Education & Skills Funding Agency

Output Specification

Technical Annex 2H: Energy

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For technical professionals involved in the design and construction of school premises

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1 Introduction

1.1.1.1 This document is one of a number of Technical Annexes which form part of the Generic Design Brief (GDB). It sets out the required technical standards and performance criteria for energy in schools and should be read in conjunction with section 2.12 of the Generic Design Brief (GDB), as well as the School-specific Brief (SSB), including the School-specific Schedule of Accommodation (SoA), Area Data Sheets (ADSs) and, where relevant, the Refurbishment Scope of Works (RSoW). The definitions in paragraph 1.3 of the GDB apply to this Technical Annex and all other parts of the OS.

1.1.1.2 The information exchange required at each stage of the procurement process is detailed in the Employer's Requirements Deliverables.

1.1.1.3 The requirements in this Technical Annex, to be provided by the Contractor, are in respect of Buildings, FF&E and ICT Infrastructure and shall apply to all parts of the Works in any New Buildings, as well as to any Building Elements or Building Services provided in Refurbished Building(s) which are designated Renewed or Replaced in the RSoW.

1.1.1.4 Where the requirements refers to an area, space or Suite of Spaces, this shall apply to all spaces in any New Building(s) or Remodelled Area. Any area or space within New Buildings or Remodelled Area shall conform to all relevant requirements in this Technical Annex.

1.1.1.5 This document has been developed for New and Refurbished Buildings to:

a. support the delivery of the requirements stated in the GDB

b. ensure energy efficient schools

c. set targets for regulated and unregulated energy use in schools

d. detail energy modelling requirements

e. provide detail for the Contractor to produce energy strategy reports

f. ensure that school energy use is managed by a responsible party with varying levels of information readily available, accessible (electronically and on-line); and presented in a manner that is understood by the School

g. allow New and Refurbished Buildings' operational annual energy uses to be benchmarked

1.2 Energy Strategy

1.2.1.1 The Contractor shall produce an Energy Strategy Report to demonstrate that thorough consideration has been given to the energy use of the Building and that

it is expected to meet the Employer's energy targets. The detailed requirements are set out in the Employer's Requirements Deliverables.

1.2.1.2 As a minimum, the Energy Strategy Report shall include the following sections.

a. Introduction to the Project.

b. Assessment of local planning requirements, Part L requirements and Employer's Requirements.

c. Approach to optimising energy use (see Section 2):

   i. Be Lean

   ii. Be Clean

   iii. Be Green

d. Concept model output data tables (see Section 4.2) or analysis of energy consumption of Existing Building(s) (see Section 6).

e. Comparison of energy targets with predicted end use energy figures (see Section 3).

f. Monitoring and targeting strategy (see Section 5).

1.3 New and Refurbished Buildings

1.3.1.1 This document gives guidance on the energy efficient design and regulation of the energy benchmarking, modelling requirements and monitoring of New and Refurbished School Buildings.

1.3.1.2 Sections 2, 3, 4 and 5 apply to the design of New Buildings. Sections 2, 3, 4.3, 5 and 6 apply to Refurbished Buildings.

1.3.1.3 For the purposes of energy analysis AD L in support of the Building Regulations uses the following definitions of new build and refurbishment.

a. **New build** - the construction of a new building; a new free-standing building on an existing site; work to a building with a total floor area greater than 1000m^2; where the work includes the construction of extensions to existing buildings with an extension floor area greater than 100m^2 and greater than 25% of the total floor area of the existing building.

b. **Refurbishment** - construction work comprising changes to external fabric thermal performance; opening up areas in the building envelope; or changes to fixed building services.

1.3.1.4 These definitions shall be applied in the context of AD L however, the definitions of Refurbishment, New Building and retained buildings given in the Generic Design Brief also apply.

1.3.1.5 Section 6 describes the different approach required for Refurbished Buildings to that required for New Buildings. In the case of Refurbished Buildings, the Contractor is not required to develop an Initial Concept Energy Model but to use the results of energy auditing and historic energy data for the Buildings. The Contractor is required to model the Refurbished Building(s) and to compare the predicted energy performance with the actual energy performance of the Existing Building(s).

2 Optimising School Energy Use

2.1.1.1 Schools must be designed to meet the relevant regulated and unregulated carbon dioxide standards, in line with the Employer's Requirements Deliverables, local planning conditions and national regulations. School design must ensure resilient energy infrastructure and a reliable energy supply which, where feasible, incorporates low and zero carbon technologies.

2.1.1.2 To reduce the energy consumption and operational cost of the development, the schools should be designed in line with the energy efficiency hierarchy:

i. Be Lean – use less energy

ii. Be Clean – efficient energy supply

iii. Be Green – renewable energy

2.2 Be Lean

2.2.1 Passive design considerations

2.2.1.1 The following are some of the least complex and most cost-effective measures which should be incorporated to help reach carbon dioxide targets. Contractors should consider and include the following measures.

a. Optimise daylight – including through dual aspect, optimal cill heights and window sizes, higher floor to ceiling heights, shallow floorplates, the use of lightwells and rooflights.

b. Control solar gain, benefitting from the heat when required but not at the expense of overheating in the summer. Optimise the size and depth of windows on each elevation to control and enhance the effect of solar gain.

c. Optimise the use of shading – limit overshadowing of windows to areas that require daylight or could benefit from solar gain or of the roof if solar renewable technologies are planned. Use shading devices and low g-value glazing to limit solar gains to areas which may be susceptible to overheating.

d. Optimise the thermal envelope – an efficient thermal envelope is key to reducing the energy performance of the Building.

e. Insulate the Building, this is one of the most cost effective ways to make a building more energy efficient, reducing the impact of external temperatures on the internal environment.

f. Eliminate thermal bridging to prevent the loss of heat and to prevent the development of cold spots which can lead to condensation and mould.

g. Maximise air tightness to minimise the impacts of uncontrolled infiltration and control the air entering and leaving the Building.

h. Optimise the use of thermal mass – which can help retain heat and reduce internal temperature fluctuations. Use light coloured materials where possible to reduce the absorption of heat therefore reducing the likelihood of overheating.

i. Maximise the potential for natural ventilation – including through openable windows, shallow floorplates, dual aspect units, designing in the 'stack effect' system where pressure differences are used to draw air through a building and double façade where the inner façade has openings to release heat without occupants being exposed to external wind and noise.

j. Maximise the efficiency of heating infrastructure by increasing pipe and storage insulation and minimising the length of pipe runs. Size pipes appropriately to reduce pressure losses and select efficient pumps and motors capable of variable flow solutions.

2.2.2 Active system considerations

2.2.2.1 Once the passive design of the Building has been maximised, the required mechanical systems must be optimised. Contractors should consider and where practical include the following measures.

a. Include low emission and carbon dioxide efficient heating systems – such as ultra-low NOx and/or condensing gas boilers for small schools and community heating systems for larger school developments.

b. Include heat recovery – collecting waste heat to pre-heat air or water increasing the efficiency of heating or hot water systems.

c. Maximise the use of passive cooling techniques and if mechanical cooling is required, use efficient systems.

d. Select efficient ventilation systems with low total system pressure losses, high efficiency fans and motors and high ventilation efficiency within occupied zones.

e. Maximise energy efficient lighting systems.

f. Incorporate other energy efficient and energy saving equipment such as heating controls, individual controls, zoning, movement sensors, photo sensors, timers, metering, building management and monitoring systems.

2.2.2.2 Careful consideration needs to be given to what areas of the Building are likely to need light, need to be warm or cool and the activities that will generate their own heat such as the use of IT equipment.

2.2.2.3 Further details on measures to prevent overheating are provided in Building Bulletin 101: ‘Guidelines on ventilation, thermal comfort and indoor air quality in schools’ (BB101). Active measures should be designed to meet the needs of the School so that plant can run efficiently. Oversized plant can lead to the inefficient use or unnecessary use of the equipment. Contractors should be satisfied that the proposed design and energy strategy is satisfactory for the intended use and should secure the appropriate design and technological measures as part of the energy strategy.

2.3 Be Clean

2.3.1.1 Once the energy demand has been reduced, the supply of energy must be addressed. The Contractor shall assess the potential for the Works to:

a. connect to an existing district heating network

b. expand an existing district heating network and connect to it

c. establish a site wide network and enable the connection of existing Buildings near the development

2.3.1.2 Where opportunities arise, developments generating energy or waste heat should maximise long term carbon dioxide savings by feeding the decentralised energy network with low or zero carbon hot water.

2.3.1.3 The Be Clean energy strategy is likely to be relevant to larger schemes with a substantial heat load comprising two or more Buildings. However, it should be considered for all schemes. When determining whether it is feasible to connect to an existing district heating network, the Contractor shall consider the following measures, as appropriate.

a. The size of the development, and the heat load and energy demands throughout the year.

b. The distance of the development to the nearest district heating network or proposed networks.

c. The presence of physical barriers such as major roads or railway lines in making a connection to the network.

d. The cost of connection and the impact this has on financial viability of the heat supply.

2.3.1.4 When determining whether it is feasible to install an energy centre and establish a heating network, the Contractor shall consider the following measures, as appropriate.

a. The size and density of the scheme, and the heat load and energy demands throughout the year.

b. The heat load and energy demands throughout the year and density of surrounding built environment.

c. The proximity of and potential supply to any public sector estates and buildings with communal heating systems.

d. The ability to secure agreements for the connection of nearby buildings or estates.

2.3.1.5 Information about existing and planned heat networks across the UK can be found through the Department for Business, Energy & Industrial Strategy website. See https://www.gov.uk/guidance/heat-networks-delivery-support.

2.3.1.6 The Contractor should investigate the feasibility of district heating and include relevant calculations and analysis in the Energy Strategy Report. The requirement for the Energy Strategy Report is set out in the Employer's Requirements Deliverables.

2.4 Be Green

2.4.1.1 Low and zero carbon technologies may be required to comply with AD L and local planning requirements to reduce carbon emissions.

2.4.1.2 The Contractor shall ensure that the low zero carbon technology incorporated into a scheme complements the primary heating equipment.

2.5 BREEAM

2.5.1.1 BREEAM is not an Employer's Requirement Deliverable. However, it may be a local planning or local Building Control requirement and, if so, the Contractor should include for this where necessary.

3 Energy Benchmarks

3.1 Design Benchmarks

3.1.1.1 During the design stage, the Contractor is required to predict the total energy consumption of the School Buildings that comprise the Works. The Contractor shall upload the estimated energy consumption to the Carbon Buzz website, http://www.carbonbuzz.org. The Contractor can choose to anonymise the data on Carbon Buzz as they wish, however, the Employer should be informed of the details.

3.1.1.2 The energy targets in this Annex have been determined through an analysis of the existing school building stock. As part of the analysis, a benchmarking exercise was carried out to determine the energy targets. The results of the benchmarking analysis are, as in Section 3.1.2, shown for information and reference only. The energy targets apply to either Whole School or Partial School Projects.

3.1.1.3 New or Refurbished Buildings shall be designed to limit energy end uses in line with the energy targets. The Contractor must prove that the design can meet the energy targets through energy modelling detailed in Section 4, and as detailed in the Employer's Requirements Deliverables.

3.1.2 Benchmarking Analysis

3.1.2.1 To determine appropriate energy targets for the Contractor to use, major energy end uses for typical recently built schools have been analysed by EFA. Benchmarking figures are dependent on the type of system used in the school, however a typical range has been determined through the analysis of the existing English school building stock. The benchmarking exercise included:

a. energy modelling of a baseline design

b. operational data from Primary, Secondary and Special Schools

c. analysis of Display Energy Certificates (DECs)

d. analysis of the performance of a selection of recently built schools

Table 1 Energy Benchmarks

System	Range[a]	Notes
External lighting	Up to 12 kWh/m^2/year	Depending on the extent of external sports and security lighting
Internal lighting	Up to 13 kWh/m^2/year	Including emergency lighting

System	Range[a]	Notes
Space heating	45 – 55 kWh/m^2/year	
Domestic hot water	3 – 10 kWh/m^2/year	
Fans and pumps	6 – 15 kWh/m^2/year	
Server rooms	4 – 8 kWh/m^2/year	
IT	8 – 10 kWh/m^2/year	Depends on pupil to PC/laptop ratio and charging method
Catering	6 - 12 kWh/m^2/year	Including hot water energy use
Miscellaneous & small power	5 – 10 kWh/m^2/year	

[a]The range is based on the energy end use for the school per square metre of gross internal floor area excluding any unheated areas. All figures are normalised across total floor area.

3.2 Energy Targets

3.2.1.1 For all New Buildings, whether a Partial or Whole School Project, the Contractor shall undertake an energy assessment to show compliance with the energy targets following the modelling requirements detailed in Section 4, and as detailed in the Employer's Requirements Deliverables. Refurbishment Projects follow the procedure in Section 6.

3.2.1.2 Energy targets are expressed as electricity equivalent kWh_e. A kWh_e is calculated by multiplying the different fuel kWh consumptions by the relevant energy weighting factor.

Table 2 Energy Weighting Factors

Category	Description	Energy Weighting Factor*
Electricity	includes mains electricity, electricity from combined heat and power and renewable energy	1.0
All fuels	includes, gas, oil, and biofuels	0.4
All thermal energy	includes geothermal, district heat and heat from combined heat and power and solar thermal	0.5

* The energy targets are quoted based on the Operational Hours detailed in Section 0.

Table 3 Annual Design Energy Targets - Primary

Type	Heating	Hot Water	Small Power	Lighting	Fans and Pumps	Cooling	Lifts	Total
Electrical equivalent (kWh/m²)	21	4	10	13	7	1	1	**57**
Allow 4 kWh/m² for building related services							**Total**	**61**

Table 4 Annual Design Energy Targets - Secondary

Type	Heating	Hot Water	Small Power	Lighting	Fans and Pumps	Cooling	Lifts	Total
Electrical equivalent (kWh/m²)	20	4	25	13	7	1	1	**71**
Allow 4 kWh/m² for building related services							**Total**	**75**

3.2.2 Carbon Targets

3.2.2.1 Where carbon emissions are calculated for Building Regulations compliance and to meet planning conditions, the Contractor shall follow the National Calculation Method (NCM) carbon emission factors found in the 'National calculation methodology modelling guide (for buildings other than dwellings in England and Wales)'.

3.3 Actual In Use Performance

3.3.1.1 Once the Building has been handed over and is in use, methods for metering, monitoring and data collection shall be in place. The systems shall be proved as part of commissioning in accordance with Annex 2F: 'Mechanical services and public health engineering' and the Employer's Requirements Deliverables. This allows the predicted design energy use to be compared with the actual energy consumption of the Building and building system performance to be continually monitored by the School and the Employer. The Contractor shall provide the School with the means to practice continual monitoring and benchmarking of energy and water consumption, and provide guidance on how to do this by means of the Building User Guide, handover training and input with monitoring during the 12 months defects period.

3.3.1.2 At the end of the 12 month defects period, the Contractor shall upload the energy end use data to the Carbon Buzz website, http://www.carbonbuzz.org. The Contractor can choose to anonymise the data on Carbon Buzz as they wish, however, the Employer should be informed of the details.

3.3.1.3 As in Section 5, the Contractor shall use the iSERV methodology for energy reporting and building system optimisation and to compare the actual energy consumption to iSERV benchmarks. This shall be carried out through the K2n database company (See Section 5 for further information on iSERV) or similar approved supplier. The benchmarks have been generated at the component,

space or activity level by K2n/iSERV from monitoring buildings and HVAC systems. See Section 5 for further details of the data monitoring required.

3.3.1.4 The aims of Carbon Buzz and iSERV are to encourage the construction industry to provide energy data by end use so that:

a. an understanding of the performance gap between predicted and actual energy consumptions can be a) analysed and b) addressed

b. data can be gathered to illustrate the trends in energy efficiency and thereby create new benchmarks that are a) realistic and b) help deliver energy efficient buildings including schools

4 Energy Baseline Models

4.1 The Modelling Process

4.1.1.1 The development of thermal models for building design is required as an integral part of the design process for both New and Refurbished Buildings and the results of the modelling shall be included in the Environmental Strategy Report as part of the Employer's Requirements Deliverables and Building Regulations submissions. Modelling can provide a detailed understanding of the energy consumption of a building for a set of defined input criteria. Thermal models should be subject to rigorous quality control procedures to reduce design errors.

4.1.1.2 During the early stages of design, information from thermal modelling should inform an iterative process to evaluate the feasibility of design concepts. At later stages, models should be used in the testing, fine-tuning and implementation of design features.

4.1.1.3 Throughout the design process, thermal models should be used to demonstrate compliance with relevant carbon emissions and energy performance requirements. In order to evaluate if the design will operate within the specified energy targets (see Section 3), the Contractor is required to develop a Concept Energy Model. The detailed requirement is set out in the Employer's Requirements Deliverables.

4.1.1.4 Once it has been demonstrated that the design meets or betters the theoretical energy performance required, the Contractor shall create a Developed Energy Model. This requirement is set out in the Employer's Requirements Deliverables.

4.1.2 Calculation Methodology

4.1.2.1 The Contractor shall use Dynamic Simulation Models (DSM) for the Concept Energy Model and the Developed Energy Model which are produced using software which is in compliance with CIBSE TM33 and be NCM approved.

4.1.2.2 The Contractor shall ensure both models use the nearest CIBSE Test Reference Year (TRY) Weather file.

4.2 Concept Energy Model

4.2.1.1 The Concept Energy Model is used to evaluate the feasibility of new building designs concerning energy. The Contractor shall produce the model following the information in this Annex and compare the predicted final energy end use figures to the energy targets outlined in Section 3. In the case of Refurbished Buildings, an analysis of the energy performance of the Existing Building based on an energy audit takes the place of the Concept Energy Model. See Section 6.

4.2.1.2 The inputs to the Concept Energy Model should comprise two types of design parameters:

a. ‘fixed’ parameters that take a prescribed value in the model

b. ‘flexible’ parameters that are based on the Contractor’s design specification, to permit a comparison between the energy and carbon performance of alternative design proposals. ‘Flexible’ parameters may also include a limitation to the range of input values that are permissible in the form of maximum or minimum values

4.2.1.3 The ‘flexible’ parameters are generally design elements that would be considered as a carbon saving measure under the ‘Be Lean’ stage of the energy hierarchy. This approach is consistent with the objective of giving priority to energy efficiency at the concept design stage before considering low carbon heat or renewable technologies.

4.2.2 Fixed and Flexible Design Criteria

Fixed:

a. School operational schedule (including opening hours and plant operating profile)

b. Room occupancy and internal gains

c. Weather data

d. Ventilation supply/extract rates and supply temperature

e. HVAC system efficiencies

f. Electrical lighting efficiency

g. Hot water demand

Flexible:

a. Building geometry (form and orientation)

b. Shading elements

c. Glazing ratio

d. Thermal mass of building fabric

e. HVAC system options

f. HVAC system fuel

g. Thermal transmittance (U-value) of building fabric (with Limiting Values)

h. Building air permeability (with Limiting Values)

i. Glazing g-value (with Limiting Values)

4.2.3 Design Parameters

4.2.3.1 The following criteria should be assumed ‘fixed’ unless stated otherwise.

Operational Hours

4.2.3.2 The operational hours are based on an NCM typical school year and provide the details of HVAC operational hours throughout the year. During times of the day/year when the School is closed, systems will be set to the setback temperatures detailed in Table 9.

Table 5 Working Week

Timetable	Detail
Opening timetable	07:00 – 17:00
Dining timetable	12:00 – 14:00
Working week*	Monday – Friday
*During dates specified in Table 6 School Calendar	

Table 6 School Calendar

From (inclusive)	To (inclusive)	Status
January 01	January 08	Closed
January 09	February 12	Open
February 13	February 19	Closed
February 20	March 19	Open
March 20	April 02	Closed
April 03	May 28	Open
May 29	June 04	Closed
June 05	July 23	Open
July 24	September 03	Closed
September 04	October 22	Open
October 23	October 29	Closed
October 30	December 21	Open
December 22	December 31	Closed

Construction Data

4.2.3.3 All values in Table 7 are flexible, limiting values. The Contractor shall be expected to design to this value or better.

Table 7 Construction Data

Construction	Value
External roof U –Value	0.25 W/(m^2.K)
External wall U-Value	0.35 W/(m^2.K)
Ground floor U-Value	0.25 W/(m^2.K)
Windows* U-value	2.2 W/(m^2.K)
North G-value	55%
East, west & south G-Value	55%
Air-permeability	10m^3/(h.m^2) @ 50Pa
* Inclusive of all glazed areas	

System Options

4.2.3.4 System types should be entered on a room by room basis based on the requirements of the individual space.

Table 8 System Option Types

Main System	Ventilation System	Cooling SSEER*	Heating SCoP**	Auxiliary Energy		Notes
				Per Floor Area (W/m^2)	Per Volume Flowrate (W/l/s)	
Heated and naturally ventilated	N/A	N/A	0.55	1.23	N/A	Auxiliary energy, calculated for operational hours.
Heated and mechanically ventilated	Centralised balanced mechanical ventilation	N/A	0.55	N/A	3.0	Auxiliary energy, calculated for operational hours.
	Zonal supply system				1.8	
	Zonal extract system				1.1	
	Local extract				0.75	
Fully air conditioned	Centralised balanced mechanical ventilation	1.17	0.55	14.0	3.0	Auxiliary energy, calculated for operational hours and using the greater of either floor area or flowrate.
	Zonal supply system				1.8	
	Zonal extract system				1.1	
	Local extract				0.75	
Changeover mixed mode	Natural ventilation	1.9	0.55	1.23	N/A	

Main System	Ventilation System	Cooling SSEER*	Heating SCoP**	Auxiliary Energy		Notes
				Per Floor Area (W/m^2)	Per Volume Flowrate (W/l/s)	
	Centralised Balanced mechanical ventilation			N/A	3.0	Auxiliary energy, calculated for operational hours.
	Zonal Supply system				1.8	
	Zonal extract system				1.1	
	Local extract				0.75	
*System Seasonal Energy Efficiency Ratio (SSEER) ** Seasonal Coefficient of Performance (SCoP)						

Room Data

4.2.3.5 The Contractor shall assign all the rooms from the list in Table 9 below.

Table 9 Room Data

Parameter		Teaching Spaces					Shared Areas		
		Typical Class Room	**Science Laboratories and Prep**	**Food Technology Rooms**	**Art and Design & Technology Rooms**	**ICT Rich Teaching Spaces**	**Atria**	**Circulation Spaces**	**Dining and Assembly Halls**
Winter design temperature (°C)		19	19	19	19	19	19	19	19
Setback design temperature (°C)		5	5	5	5	5	5	5	5
Summertime design temperature* (°C)		25	25	25	25	25	25	25	25
Ventilation rate**		8 l/s/person	4 l/s/m^2	2.5 l/s/m^2	8 l/s/person	8 l/s/person	1.2 l/s/m^2	1.2 l/s/m^2	2.25 l/s/m^2
Mechanical extract		-	Yes	Yes	Yes, depending on room use		-	-	Yes
Occupancy density		As School-specific SoA and School-specific ADS					N/A	N/A	As SoA and ADS
Sensible heat gains	**Lighting (W/m^2)**	10	10	10	10	10	10	10	10
	People (W/person)	70	70	70	70	70	N/A	N/A	70
	ICT equipment (W/m^2)	10	10	5	15 or higher depending on room use	19	N/A	N/A	N/A
	Other equipment To be added according to room use	-	Fume cupboards	Cookers	Machinery	-	-	-	Servery equipment

Parameter		Sports			Food Preparation	Auxiliary			
		Swimming Pool Halls	**Changing Areas**	**Sports Hall**	**Commercial Kitchen**	**Admin Offices**	**Store and Plant Rooms**	**WC's and Sanitary Accommodation**	**ICT Server Rooms**
Winter design temperature (°C)		20	20	13	16	19	12	19	19[3]
Setback design temperature (°C)		15	5	5	5	5	5	5	10
Summertime design temperature(°C)[1]		25	25	25	26	25	N/A	15	22[3]
Ventilation rate[2]		4.5 l/s/m^2	4.5 l/s/m^2	12 l/s/person	30l/s/m^2	12 l/s/person	0.3 l/s/m2	6l/s per WC/urinal	8 l/s/person[3]
Mechanical extract		YES	YES	-	YES	-	-	YES	-
Occupancy density		N/A	N/A	10m^2/per person	10m^2/per person	3 people	N/A	N/A	3 people
Sensible heat gains	**Lighting (W/m^2)**	10	10	10	10	10	10	10	10
	People (W/person)	N/A	N/A	90	70	70	N/A	N/A	N/A
	ICT Equipment (W/m^2)	N/A	N/A	N/A	N/A	10	N/A	N/A	250
	Other equipment To be added according to room use	N/A	N/A	N/A	20	Photocopiers, etc.	N/A	N/A	N/A

1. Summertime design temperatures given shall only be applicable if the room is being cooled. The requirement for cooling will be established with regards to thermal comfort, in line with Section 9 of Annex 2F: Mechanical services and public health engineering.

2. All ventilation rates given in (l/s)/m^2 are based on a standard room height of 2.7m, if this room height is not representative of the room being modelled. The ventilation rate shall be re-calculated using the actual room height.

3. See Technical Annex 2F: 'Mechanical services and public health engineering' for details of vent rate and temperatures required for server rooms. Out of hours the temperature setback is 15^{o}C in winter and the maximum summertime temperatures are as described in Technical Annex 2F: 'Mechanical services and public health engineering', section on Server Rooms.

4.2.4 Hot water requirement

4.2.4.1 The daily hot water consumption shall be a fixed term for the total Building capacity:

a. Primary School: 2.3 litres per person

b. Secondary School with shower use: 4 litres per person benchmark comparison

4.2.4.2 The Contractor shall compare the Concept Energy Model calculated end use energy consumption (in kWh) to the energy targets detailed in Section 3. The Contractor shall ensure that the calculated energy consumption of the School is equal or better than the energy targets. The comparison should be included in the Energy Strategy report, as defined in Employer's Requirements Deliverables.

4.3 Developed Energy Model

4.3.1.1 The Developed Energy Model for the Works shall be a realistic representation of the final design of the Project. The Contractor shall ensure that the model accurately calculates the predicted regulated and unregulated energy loads of the School. The Contractor shall produce the model and analyse the results to be included in the updated Energy Strategy report.

4.3.1.2 The model shall reflect the School-specific circumstances rather than the 'fixed' and 'flexible' input data required for the Concept Energy Model. The anticipated annual energy end use figures shall be compared to the energy targets as detailed in Section 3.

4.3.1.3 The Contractor shall ensure that the model is consistent and representative of the energy consumption estimates for all regulated and unregulated loads.

4.3.1.4 The model shall be designed to accurately predict the Building performance. The model should reflect the final design specifications including updated values such as:

a. predicted School use patterns

b. the final construction data

c. detailed HVAC system performance specifications

d. expected occupancy densities

e. expected DHW and other unregulated energy consumptions

f. expected controls strategy

5 In Use Monitoring

5.1.1.1 A well designed and commissioned and fully functioning metering and monitoring system as described in this Section is an Employer's Requirement Deliverable, and fundamental to the monitoring and targeting process that is, in turn, an essential part of energy management. The Contractor is required to establish feedback mechanisms which enable monitoring of the energy status and operation of the School. These mechanisms should be used to inform building managers whether the energy consumption is greater than expected.

5.1.1.2 Metering and monitoring are used to obtain robust, error free insights into the operation and energy consumption of a system. Metering, monitoring and reporting in a clear readily understandable format is a requirement to improve operational energy, water efficiency and building performance.

5.1.1.3 Metering enables the Building operator to measure and verify the energy and water consumption of the Building and identify areas where irregular energy consumption occurs. The information collated from the energy meters should allow continuous monitoring, benchmarking and post occupancy Building Performance Evaluation against operational targets.

5.1.1.4 The metering and monitoring strategy should reflect the size, complexity and facilities management approach of the School. The more complex the services solution, the more sub-metering will be required. End use data should always be able to be presented as simply as possible to aid understanding.

5.1.1.5 The Contractor shall ensure that the systems are metered according to the requirements detailed in the GDB and Annex 2I: Controls.

5.1.1.6 The Contractor shall update their Carbon Buzz account to show the first year's annual operational energy consumption data. The public domain website enables users to compare design CO_2 emission benchmarks to operational figures and highlight reasons for any differences, targeting potential areas for improvement.

5.2 Continuous Monitoring

5.2.1.1 Continuous monitoring of the energy end uses shall be used to compare consumption to benchmark end use loads. The data will allow the School's facility managers to identify and remedy problems such as inadequate system control or incorrect default settings.

5.2.1.2 Contractors shall use the iSERV methodology to automatically monitor and report on the energy and water use of the School, or Buildings in the case of a project involving part of the school. This requirement applies for any building of over 500m^2. The reporting of consumption and performance in use of the Buildings

shall be carried out using the K2n system or similar system approved by the Employer.

5.2.1.3 iSERV enables continuous improvement in schools energy and water performance based on potential savings identified by the collection and analysis of real time energy and water end use data. It monitors plant performance related to different activity areas and compares performance to existing benchmark data. It can be used to identify Energy Conservation Opportunities (ECOs).

5.2.1.4 The Contractor shall complete the K2n services description spreadsheet, ensuring all component, system, sensor and meter names relate to physical items or spaces where possible. The Contractor will be required to provide the initial 15 month subscription and setup this service for the School or Buildings and help the School to use the system to benchmark the performance of the School or Buildings during the 12 months post handover. The Contractor will use the system to prove that all connected meters are calibrated correctly and will remedy any faults in the metering system during the defects period. Further information can be found at www.k2nenergy.com.

5.3 Requirement

5.3.1.1 Contractors shall supply 15 minute interval continuous monitoring and benchmarking data to the K2n national benchmarking database (or similar system approved by the Employer) on at least a monthly basis, and preferably on a daily basis, to enable automated reporting against EFA targets on a monthly basis and quarterly feedback from the Contractor to the School during the 12 months defect period.

5.3.1.2 EFA and K2n have set up and developed the benchmarking database, based on the iSERV methodology, to establish realistic benchmarks and feedback in use for school buildings and have developed reporting formats for monthly reports to schools and Contractors. These reports will help schools to manage their energy consumption and identify avoidable waste.

5.4 Monthly reports of achieved performance

5.4.1.1 The K2n reports should be used to provide the feedback interface for the School users by means of the monthly reporting templates. Providing these monthly reports to the Schools will enable them to provide appropriate control over those energy consumers which they influence, helping the overall School energy targets to be achieved. Alternatively, with the Employers' approval, Contractors can choose to use other energy management reporting software to produce similar feedback reports for the School.

5.4.1.2 After the first full year's report, subsequent monthly reports should be set to report progress against a designated end of year month. This enables progress against contractual targets to be assessed as part of BPE, See Section 2.15 of GDB, and early corrective action to be taken if needed.

5.5 Data required

5.5.1.1 To participate in the wider community of Building Owners/Operators/energy Managers providing data to K2n and the EFA, which enables up-to-date national benchmarks to be produced and maintained for EFA funded schools and their systems, the EFA requires the Contractor to comply with the K2n data reporting standards. To enable this to happen, the data from schools must be submitted in the K2n format or an alternative format approved by the Employer.

5.5.1.2 This requires the Contractor to fully describe each School with the data requested in the fields marked in red in the K2n asset spreadsheet. The Contractor shall request the latest EFA spreadsheet from K2n. The latest version can be obtained on request from info@k2nenergy.com. A completed spreadsheet for an example school will also be provided.

5.5.1.3 The operational data required for the meters and sensors described in the asset spreadsheet can be exported via a BEMS system, or directly from meters and sensors with the appropriate data collection and transmission facilities.

5.5.1.4 Manual transmission of the data to a dedicated email address can also be used to transmit the data to K2n. This will need to be sent by midnight on the 1st of each month, including all data for the previous month, to enable inclusion in the automated reports which will be sent to the Contractor and the Employer (and School if required).

5.5.1.5 The minimum level of sensor data required is space temperature and carbon dioxide sensor data for each heating zone and data from an outside temperature sensor. This allows energy performance and building systems performance to be evaluated. The Contractor may choose to include additional sensor data, e.g. room temperature and CO_2 sensor data for each room, in order that further insights into the effectiveness of the building services HVAC systems can be provided to the School and Contractor. The K2n platform is capable of assessing energy use per space if appropriate sensors are in place.

5.5.1.6 Contractors can use this data to aid seasonal commissioning adjustments during the 12 month defect period. Correlating the internal conditions with energy consumption enables the identification of avoidable energy use, building performance issues and sensors or meters that are likely to be out of calibration. This is a powerful means of remote system diagnosis.

6 Specific Requirements

6.1 Refurbished Buildings

6.1.1.1 The Contractor should work with the School to limit energy end uses to the energy targets. The Contractor shall establish a strategy for reducing energy demands through energy audits and modelling.

6.1.1.2 In Refurbished Buildings, an Energy Audit takes the place of the Concept Energy Model and this is then used to produce an Energy Model.

6.1.1.3 The requirement for information exchange at each stage of the process is set out in the Employer's Requirements Deliverables.

6.1.2 Energy Audits Refurbished Buildings

6.1.2.1 The Contractor shall carry out an Energy Audit to assess the existing Building(s) included in the Works, including any external lighting, and detail the best methods to improve energy efficiency. It should identify principal energy uses and compare the performance against the energy targets in Section 3. The assessment should be based on overall energy use, separating loads by supply so that the different costs and environmental impacts of the fuels can be established and the relevant energy-weighting factor can be applied. Energy use data shall be obtained from:

a. information supplied to the Contractor by the Employer

b. occupant feedback on the performance of building services and existing energy monitoring

c. metered energy data

6.1.2.2 Once the data has been collected, an accurate Energy Model shall be built to estimate the energy saving potential.

6.2 Developed Energy Modelling for Refurbished Buildings

6.2.1.1 The model shall use actual data obtained through the Energy Audit and be a realistic representation of the existing School. The model should use actual existing data for values such as;

a. actual school use patterns

b. final construction data

c. actual HVAC system performance specifications

d. actual occupancy densities

e. actual DHW and other unregulated energy consumptions

f. installed controls strategy

6.2.1.2 The Contractor shall produce the Energy Model and check the results are in line with the metered energy use. To understand the most effective methods for refurbishment, iterative improvements shall be modelled and the energy saving potential shall be assessed. The improved predicted annual energy end-use figures shall be compared to the existing energy use and the energy targets as detailed in Section 3.

6.3 Reference Standards

6.3.1.1 In addition to EFA publications and the requirements set out within this Annex and the GDB, the Contractor shall ensure that the design and installation is compliant with regulations and takes account of the following documents (or updated documents where relevant):

1. Approved Document L2A
2. Approved Document L2B
3. Non Domestic Building Services Compliance Guide
4. CIBSE TM57 ‘Integrated School Design’
5. CIBSE Guides A, B, C, F, H, M
6. BS EN ISO 13370 ‘Thermal performance of buildings’
7. CIBSE TM54 ‘Evaluating operational energy performance of buildings at the design stage’
8. CIBSE TM37 ‘Design for improved solar shading control’
9. CIBSE TM52 ‘The limits of thermal comfort: avoiding overheating in European buildings’
10. CIBSE AM10 ‘Natural Ventilation in Non-Domestic Buildings’
11. CIBSE AM12 ‘Combined Heat and Power for Buildings’
12. CIBSE AM13 ‘Mixed Mode Ventilation’
13. CIBSE AM14 ‘Non-Domestic Hot Water Heating Systems’
14. CIBSE TM39 ‘Building energy metering’
15. ASHRAE ‘Handbook Fundamentals’
16. ASHRAE 90.1 ‘Energy Standard for Buildings Except Low-Rise Residential Buildings’

17. CIBSE TM46 ‘Energy Benchmarks’
18. CIBSE TM38 ‘Renewable Energy Sources for Buildings’
19. DCLG ‘National calculation methodology modelling guide (for buildings other than dwellings in England and Wales)’
20. SBEM Technical Manual
21. CIBSE AM11 ‘Building Performance modelling’
22. CIBSE Commissioning Codes
23. BSRIA BG 8/2009 ‘Model Commissioning Plan’
24. Carbon Trust ‘Monitoring and Targeting CTG077’
25. BSRIA BG 54 ‘The soft landings framework’
26. BSRIA BG 9 ‘Soft landings for Schools: Case Studies’
27. BSRIA BG 26/2011 ‘Building manuals and building user guides’
28. CIBSE TM31 ‘Building Log Book Toolkit’
29. CIBSE TM22 ‘Energy Assessment & Reporting Methodology’
30. Carbon Trust Schools CTV019 ‘Schools, learning to improve energy efficiency’
31. Government Soft landings