should guide the user on how to design for them.

Consultees suggested including specific guidance on weekend, after hours and summer occupancy of schools.

Consultation responses	Total	Percent
Yes	20	74%
No	4	15%
Not sure	3	11%

## Government response

Reference to TM49 has been replaced by reference to the latest CIBSE DSY 2020 (50<sup>th</sup>. percentile) weather files.

The new method to prevent summertime overheating is in line with the established CIBSE Technical Memorandum 52 adaptive thermal comfort method based on BS EN 15251 that has been quoted in the ESFA Output Specification since 2013 as the design method to use. The previous 2006 edition of BB101 used a fixed temperature threshold of 28°C and the Test Reference Year for summertime overheating assessment. This means that designs built to the revised BB101 will perform much better in summertime than those designed to the current BB101 2006 overheating standards.

Use of this adaptive thermal comfort Overheating Risk Assessment (ORA) method has been simplified from the three criteria used in the 2013 ESFA Output Specification. This was as a result of detailed thermal modelling of recent school designs which proved that a single criteria is adequate for compliance and that the DSY 2020 (50<sup>th</sup>. percentile range) is the Design Summer Weather Year that should be used for ORA modelling.

This is one of the latest weather years published by CIBSE. It is not the most onerous of the probabilistic weather years, which depend on the future weather scenario chosen, but is considered to provide adequate future proofing of designs against the effects of climate change.

The ORA occupancy profiles have been made more detailed including details for lunch breaks.

## Question 14

**Section 4 of BB101 provides the core guidance on design of ventilation. Do you think that the design guidance is adequate? If not please suggest changes/amendments with reasons.**

Consultees felt that the guidance in this section could be improved by making figures and tables clearer. Respondents also said that references and hyperlinks were not functioning properly.

Some respondents said that BB101 could be more in line with industry standards, such as with heating selection.

It was suggested that rapid purging is needed for certain times of the day.

Respondents said that non-teaching spaces should be considered in more detail.

Consultation responses	Total	Percent
Yes	13	48%
No	8	29%
Not sure	6	22%

## Government response

We are confident that the majority of the concerns have been adequately addressed in the revision of the consultation draft.

A new section 5 'Ventilation for particular areas and activities' has been included that covers non-teaching spaces as well as specialist teaching spaces. This had previously been deleted to shorten the document.

The diagrams have been redrawn to improve their clarity. Purge ventilation has been introduced with a higher noise level allowed during purge ventilation.

Guidance on heating selection and sizing was revised by reference to the CIBSE guide industry standard.

## Question 15

**Section 5 of BB101 is a guide to design calculations. Do you think that the guidance is adequate? If not please suggest changes/amendments with reasons.**

Some respondents said that calculation models are complicated and will be time consuming.

Consultees said that references often direct the user to external sources that may be unreliable. Respondents felt that this makes the guidance less accessible as further information might be stored in a place that is hard to access.

Respondents suggested including a consolidated list of definitions and diagrams.

Consultation responses	Total	Percent
Yes	13	48%
No	10	37%
Not sure	4	15%

## Government response

Section 8, previously section 5, on design calculations has been revised in the light of comments received and further considerations of the editorial group. We are confident that the majority of the concerns have been adequately addressed in the revision of the consultation draft.

All design calculations have been simplified and more complex calculation methods that are rarely needed have been omitted.

The calculation method for radiant temperature asymmetry from overhead radiant heating has been replaced by simple look-up tables for designers and a spreadsheet calculator for designs not covered by the tables.

A simple calculator has been produced for estimating the discharge coefficient and effective area of windows and natural ventilation openings.

## Question 16

**Do you think that the annexes and references are useful and adequate? If not, please suggest changes/amendments with reasons.**

Some respondents said that references should be hyperlinks. Others said that hyperlinks would be unreliable. Consultees said that the annexes should make more reference to pollutants and other guidance where the user could get further information. Additionally, people pointed out that some references needed checking.

Some respondents pointed out that the annexes made reference to data recently updated.

On the whole, consultees felt that the annexes should be reformatted to make them more accessible.

Consultation responses	Total	Percent
Yes	18	67%
No	5	19%
Not sure	4	15%

## Government response

References were checked and updated where necessary. Hyperlinks were formatted under Microsoft accessibility good practice and a new Annex D on calculating effective areas of openings was added.

## Question 17

**Is the guidance on BB101 as short and concise as possible whilst being fit for purpose?**

Consultees said that the guidance was too long and too discursive. Some respondents pointed out that the consultation draft is longer than the original BB101.

Some respondents suggested simplifying the document by making sections requiring compliance more prominent. An alternative suggestion was to include a summary table in the executive summary. This would show guidance, regulations and DfE performance standards. Another option was moving some sections of the guidance to the appendices to make it more concise allowing the user to refer to appendices for extra information when necessary.



Some respondents said there were too many references for non-specialist readers. Others said that the document should avoid quoting data but should include more references to avoid providing out-of-date information.

Consultation responses	Total	Percent
Yes	12	44%
No	7	26%
Not sure	8	30%

## Government response

We have shortened sections where possible. However, there are a number of reasons why the proposed BB101 at 150 pages is considerably longer than the current version.

There is considerably more information on thermal comfort in BB101 as the BB101 2006 was deficient in this area and this has caused comfort problems in existing schools eg, due to cold draughts and summertime overheating.

The restructuring suggested by the editorial group added a new summary section. The summary is included to act as a quick reference guide that shows which sections of BB101 are: regulatory; contractual requirements for ESFA funded projects; and further information and guidance. This was added to help designers navigate the document more easily.

The response to Question 14 led to a new section 5 'Ventilation for particular areas and activities' being included that covers non-teaching spaces as well as specialist teaching spaces. Sections on particular areas and activities had previously been deleted from the public consultation draft to shorten the document. However both the consultation response and the editorial group thought this was a mistake and these sections were reinstated.

The omission of complex calculation methods and replacement with simpler look-up tables also resulted in an increase in page length.

There is considerably more information on the negative health effects of indoor air pollutants than in the current BB101. This has been added on the advice on Public Health England and is due to government funded research since 2006 into the health effects of indoor air pollutants in schools.

## Question 18

### Should any supporting tools be provided by DfE on the website?

Respondents were not all in agreement over including more tools. Some consultees said that including tools for thermal modelling would be inappropriate as this modelling is lengthy and expensive and there are already many tools available. Some felt that more tools would confuse the situation.

Other respondents said that simple, standard tools should be provided to help non-specialists as technical details may be too complex for non-specialists. One area where respondents said a further tool would be useful was in predicting CO<sub>2</sub> levels.

Some respondents said that design tools were helpful, but that the current ClassVent and ClassCool tools are more useful in the very early design stages and may not be suitable for a revised guidance. A further area where consultees suggested a need for more tools was on modelling the location and orientation of their buildings.

Consultation responses	Total	Percent
Yes	10	37%
No	5	19%
Not sure	12	44%

### Government response

Five simple spreadsheet design tools have been developed to support calculations to comply with BB101. These include:

- an ICT equipment heat load estimation tool for classrooms and other teaching spaces
- a window and damper draught - line plume - calculator for prediction of cold draughts from natural ventilation openings such as windows
- a CO<sub>2</sub> calculator for teaching spaces
- a discharge coefficient calculator for estimating the effective area of windows and other natural ventilation openings
- and a radiant temperature asymmetry calculator for sizing overhead radiant panels in teaching spaces including halls.

## Question 19

### Do you have any other comments on the proposed revision of BB101?

Eighteen further comments were provided under this question.

Consultees felt that BB101 could be shorter. Some felt that extra detail provided, for example on thermal modelling, makes the guidance more complicated.

Some consultees said that more clarity throughout the document on guidance and regulation would improve the document. It was suggested that this could be achieved by including a comprehensive summary table for guidance and regulations.

Further clarity was requested around guidance and regulation for refurbished buildings in particular.

Clarity was requested on the differences in CO<sub>2</sub> guidelines between natural and mechanical ventilation.

Respondents pointed out that a number of hyperlinks did not function properly.

They appreciated that BB101 had been aligned with the ESFA's Output Specification.

### Government response

The guidance on thermal comfort has been simplified to a great extent.

A summary has been provided, see response to question 17.

Greater clarity is now provided on differences between new build and refurbishment.

CO<sub>2</sub> guidelines have been supplemented by a new clause applying to natural ventilation and hybrid systems acting in natural mode at Section 2.4 paragraph 2.b to take into account differences between natural and mechanical ventilation with the aim of providing a similar level of indoor air quality by either method of ventilation. See response to question 7.

Hyperlinks have been checked and formatted according to Microsoft accessibility good practice.

BB101 is fully aligned with the ESFA's Output Specification: Generic Design Brief and it's Technical Annexes to be published in April/May 2017.

## **Next steps**

The consultation phase on BB101 has now closed and the comments and suggestions set out in this report have been taken into full consideration in revising the draft guidance for publication.

The revised guidance will be published in August 2018.

## **Annex A: List of organisations that responded to the consultation**

- Anderson Green Ltd
- Archineers
- Aspire Academy Trust
- Bowmer and Kirkland Construction
- Breathing Buildings
- British Blind and Shutter Association (BBSA)
- Building and Engineering Services association
- Chapel St Community Schools Trust
- CLEAPSS
- Cundall
- Diocese of Arundel and Brighton
- Educational Consultancy
- Envirotec
- Genano UK Ltd
- KIER Construction
- Mace
- Monodraught
- MPA - The Concrete Centre
- Public Health England
- Richard Wilkins Consultancy Ltd
- Saint-Gobain
- SAV-Systems, UK
- SE Controls
- Sustainability By Design Ltd
- Van Zyl & de Villiers Ltd



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