User Guide

MBEAT

Mauritius Building Energy Audit Tool

A User Guide to MBEAT

Version 4.1.h

16 September 2011

Ministry of Energy and Public Utilities

Republic of **Mauritius**

gef GLOBAL ENVIRONMENT FACILITY
INVESTING IN OUR PLANET

This user guide and the adaptation of the software tool (MBEAT) described in it were developed by the BRE for the Republic of Mauritius Ministry for Energy and Public Utilities from the original MBEAT User Guide which, together with the software tool described in it, were developed by the BRE for the UK's Department for Communities and Local Government (DCLG).

Disclaimer

The MBEAT User Guide cannot provide legal advice or a definitive interpretation of the law. The guidance provided in this document is limited to the technical operation of the software tool. It is offered in good faith but is not binding on any person(s) or organization. The same applies to the default values in the interface, which should be viewed as conservative suggestions intended to be replaced by actual values.

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Acronyms used in MBEAT and this guide

AHU	Air Handling Unit
CCHP	Combined Cooling, Heat, and Power
CEN	Comité Européen de Normalisation (The European Committee for Standardisation)
CHP	Combined Heat and Power
CO_2	Carbon dioxide
EER	Energy Efficiency Ratio
HEPA	High Efficiency Particulate Air
HTHW	High Temperature Hot Water (boiler)
HVAC	Heating Ventilation and Air Conditioning
HWS	Hot Water System
iSBEM	Interface to Simplified Building Energy Model
LTHW	Low Temperature Hot Water (boiler)
LZC	Low or Zero Carbon
MBEAT	Mauritius Building Energy Audit Tool
MTHW	Medium Temperature Hot Water (boiler)
PVS	Photovoltaic System
SBEM	Simplified Building Energy Model
SSEER	Seasonal System Energy Efficiency Ratio
SSEff	Seasonal System Efficiency
SES	Solar Energy System
SFP	Specific Fan Power
VAV	Variable Air Volume
VRF	Variable Refrigeration Flow

1. HOW TO USE THIS GUIDE

1.1. Scope of the guide

The purpose of this guide is to give an introduction to the use of MBEAT, a software tool for performing an energy audit on buildings.

This guide includes:
- An explanation of the role of MBEAT within a brief overview of the energy audit methodology.
- How to set up MBEAT to operate on your computer.
- How to work through the steps of the input procedure.
- How to obtain the Energy Audit Report.
- Guidance on how to assemble the required information for your own building.
- How to convert files created with previous versions of MBEAT (or UK iSBEM) to be compatible with the current version of MBEAT (4.1.h).

1.2. Structure of the guide

This guide is split into the following chapters and appendices.

Chapter 1: HOW TO USE THIS GUIDE

Chapter 2: INTRODUCTION TO

Chapter 3: ASSEMBLING REAL BUILDING DATA

This chapter provides guidance on preparing building data for inputting into MBEAT, including how to zone a building.

Chapter 4: MBEAT BASICS – GETTING STARTED

This chapter includes instructions on how to install MBEAT, start a new or open an existing project, and correctly save and close projects.

Chapter 5: TOUR OF MBEAT

This chapter introduces the structure of MBEAT in terms of its *forms*, *tabs*, and *sub-tabs*.

Chapter 6: BASIC MBEAT FUNCTIONALITY AND THE HELP MENU

This chapter details some of MBEAT's key commands, buttons, and functionality.

Chapter 7: ENTERING A BUILDING INTO MBEAT

This chapter takes the user through each of the forms in turn and explains the steps of inputting a building into MBEAT.

Chapter 8: CALCULATING AND VIEWING THE ENERGY PERFORMANCE OF THE BUILDING - THE RATINGS FORM AND OUTPUT REPORTS

This chapter explains how to obtain the Asset Rating, and view the other output documents produced by MBEAT.

APPENDIX A: Example building details and MBEAT

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2. INTRODUCTION TO MBEAT

2.1. What is MBEAT?

The Energy Performance of Buildings Directive (EPBD) 2002/91/EC of the European Parliament and Council requires that the energy performance of new buildings be evaluated with a calculation methodology that complies with the Directive. Additionally, the Directive calls for the production of energy performance certificates for existing buildings. This uses the same calculation methodology, although this is not mandatory. In response, the UK Department for Communities and Local Government (DCLG) commissioned the National Calculation Methodology (NCM) for the energy performance of buildings. SBEM, its interface iSBEM, and the associated databases and files were developed by BRE for DCLG as an implementation of the non-domestic building part of the NCM.

The Mauritius Ministry of Energy and Public Utilities commissioned BRE to adapt the UK's NCM and SBEM into the energy auditing methodology and the Mauritius Building Energy Audit Tool (MBEAT), an energy auditing software tool for non-domestic buildings in the Republic of Mauritius. This manual describes how to use MBEAT.

The MBEAT[i] tool comprises a calculation engine with a user interface. The purpose of MBEAT and its interface is to produce consistent and reliable evaluations of energy use in non-domestic buildings for energy auditing purposes. Although it may assist the design process, it is not primarily a design tool and should **not** be used for making strategic design decisions.

MBEAT consists of a calculation methodology (briefly described below), which runs together with an Energy Audit generator (EAgenMA) which utilises some of the same data during the calculation. The user sees the interface software, which interweaves these components together and interacts with a series of databases to provide consistent data to the calculation while simplifying the user's need to obtain raw building construction data.

MBEAT is an energy audit procedure and not a design tool. If the performance of a particular feature is critical to the design, even if it can be represented in MBEAT, it is prudent to use the most appropriate modelling tool for design purposes. In any case, MBEAT should not be used for system sizing.

2.2. Asset and operational energy usage and the energy management tool

The Mauritian Building Energy Audit Tool, or MBEAT, compares and adjusts both the asset and operation energy usage of a building. To understand and manage the energy use in a building, both modes of energy usage are required as they show different aspects of a buildings total energy performance. The operational energy usage benchmarks them against buildings of similar use. The asset energy usage models the theoretical, as designed, energy efficiency of a particular building, based on the performance potential of the building itself (the fabric) and its services (such as heating, ventilation, and lighting), compared to a benchmark, if available.

The building quality (provided by the asset energy usage) has a large impact on the total emissions (from the operational energy usage), but does not explain all emissions. Other

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[i] Pronounced m-beat.

factors such as unregulated loads (e.g. IT, plug-in appliances) or building user behaviour also create emissions, which are reflected in the operational energy usage. However, in order to understand what is driving these emissions, the asset energy usage is critical in separating the influence of building quality from other influences such as end user behaviours. To truly understand the energy used, and carbon emitted from a building, a building needs both types.

The asset energy usage is a measure of building quality and the higher the usage the worse the building is and the greater the opportunity to reduce carbon emissions and improve the building itself. However, the asset energy usage provides no information about how the building operates. Two offices with the same asset energy usages could have very different operational energy usages. The lower usage reflects a building used well by the occupants. The higher usage reflects a building used badly, where behavioural, end user focused measures are the best options for carbon reduction.

In order to adjust the asset energy usage, one must first address the issue of the Poorly Energy Managed Building (PEMB) definition.

2.2.1. Poorly Energy Managed Building (PEMB) definition

2.2.1.1. Introduction

The PEMB is needed to calculate one end of a scale between well managed (equivalent to the asset energy usage, where the building is perfectly controlled to the requirements of the activity databases) and poorly managed (where the activity database parameters are not adhered to). A separate scoring exercise places the actual building on this scale, which is transposed from the calculated to an "actual" scale. The position on the scale indicates where the metered performance is expected to be, and hence the theoretical split between asset and operational performance can be transposed onto the actual scale, and theoretical predictions about the impact of improvements can also be transposed to the actual scale.

2.2.1.2. How might activity database parameters be degraded?

If a zone is not controlled to the "ideal" set points and timings in the database for the activity in that space, it can be regarded as inadequately managed. Alternatively, some parameters might change as a result of overloading rather than mismanagement. The question is: how far might they be expected to drift before the zone and building can be considered "poorly" managed? And in which direction might they drift?

1. The amount of change that constitutes poor management, or results from some issue, over which the energy manager has no control, has to be a judgement based on what could reasonably be expected in the situation.

2. The direction we are concerned with is that which causes energy consumption to rise.

2.2.1.3. Which activity database parameters might change?

As a result of inadequate management control:

- Duration of operation on/off

    o Separately for HVAC, ventilation, lighting?

    o Anything from reasonable extra hours, e.g., extra three per working day, up to continuous operation, e.g., as result of no time switches, or manual control by occupants

    o Perhaps don't distinguish between days of week

    o Don't consider fewer hours

- Occupation density fraction
    - Perhaps don't distinguish between days of week, week of year etc – make it all at most occupation intensive level
    - Does this only affect ventilation? Could we achieve same outcome by disabling demand controlled ventilation?
- Temperature set points
    - Generally lower (since they are predominantly cooling)
    - But by how much? 20oC instead of 24oC? Or how about 16oC like they have in Dubai?
- Hot water quantity
    - How much more would a badly managed building use? 2x? 3x?
    - Probably necessary to make losses higher due to poor maintenance of insulation, and have circulation pump running continuously
- Ventilation air per person
    - How much more would a badly managed building use? 2x? 3x?
    - Is poor management counted by increasing duration of operation?
- Humidity set points – am I right that these don't affect calculation? They are set very wide to avoid triggering energy consumption anyway.

Changes over which manager has no control

- Occupation density
    - Likely to be less than UK, so maybe don't need to change
- Equipment loading
    - Probably linked to occupation density – can we say this is less than UK so we don't need to change?
- Metabolic rate
    - Is this higher in tropical climate?

2.2.1.4. <u>Adjustment to asset parameters to account for poor management</u>

Some management issues can be simulated by changes to asset parameters, in particular poor maintenance:

Issue	Simulate by	How much for poor management?
Cooling generator poor maintenance	Degraded SEER	-0.5? -1.0?
Air filters not cleaned, ductwork not cleaned	Increased SFP; ensure leakage testing not selected	+0.5? +1.0?
Luminaires not cleaned (although perhaps lighting would just underperform rather than require more energy)	Reduced efficacy lumens/watt	-25% (would have to express as wattage change)
Inadequate lamp replacement policy	No change – just underperforms	

Poor management of hot water systems	Increase heat losses and untick time control of pump	50% increased loss over default?
Poor central controls	Do not have optimum start/stop, weather compensation etc (although these don't affect cooling energy anyway)	None
Lack of management supervision	Do not select M&T etc	None
Poor localisation of time, temperature controls	Apply activity with longest duration, lowest cooling set points, most ventilation to whole building	Need to be careful that this is not accidentally beneficial to some other aspect of energy consumption
Poor localisation of lighting control, lack of tailoring lighting levels to different activities	Apply activity with highest lighting lux level to whole building; untick local manual switching	Should tend to give higher cooling energy as well
Lack of daylight and occupancy controls	Do not select any of these controls	
Lack of weather tightness	Debatable whether to adjust air permeability as this may be beneficial by introducing more passive cooling	
Poorly maintained/operated shading	Change shading transmission factor	1.0 for all windows
White roofs allowed to deteriorate	Override absorptivity of roof	What would it be for dirty white?
No cleaning of solar thermal panels	Equivalent to reducing area? Or just remove from calculation?	50%?
Poor staff training in using systems	Covered by adjustments to schedules and set points at activity database level	None

Table 1: Management issues simulated by changes to asset parameters

2.2.1. The Energy Management tool

The first step in this process is to determine an energy management score using the energy management tool, which is contained within the locked excel file *Mauritius E-audit tool V3.xlsx*.

This contains a number of worksheets which address all the energy management issues (see Table 2). Each worksheet contains a single matrix, for example that covering Central plant level controls which is show in section 2.2.1.1 along with the other matrices.

Matrices	Summary Score	Total possible score

Matrix 1: Use of Controls	0	40
Matrix 2: Use of Controls - Local (zone level) comfort controls	0	40
Matrix 3: Use of Controls - Lighting	0	36
Matrix 4: Quality of maintenance - Building	0	40
Matrix 5: Quality of maintenance - HVAC plant & Lighting	0	40
Matrix 6: Motivation - Occupants & Management	0	32
Final score	0	228

Table 2: Summary table of the Energy Management Matrices

In order to populate the tool, the auditor must answer each of questions with a score between 0 and 4 depending on the level of management within the building as determined by the energy survey of building and its occupants. The score must be a whole number (i.e. 0, 1, 2.3 or 4) - it cannot be a fraction or a decimal. Also, the auditor must choose the lowest common denominator, e.g., if a building has a central control panel (scores 2) which controls the majority of the building but the rest of the building has the controls dispersed around (scores 1), the auditor must choose the lowest common denominator which is 1 and enter this against the Question - *Location of controls* – see Figure 1.

If there is insufficient information to completely answer a question, the auditor must enter a zero score.

Once the score is entered, the worksheet multiplies this score by a weighting. In this case, it is one so the overall score for that question is 1 (score) x 1 (weighting) =1. This is done for each of questions within the worksheet, which then gives a total score for the area of **Use of controls: Central plant level controls**. The worksheet also gives you the highest total possible score for this matrix which in this case is 40.

	A	B	C	D	E	F
1	Matrix 1: Use of Controls					
2	Building:		0	*(Enter name on summary scores sheet)*		
3						
4	Topic	Use of Controls				
5	Subject	Central plant level controls				
6	Question	Location of controls	Operating times	Time response to day to day changes	Central plant temperature settings	Energy manager understanding
7	Score		1			
8	4	BEMS with trained personnel to operate it	Different schedules for each day	Optimum start and stop depending on internal temperature performance on previous day	Cold set points adjusted to allow highest evaporating temperature and hence highest COP consistent with providing cooling needs based on exterior weather conditions	Rigorous checking of controls function, settings, and system balance carried out once per year. Documented procedures and comprehensive records of results.
9	3	Computer-based building energy management system (BEMS)	Set to exactly normal occupancy	Optimum start (only) depending on internal temperature performance on previous day	Cold set points adjusted depending on differing dehumidification requirements based on exterior weather conditions	Full checking of controls function, controls, settings, and system balance carried out once per year. Documented procedures exist for each check. Some results on record.
10	2	Central control panel from which time, temperature etc settings can be adjusted	Turned on/off by staff	Time switch with seasonal differences	No central chiller plant	Informal checking of controls function and system balance carried out once per year. Schedule of checks exists but no proof of occupancy
11	1	Controls dispersed around building	More hours than normal occupancy	Time switch only	No changes (eg evaporator or chilled water temperatures as set by manufacturer)	Annual functional checks carried out although these are not well documented.
12	0	Don't know where controls are OR There are no controls	No control (enabled constantly)	No response to changes	Don't know what settings are OR what you mean by this	Maintenance is on breakdown basis and controls are checked only when things go wrong.
13	Weighting for relevance to calculation	1	3	2	1	3
14	Overall Score	1	0	0	0	0
15	*Enter scores on red row above, not here*					
16	Total score	1				
17						
18	Total possible score	40				

Figure 1: Screen shot of Central plant level controls matrix

This exercise is carried out for each of the six matrices (see section 2.2.1.1), and the workbook then sums these together to give a final score for the building out of 228. The summary worksheet captures these scores and then normalises the final score to one with a range between 0-100 (see Figure 2).

Figure 2: Screen shot of the summary scores worksheet

This score is entered into the MBEAT tool with the model in Asset energy mode (Audit type set to "Assessment of current performance" in the *General* form > *General Information* tab > *Project Details* sub-tab), see Figure 3.

Figure 3: Screen shot of MBEAT Project Details sub-tab

The normalised management score of between 0 and 100 is entered in the current field in the management scores within the *Building Services* form > *Global and Defaults* tab > *Services Management* sub-tab, see Figure 4.

Figure 4: Screen shot of MBEAT Services Management sub-tab

At this point, the auditor needs to consider how the management score could be improved. Whilst carrying out the energy survey of building and its occupants, the auditor should have got initial ideas of how each score within each matrix could be improved and would have matched those within the recommendations report. After saving the model (.nct file), the auditor will save it again in a new folder, close it and re-open it. The auditor must first run it in Asset energy mode (Assessment of current performance mode), because the tool generates a secondary file in this mode which is essential to any further analysis. The auditor will now run the model with MBEAT in Audit energy mode (Assessment of improved performance mode). The auditor would have then identified those operational recommendations that could be removed, removed them and added a reason for the audit trail. At the same time, the auditor re-visits the energy management tool and re-enters the scores based upon his/hers suggested improvements. The spreadsheet tool recalculates the final score for the building and this new improved score of between 0 and 100 is entered in the improved field in the management scores within the *Building Services* form > *Global and Defaults* tab > *Services Management* sub-tab, see Figure 4. It should be pointed out that the Energy Management tool and MBEAT will only give an indication of possible savings and feasibility studies may be required.

2.2.1.1. Energy Management Matrices

Topic	Use of Controls				
Subject	Central plant level controls				
Question	Location of controls	Operating times	Time response to day to day	Central plant temperature settings	Energy manager understanding

			changes		
Score					
4	BEMS with trained personnel to operate it	Different schedules for each day	Optimum start and stop depending on internal temperature performance on previous day	Cold set points adjusted to allow highest evaporating temperature and hence highest COP consistent with providing cooling needs based on exterior weather conditions	Rigorous checking of controls function, settings, and system balance carried out once per year. Documented procedures and comprehensive records of results.
3	Computer-based building energy management system (BEMS)	Set to exactly normal occupancy	Optimum start (only) depending on internal temperature performance on previous day	Cold set points adjusted depending on differing dehumidification requirements based on exterior weather conditions	Full checking of controls function, controls, settings, and system balance carried out once per year. Documented procedures exist for each check. Some results on record.
2	Central control panel from which time, temperature etc settings can be adjusted	Turned on/off by staff	Time switch with seasonal differences	No central chiller plant	Informal checking of controls function and system balance carried out once per year. Schedule of checks exists but no proof of occupancy
1	Controls dispersed around building	More hours than normal occupancy	Time switch only	No changes (e.g. evaporator or chilled water temperatures as set by manufacturer)	Annual functional checks carried out although these are not well documented.
0	Don't know where controls are OR There are no controls	No control (enabled constantly)	No response to changes	Don't know what settings are OR what you mean by this	Maintenance is on breakdown basis and controls are checked only when things go wrong.
Weighting for relevance to calculation	1	3	2	1	3

Topic	Use of Controls			
Subject	Local (zone level) comfort controls			
Question	Localisation of control	Operating times	Local temperature & humidity settings	User understanding (cooling)
Score				
4	Subdivision within zones/rooms	Time control with different schedules for each day	Set to recommended values but with relaxed control (e.g. +/- 2°C, no dehumidification below 70%RH)	All staff understand how their roles impact on energy efficiency and take positive steps to minimise energy use. Staff receive targeted training in energy efficiency.
3	Individual to each zone/room	Time control can be adjusted for unusual occupancy	Set to recommended values but with close control (e.g. +/- 0.5°C, +/- 5%RH);	Staff are aware of how they affect energy use and take all good housekeeping measures to save energy. Further training received on a regular basis.
2	Single control for groups of rooms with similar occupancy pattern	Time control set to exactly normal occupancy	Occupants allowed to set to whatever they like, but with advice on recommended values	Most good house keeping practices are adhered to in an attempt to reduce energy usage. Occasional energy

				efficiency training received.
1	Single control for whole floor	More hours than normal occupancy or manual control by dedicated person	When cooling, set to 3°C or more below recommended values	Energy-saving techniques are only adopted where they can be easily accommodated within traditional working practices.
0	One control for whole building	No time control or manual control by occupant	Don't know what recommended conditions are	No consideration is given to energy efficiency during working operations.
Weighting for relevance to calculation	2	3	3	2

Topic	Use of Controls				
Subject	Lighting				
Question	Localisation of control	When is lighting available?	Adjustment for daylight	Designed lighting levels	User understanding (lighting)
Score					
4	Subdivision of rooms using switches by the door , plus task lighting	Occupancy sensors in all areas	Daylight sensing to all perimeter rooms	Schedule of different levels for different tasks (e.g. for night time cleaning)	All staff understand how their roles impact on energy efficiency and take positive steps to minimise energy use. Staff receive targeted training in energy efficiency.
3	Subdivision of rooms using switches by the door	Occupancy sensors in key areas where a calculation of their effectiveness has been undertaken	Daylight sensing in a few perimeter rooms	Lighting to recommended levels with dimming in some areas for cosmetic purposes (e.g. in a restaurant);	Staff are aware of how they affect energy use and take all good housekeeping measures to save energy. Further training received on a regular basis.
2	Whole of lighting in each individual room	Occupancy sensors in intermittently occupied areas like toilets	Switching in rows parallel to windows, with manual control by occupant if daylight is adequate	Lighting to recommended levels but no variation depending on actual activity taking place	Most good house keeping practices are adhered to in an attempt to reduce energy usage. Occasional energy efficiency training received.
1	All lighting on a floor switched together	Time controls on display lighting (if present)	Switching of whole room, with manual control by occupant if daylight is adequate	Lighting installed without considering recommended levels e.g. light fittings selected to match existing wiring layout	Energy-saving techniques are only adopted where they can be easily accommodated within traditional working practices.
0	All lighting in building switched together	No time control – all lighting switching depends on occupant initiative	Switching off if daylight is adequate depends on central control by manager or similar person	Don't know what lighting levels should be	No consideration is given to energy efficiency during working operations.
Weighting for relevance to calculation	1	1	2	3	2

Topic	Quality of maintenance				
Subject	Building				
Question	Water tightness	Air tightness	Moveable shading	Fixed shading (e.g.	External surface

			devices	overhangs, solar films)	reflectivity
Score					
4	Regular inspection for water ingress and programme of remedial measures	Regular inspection for air leakiness and programme of remedial measures	Operable, undamaged and controlled appropriately by automatic system	Regular inspection of fixed shading and programme of remedial measures	Regular inspection of external reflectivity and programme of improvements and repairs
3	No water ingress reported	No air penetration when windows and doors are closed	Operable, undamaged and controlled appropriately by occupants	Exterior fixed shading (e.g. overhangs)	Clean white roof and walls
2	Water ingress through windows or surrounds	Wind-driven air movement detectable only adjacent to windows that are supposed to be closed	Operable and undamaged	No exterior fixed shading (e.g. overhangs), film applied to windows and it is in good condition	Clean white roof
1	Water ingress through building fabric causing disruption to internal activities only during prolonged rain storms	Wind-driven air movement detectable other than around windows (e.g. through cracks), during tropical storms	Jammed or operable but damaged	No exterior fixed shading (e.g. overhangs), film applied to windows but it is peeling or bubbling	White roof but with some damage
0	Water ingress through building fabric causing disruption to internal activities every time it rains	Wind-driven air movement detectable other than around windows (e.g. through cracks), during normal weather	No moveable shading devices	No fixed shading	Dirty/unpainted walls and roofs
Weighting for relevance to calculation	1	2	2	2	3

Topic	Quality of maintenance				
Subject	HVAC plant			Lighting	
Question	Servicing frequency	Air handling filter cleaning	Cleanliness of air handling components	Luminaire cleaning	Lamp replacement
Score					
4	At frequency determined by monitoring and recording performance in log book	Regular inspection and replacement when pressure drop excessive	Regular cleaning throughout ductwork to minimise surface roughness	Luminaires dismantled, diffusers and reflectors cleaned at regular intervals	Frequency determined on basis of predicted failure procedure
3	At frequency recommended by supplier	At interval recommended by filter supplier	Cleaning where ductwork is accessible close to grilles	Diffusers and reflectors cleaned at regular intervals	Bulk lamp replacement when lighting level falls below recommended threshold
2	Approx half frequency recommended by supplier	When dirt is obvious to customers/ occupants	When dirt is obvious to customers/ occupants	Interior of enclosures cleaned for cosmetic reasons (e.g. insects visible)	Lamps replaced within 1 day of reported failure
1	Only on breakdown	When filters are blocked	When filters are blocked	Exterior dusted occasionally	Lamps replaced within 1 week of reported failure
0	Never	Never	Never	Never	Failed lamps not

					replaced until occupants complain repeatedly
Weighting for relevance to calculation	1	2	2	2	3

Topic	Motivation				
Subject	Occupants		Management		
Question	Training on how to use systems	What's in it for occupants to be energy efficient?	Is managing energy part of somebody's job description?	Are suitably qualified /trained staff running the systems?	Monitoring energy use and targeting
Score					
4	Sustained marketing campaign to remind occupants about their role and what they can/should do	Linkage to cost centres that each staff member is responsible for; part of regular job appraisal	One or more specific person(s) spending a designated proportion of resource on energy management, with board champion to report and encourage better performance company-wide	Retraining by designer or installer on using systems, backed by operating instructions with annotations to explain operation in terms understandable by the manager	Energy sub-metered by different end uses; 24-hourly profiles set up and compared with actual energy use; actions taken to avoid excess consumption
3	Occasional reminders about consequences of using controls badly	Financial benefits (could be either direct, or indirect e.g. contribution of proportion of metered saving to charity or towards discretionary activities)	One or more specific person(s) spending a designated proportion of resource on energy management	Operating instructions with annotations to explain operation in terms understandable by the manager	Energy sub-metered by different end uses; weekly profiles set up and compared with actual energy use; actions taken to avoid excess consumption
2	Training during initial induction to job	Majority of occupants are motivated to care for the environment	Specific part of office/facilities manager's job	Explicit operating instructions handed down from original designer via previous managers	Overall energy consumption meter readings compared with monthly profiles and explanation sought retrospectively for anomalies
1	From other occupants	Written or verbal reminders of general environmental consequences	One of many concerns of general management; part of office/facilities management team responsibilities	Information from installer/ supplier/ designer when first installed	Monthly utility meter readings taken and recorded to confirm bills
0	None	No benefits	No	No explanation given to staff	No record of energy consumption other than utility bills
Weighting for relevance to calculation	1	1	1	2	3

2.3. Calculation basics for energy auditing purposes

The calculation procedure implemented in MBEAT is suitable for use with the majority of buildings, but some designs will contain features that mean that more accurate energy calculations may be obtained by more sophisticated calculation methods.

MBEAT calculates the energy demands of each space in the building according to the activity within it. Different activities may have different temperatures, operating periods, lighting standards, etc. MBEAT calculates heating and cooling energy demands by carrying out an energy balance based on monthly average weather conditions. This is combined with information about system efficiencies in order to determine the energy consumption. The energy used for lighting and hot water is also calculated. This requires information from the following sources:

Information	Source
Building geometry such as areas, orientation, etc.	Energy auditor reads from drawings or direct measurement.
Weather data	Internal database.
Selection of occupancy profiles for activity areas	For consistency, these come from an internal Activity Database – energy auditor selects by choosing building type and activity from the database for each zone.
Activity assigned to each space	Energy auditor defines within MBEAT by selecting from internal database (the user should identify suitable zones for the analysis by examining the building or drawings).
Building envelope constructions	Energy auditor selects from internal Construction and Glazing databases or inputs parameters directly. Energy auditor can also define their own constructions in the user-defined construction database.
HVAC systems	Energy auditor selects from internal databases or inputs parameters directly.
Lighting	Energy auditor selects from internal databases or inputs parameters directly.

Table 3: Calculation parameters for MBEAT

Once the total energy consumed in the building is calculated, MBEAT then determines:

a. the potential operational saving for the building if management improvements were applied, based on the energy performance of the building that corresponds to the current and improved management scores as input by the energy auditor

b. the potential asset saving if asset improvements were applied to the building, based on the energy performance of the current and improved building models as input by the energy auditor.

NB: The domestic type activities available under the building type "Residential spaces" in MBEAT are to allow the energy calculations and auditing for a building which contains residential accommodation above a non-domestic space (e.g., a shop or a pub) provided that the residential space can only be accessed from within the non-domestic space, i.e.,

the residential part is not designed or altered for use as a separate independent dwelling. These are the **only** cases where MBEAT can be used to model domestic areas.

2.4. Deciding whether MBEAT is appropriate

All calculation processes involve some approximations and compromises, and MBEAT is no exception. The most obvious limitations relate to the use of the CEN monthly heat balance method. This means that processes which vary non-linearly at shorter time-steps have to be approximated or represented by monthly parameters. The HVAC system efficiencies are an example of this. On the other hand, MBEAT does have provision to account for processes that may not be present in software packages that contain more sophisticated fabric heat flow algorithms, such as, duct leakage and infiltration allowances.

It is, therefore, difficult to give absolute rules about when MBEAT can and cannot be used. As broad guidance, it is more likely to be difficult to use MBEAT satisfactorily if the building and its systems have features that are (a) not already included in MBEAT and (b) have properties that vary non-linearly over periods of the order of an hour. However, as the example above shows, this is not a universal rule. There is a balance between the time and effort required to carry out parametric studies to establish input values for MBEAT and detailed explicit modelling of a particular building.

Features which cannot currently be represented in MBEAT:

- Ventilation with enhanced thermal coupling to structure
- Light transfer within a building, for e.g., through highly glazed internal surfaces between atria and surrounding spaces

2.5. Overview of how a building is defined in MBEAT

There is a number of stages to inputting a building in MBEAT:

a   Enter general information about the building, the owner, and the energy auditor, and select the appropriate weather data.

b   Build up a database of the different forms of constructions and glazing types used in the fabric of the building.

c   After "zoning" the building (on the drawings), create the zones in the interface, and enter their basic dimensions, along with the air permeability of the space.

d   Define the envelopes of each zone, i.e., walls, floor, ceiling, etc. The envelopes' areas, orientations, the conditions of the adjacent spaces, and the constructions used all need to be defined.

e   Within each envelope element, there may be windows/rooflights or doors. The areas and types of glazing or door within each envelope element need to be entered.

f   Define the HVAC (heating, ventilation, and air conditioning) systems, the HWS (hot water systems), and any SES (solar energy systems), PVS (photovoltaic systems), wind generators, or CHP (combined heat and power) generators used in the building.

g   Define the lighting system and local ventilation characteristics of each zone, and assign the zones to the appropriate HVAC system and HWS.

h   Run the calculation and assess energy performance.

The building services systems, zones, envelope elements, windows, and doors are all referred to as "**building objects**" in MBEAT. Figure 5 shows each of these building objects and demonstrates how they are linked together so that MBEAT can calculate the energy consumption of the building. This diagram gives you an overview of what information is required and where you have to enter it in MBEAT. It may be useful to return to this figure at the end of the tutorial, by which point you will have been introduced to all the building objects. Each building object should be given a unique name when modelling the building in MBEAT, for e.g., do not give the same name to two different constructions in the *Project Database* form.

Figure 5 serves to provide an overview of the structure of the building objects that you will be introduced to in this User Guide. More details on each item and how they are defined and linked together will be provided in detail in Chapters 5 to 8 and through the *Help* menu accessible from within MBEAT.

Building object	Key parameters needed to define this building object	Object(s) to which it needs to be linked	Where it is defined in MBEAT	Hierarchy of MBEAT building objects
Zones	Dimensions, activity type, details on lighting, heating, and ventilation strategy.	HVAC and HWS	Geometry form > Zones tab and in the Building Services form > Zones tab	
Envelope elements	Type of envelope (wall/floor/roof), area, orientation, construction type, perimeter length, and condition of adjoining space.	Zone	Geometry form > Envelopes tab or the Geometry form > Zones tab > Quick-Envelopes sub-tab	
Windows	Dimensions, glazing type, shading system, frame factor, aspect ratio, and whether it is a display window or not.	Envelope element	Geometry form > Windows & Rooflights tab or the Geometry Form > Zones tab > Quick Envelopes sub-tab	
Doors	Area, construction type and type of door.	Envelope element	Geometry form > Doors tab	
HVAC	System type, heat source, fuel type, further details on efficiencies, duct leakage, specific fan power, and controls.	Zone	Building Services form > HVAC systems tab	
HWS	Generator type, fuel type, details on efficiency and whether it is a storage system.	Zone	Building Services form > HWS tab	
SES	Dimensions, orientation, inclination, storage.	HWS	Building Services form > SES tab	
PVS	Dimensions, orientation, inclination and type.	-	Building Services form > PVS tab	
Wind generator	Terrain type, dimensions, and power.	-	Building Services form > Wind generator	
CHP generator	Fuel type, details on efficiency, building heat and hot water supplied, and thermal and electrical efficiencies.	HVAC	Building Services form > CHP tab	
TSC	Type, operation, control type, absorptivity, and design air flow.	Zone and Envelope element	Building Services form > TSC tab, Geometry form > Envelopes tab, and Building Services form > Zones tab	

Figure 5: Structure of MBEAT objects

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3. ASSEMBLING REAL BUILDING DATA

3.1. Introduction

There are four steps to calculating the ratings for a building. First, a decision needs to be made on whether MBEAT is the appropriate analysis tool. Then, information on the building needs to be gathered, analysed, and finally, entered into the interface. To focus on the functionality of the tool, all the information on the Example building (installed automatically with the tool) is provided in the appendices, and the zoning is done for you. However, when analysing a real building, you will need to collect and analyse the building data yourself. This chapter will guide you on what information you need to gather, and how you need to process this information before you can enter it into the interface.

Step 1

Decide whether MBEAT is the appropriate analysis tool (see Section 2.4)

Step 2

Gather the raw data on your building (see Section 3.2)

Step 3

Analyse the information and identify the different zones (see Section 3.3)

Step 4

Enter the information into the interface, double-check it, and run the calculation (see Chapters 5 to 8)
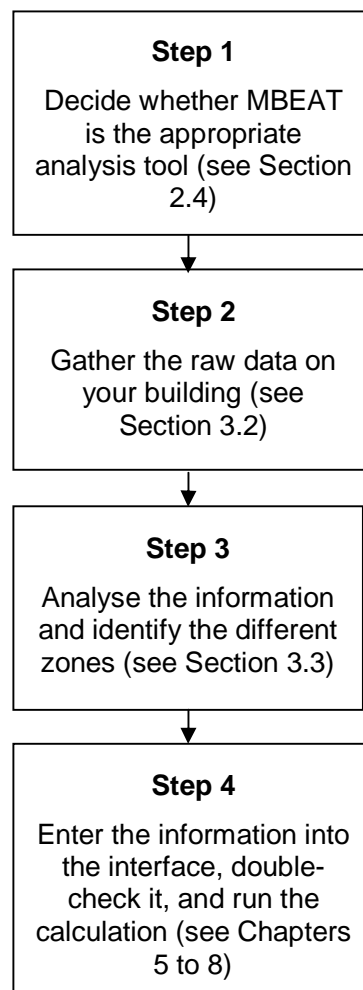
Figure 6: Steps for calculating the energy performance of a building

3.2. Tips for gathering information for MBEAT

Item	Requirements	Potential issues and experiences	
		New build and refurbishment	**Existing building**
Architectural: building spatial layout of functions, geometry, and orientations	Building plans, sections, site plan	Plans and schedules should be available at this stage. What degree of detail do they show? For instance, have decisions been made on usage of each space in the building?	Are plans available? Have they been kept up-to-date? Can they be used? What degree of detail do the plans show? Have there been changes to the internal layout (with consequent effects on activity type, area, and geometry)? Don't assume that adequate information on an existing building can be obtained easily. Any planning should include time to physically survey at least some parts of the building. Note that there may be practical obstacles to overcome, such as gaining access to secure parts of the building, e.g., plant rooms or areas where confidential work takes place. This may need to be resolved with the building owner or occupier prior to the visit. There could also be safety issues to consider, such as access to the roof or looking into ceiling voids.
Envelope construction materials, air permeability	Detailed drawings, schedules of construction details, pressure test result	Detailed drawings and schedules should be available. What degree of detail do they show? Do they rely on the constructors to use initiative to select suitable materials? Has there been confirmation that as-built constructions are equivalent to or better than as-designed?	Are drawings and schedules available? How up-to-date are they? What degree of detail do they show? Have there been changes, for instance replacement of windows, re-roofing, or additional insulation? Any direct investigation of construction details, such as, wall or roof constructions by opening them up should only be undertaken with the written approval of the building owner and consent of occupants. If this is not given (it would be unusual), then it is possible, using databases built into the software, to infer construction details from non-invasive observations. Any assumptions made must err on the pessimistic side (i.e., constructions that are older and/or do not contain cavities unless their presence can be inferred from the external appearance).
Building	Description of	Detailed drawings	Are drawings and schedules

| Services | plant and its controls, schedules of plant sizing including fans, information on construction standards (e.g., leakage tests on ductwork). | and schedules should be available. What degree of detail do they show? For instance, is it possible to work out specific fan power from fan power and air quantity? Has the fine detail of installation been left to equipment suppliers and installers – If so, could they inadvertently compromise the design intent? Are any test certificates available? Is lighting design information available, rather than relying on simple lamp type information? | available? Are they held on-site or by a maintenance or other remote contractor? Is there a building log book? How up-to-date are they? What degree of detail do they show? Have there been changes, such as, plant replacement or to the control process? Are there any results of tests on the equipment as installed, such as, seasonal system efficiencies, leakage tests on ductwork and/or air handling plant, confirmation of air volumes, etc?

It would also be useful to confirm with the facilities manager which lamp types are used in each zone, and which zones have which types of lighting control applied.

If written information is not available, the plant will need to be surveyed. Who has access to plant rooms and when? There are safety issues. Is the surveyor familiar with plant type and specifications? It can be difficult to identify systems from simple visual inspection. Default efficiencies will depend on the installation date and/or ECA listing of equipment – can this be verified from purchase documentation? Any assumptions made must err towards a less efficient plant and/or less precise control.

If an external contractor has responsibility for operation or maintenance, it may be necessary to probe carefully how the plant is actually configured. This is to avoid misunderstandings on how it should work. |
|---|---|---|---|

Table 4: Tips for gathering information for MBEAT

Convention: <u>Use of default values</u>

The energy auditor shall only use the default values within the software tool in the absence of more specific information on the building. Where a default value is selected, the energy auditor must provide evidence in the *Ratings* form > *Energy Audit tab* > *Audit Trail* sub-tab detailing why the default value has been selected.

Use of default values should be avoided where possible.

3.3. Zoning guide – How to zone your building

The way a building is subdivided into zones will influence the predictions of energy performance. Therefore, the zoning rules must be applied when assessing a building for energy auditing purposes. The end result of the zoning process should be a set of zones where each is distinguished from all others in contact with it by differences in one or more of the following:

- The activity attached to it

- The HVAC system which serves it

- The lighting system within it

- The access to daylight (through windows or rooflights).

To this end, the suggested zoning process within a given floor plate is as follows:

1. Divide the floor into separate physical areas, bounded by physical boundaries, such as structural walls or other permanent elements.

2. If any part of an area is served by a different HVAC or lighting system, create a separate area bounded by the extent of those services.

3. If any part of an area has a different activity taking place in it, create a separate area for each activity.

4. Attribute just one "activity" (selected from the drop-down list available for each building type) to each resulting area.

5. Divide each resulting area into "zones", each receiving significantly different amounts of daylight, defined by boundaries which are:

    - At a distance of 6m from an external wall containing at least 20% glazing.

    - At a distance of 1.5 room heights beyond the edge of an array of rooflights if the area of the rooflights is at least 10% of the floor area.

    - If any resulting zone is less than 3m wide, absorb it within surrounding zones.

    - If any resulting zones overlap, use your discretion to allocate the overlap to one or more of the zones.

NB: Currently, MBEAT is not able to realistically model sunspaces or atria as it cannot represent light transfer between highly glazed/reflective internal spaces such as these.

Convention: Passive daylight features

Buildings with the following features may be assessed using MBEAT, as long as other features that cannot be modelled by MBEAT are not present:

- Light wells open to the sky can be treated as courtyards (i.e., for consistency, they are approximated as exterior spaces with ordinary daylight access).

- Sun/light pipes should be ignored for the purposes of zoning and the daylight contribution they make.

---

6. Merge any contiguous areas which are served by the same HVAC and lighting systems, have the same activity within them (e.g., adjacent identical hotel rooms, cellular offices, etc.), and which have similar access to daylight, unless there is a good reason not to.

NB: Small unconditioned spaces like store cupboards, riser ducts, etc., can be absorbed into the adjacent conditioned spaces. In MBEAT, this would involve adding their floor area to that of the adjacent conditioned space. Larger areas should be treated as indirectly conditioned spaces, subject to the conditions in the note within Section 7.6.9: Defining the zone specific building services, regarding indirectly conditioned spaces.

7. Each zone should then have its envelopes described by the area and properties of each physical boundary. Where a zone boundary is <u>virtual</u>, e.g., between a daylit perimeter and a core zone, no envelope element should be defined. MBEAT will then assume no transfer of heat, coolth, or light across the boundary, in either direction. In the context of MBEAT, the building needs to be divided into separate zones for each activity area, subdivided where more than one HVAC system serves an activity area.

NB: If the internal envelopes between merged zones have been designed of heavy construction to have thermal mass, then their K_m value will contribute to how the building retains and emits heat, and hence they should be defined in MBEAT. You can sum the areas of two or more internal walls (between merged zones) with the same construction and orientation and enter them as one envelope (assigned to the zone resulting from the merging) with the adjacency of "Same space". If, on the other hand, the internal walls are partitions of light construction and very small thermal mass, then they should not cause any significant effects on the calculation if they were omitted from the MBEAT model. If in doubt about the thermal mass of the internal partitions, it is better to err on the side of caution and include them in your model as described above.

NB: The term "zone" is used as a short hand for "activity area" throughout this User Guide. It should not be assumed to be the same as a building services control zone, for instance, on the basis of building façade, although in some cases they may align.

NB: For energy auditing purposes, we recommend that users generally avoid creating more than 100-150 zones in MBEAT. However, the processing time will depend on the total number of objects (not just zones) that need to be processed by MBEAT, i.e., zones, envelopes, windows, etc. Hence, creating a project with a very large number of objects will slow down the calculation and may cause it to crash.

3.4. Measurement and other conventions

In order to provide consistency of application, standard measurement conventions have been adopted to be used as part of the methodology for MBEAT. These conventions are specified in Table 5 below:

Parameter	Definition
Zone Height	Floor to floor height (floor to soffit for top floor), i.e., including floor void, ceiling void, and floor slab. Used for calculating length of wall-to-wall junctions, radiant and temperature gradient corrections, and air flow through the external envelopes due to the stack effect.
	Convention: <u>Dimension conventions</u> For further guidance on defining zone height in a range of building configurations, see APPENDIX G:
Zone Area	Floor area of zone calculated using the internal horizontal dimensions between the internal surfaces of the external zone walls and half-way through the thickness of the internal zone walls (see Figure 7). Used to multiply area-related parameters in databases.

	NB: If the zone has any virtual boundaries, the area of the zone is that delimited by the 'line' created by that virtual boundary.
	Convention: Dimension conventions For further guidance on defining horizontal dimensions in a range of building configurations, see APPENDIX G:
(Building) Total Floor Area	Sum of zone areas. Used to check that all zones have been entered in MBEAT.
Envelope perimeter length	Horizontal dimension of the wall. Limits for that horizontal dimension are defined by type of adjacent walls. If the adjacent wall is external or a perimeter wall, the limit will be the internal side of the adjacent wall. If the adjacent wall is internal, the limit will be half-way through its thickness.
Envelope Area	Area of vertical envelopes (walls) = h * w, where: h=floor to floor height (floor to soffit on top floor), i.e., including floor void, ceiling void, and floor slab. w=horizontal dimension of wall. Limits for that horizontal dimension are defined by type of adjacent walls. If the adjacent wall is external or a perimeter wall, the limit will be the internal side of the adjacent wall. If the adjacent wall is internal, the limit will be half-way through its thickness. NB: Areas of floor, ceilings, and flat roofs are calculated in the same manner as the zone area. Area for an exposed pitched roof (i.e., without an internal horizontal ceiling) will be the inner surface area of the roof. Used to calculate fabric heat loss so this is the area to which the U-value is applied.
	Convention: Dimension conventions For further guidance on defining envelope areas in a range of building configurations, see APPENDIX G:
Window Area	Area of the structural opening in the wall/roof, i.e., it includes the glass and the frame.
Aspect ratio (window)	Ratio of the window's height to its width.
Frame factor (window)	Ratio of the window area which is occupied by the frame to the total window area (see definition above).
Deadleg Length	Length of the draw-off pipe to the outlet in the space (only used for zones where the water is drawn off). Used to determine the additional volume of water to be heated because the cold water in the deadleg has to be drawn off before hot water is obtained. Assumes that HWS circulation maintains hot water up to the boundary of the zone, or that the pipe runs from circulation or storage vessel within the zone.
Flat Roof	Roof with a pitch of 10 degrees or less.
Pitched Roof	Roof with a pitch greater than 10º and less than or equal to

	70º. If the pitch is greater than 70º, the envelope should be considered a wall.
Glazed door	When doors have more than 50% glazing, then the light/solar gain characteristics must be included in the calculation. This is achieved by defining these doors as windows. (Otherwise, they are defined as opaque doors.)

Table 5: Measurement and other conventions
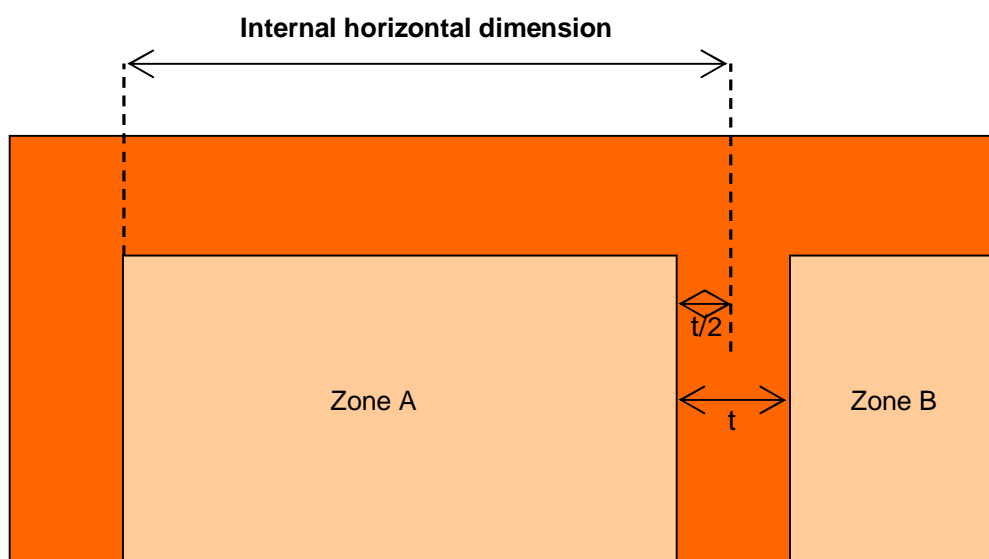
Figure 7: Internal horizontal dimension of a zone

3.5. MBEAT Nomenclature

3.5.1. Naming zones, envelope elements, windows, and doors

There is no set nomenclature for the different items in the *Geometry* form. The only requirement is that they are all unique, for e.g., do not give the same name to two different constructions in the *Project Database* form. You may prefer to assign familiar/representative names. However, with a large building, a methodical nomenclature can make it easier to identify elements and keep track of what has been input.

Below is a suggested nomenclature. If you use *Quick Envelopes* or the "Copy Record" function, the elements you create will be named in this way.

Element	Suggested name	Explanation
Zone	z#/##	The **z** stands for zone, and the first number is the storey number (0 for ground floor and 1 for first floor etc.). After the slash, the number(s) stands for the number of the zone on that floor. These can run consecutively throughout the building or start again at 1 for each floor.
Walls	z#/##/ot	The first two groups of figures are to identify, as described above, which zone the wall is part of. Then the **o** is the orientation

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		(n/nw/e/se etc.) and **t is the type** (**i** means internal, **u** means underground, and no letter means external).
Floors	**z#/##/ft**	Similar to walls, the first two groups of figures identify the zone. This is followed by an **f** for floor and then the **type t** (**i** for internal floor, **e** for external space, and no letter for ground floor).
Ceilings/ roofs	**z#/##/ct**	Similar to walls, the first two groups of figures identify the zone. This is followed by **c** for ceiling and **t is the type** (**i** is for internal ceiling and no letter means the ceiling has no occupied space above it, i.e., it is, in fact, a roof).
Window	**z#/##/ot/g**	The first three groups of figures identify which envelope the window is attached to, as described above. The **g** stands for glazing.
Door	**z#/##/ot/d**	The first three groups of figures identify which envelope the door is attached to, as described above. The **d** stands for door.
And for all the above elements	**(name).#**	If there is more than one element which would have the same name following the above nomenclature, "**.1**" is added for the second element and "**.2**" is added to the third, etc. For example, if there were two north walls in a zone (z0/01), with the same orientation and type, then the first wall would be named "z0/01/n" and the second would have a ".1" added to the end and therefore be named "z0/01/n.1".

Table 6: Suggested MBEAT nomenclature

See Table 7 for examples.

Name	Description of element
z0/01	Zone 01 on the ground floor (0)
z0/01/n	First North facing external wall of zone 0/01
z0/01/n.1	Second North facing external wall of zone 0/01
z0/01/n.2	Third North facing external wall of zone 0/01
z0/01/ni	A North facing wall of zone 0/01, which is internal
z0/01/nu	A North facing underground wall of zone 0/01
z0/01/n/g	Glazing in the North external wall of zone 0/01
z0/01/n/d	Door in the North external wall of zone 0/01
z0/01/f	Ground floor of zone 0/01
z0/01/fi	Internal floor of zone 0/01, i.e., there is an interior space below
z0/01/fe	External floor of zone 0/01, i.e., there is an exterior space below
z0/01/c	Roof of zone 0/01, i.e., there is an exterior space above
z0/01/ci	Ceiling of zone 0/01, i.e., there is an interior space above

Table 7: Examples of building element names

Recommendations if you set up your own nomenclature:
- Use names which link subordinate parts of the construction (e.g., windows) to the element of which they are part (e.g., walls).
- Incorporate reminders about major distinctions like whether the wall is internal or external, or unusual features like suspended floors over an exterior space.
- Choose characters which avoid using shift keys, e.g., avoid capital letters.

Other points on naming:
- If you use the *Quick Envelopes* (see Section 7.5.8) to create the walls, roofs, floors, ceilings, and windows, the names are created automatically for you based on the name

you gave to the zone to which they are attached. If you follow the suggested nomenclature for the zones, the names for the walls/floors/windows, etc., will be exactly as described above. If you choose another way of naming your zones, the above endings will be added to your zone's name. For example, if you named your first zone, "room1", then the first north wall created for that zone would be automatically called "room1/n".

- It is not possible to have two elements with the same name. If you try to use the same name twice, MBEAT automatically renames the second element for you. For example, if you attempt to create a second zone named "z0/01" or a second wall named "z0/01/n", MBEAT will rename them "z0/01.1" and "z0/01/n.1", respectively.

- If you use the "Copy Record" function, a name is generated automatically for you. For example, if you copy zone "z0/01", the new zone will be automatically named "z0/01.1", which you can later rename. However, any building objects (i.e., envelopes, windows, doors) assigned to the zone, which are also copied as a result, retain the same names as those which they are copied from (e.g., z0/01/n, z0/01/n/g, etc). It is recommended that you appropriately rename any copied elements.

3.5.2. Naming constructions and building services systems

As there are generally far fewer constructions and building services systems in a building, such a methodical nomenclature system, as that recommended for the geometrical definition of the building, is not generally required, as long as the names you give them are unique, for e.g., do not give the same name to two different constructions in the *Project Database* form. However, names which clearly identify the type and/or use of the construction or building services system are recommended.

4. MBEAT BASICS – GETTING STARTED

This chapter will show you how to install and open MBEAT, start a new project or open an existing project, and finally, close the application correctly.

There is an example building model that is installed automatically with the tool, which you can use as a tutorial. It is a simple, two storey, rectangular building to demonstrate the different aspects of the application. Details of this building can be found in APPENDIX A:.

4.1. System Requirements

The current version of MBEAT (MBEAT_v4.1.h.mdb) runs on Microsoft Access 2003 onwards. If you do not have a 'full' version of Microsoft Access on your computer, installing a run-time version would be sufficient for running MBEAT. A run-time version of Access 2007 is available for download free from the Microsoft website[ii].

We recommend at least 512 MB RAM on your computer to run the application. To view all of the output documents produced by MBEAT, you will also need Microsoft Internet Explorer, Microsoft Excel, and Adobe Acrobat Reader installed on your computer.

There is a version of MBEAT specifically for Access 2007 users in addition to the version for Access 2003 users. Please ensure that you download and install the MBEAT version suitable for your version of MS Access.

The approved version of MBEAT has been developed to work on a Windows platform only (Windows XP, Windows Vista, and Windows 7). Unfortunately MBEAT is not compatible with Mac or Linux. MBEAT itself will run on most platforms as it is standard C++ and, subject to funding, can be compiled in Mac or Linux, but the MBEAT interface is a Microsoft Access application which will not run on Linux or Mac operating systems.

NB: Ensure that you have full read and write access permissions on the NCM folder (on the C:\ drive), where MBEAT is installed by default on your computer. If you are unable to do this, you need to contact the IT department of your company and ask them to adjust your settings to give you full read and write access rights on the NCM folder on your computer.

4.2. Installing MBEAT on your computer

The current version is: **MBEAT_v4.1.h**.

How to install MBEAT:

1. Go to the appropriate website for downloading the software as advertised by the Ministry of Energy and Public Affairs..

2. Click on the hyperlink to download the tool.

3. Save the **MBEAT_v4.1.h.exe** file to a folder of your choice on your hard drive (**do not try to open the file at this point**), such as the Desktop.

4. Once the download is complete, double-click on the **MBEAT_v4.1.h.exe** icon, and then click on "**Unzip**' to initiate the self-extracting process. This will automatically install the application in a new folder on your hard drive (default folder: **C:\NCM**). You may change the installation path if you wish.

[ii] http://www.microsoft.com/downloads/details.aspx?familyid=d9ae78d9-9dc6-4b38-9fa6-2c745a175aed&displaylang=en

5. Once the file has been unzipped to your hard drive, the message "xx file(s) unzipped successfully" will appear (xx is the number of files and may change with future versions of the tool). Click on '**OK**', and then close the **WinZip** Self-Extractor window (click on '**Close**' or on the cross in the top right hand corner of the window).

   MBEAT is now installed on your computer.

6. To locate MBEAT on your computer, open **Windows Explorer**, and navigate through the following (assuming the default installation path was not changed):

   My Computer

   C:\ (drive)

   NCM\

   MBEAT_v4.1.h

MBEAT_v4.1.h.mdb (the tool itself) along with all of its associated databases and files are located within this folder (MBEAT_v4.1.h). <u>**NB:**</u> For users of Access 2007, the Microsoft Access file is called **MBEAT_v4.1.h.accdb**.

NB: If you changed the installation path (in step 4), the tool will be located in:

your selected path\MBEAT_v4.1.h.

TIP: You may wish to create a shortcut to the "MBEAT_v4.1.h folder" on your **Desktop** or elsewhere in your system so that you can access it more easily. To create a shortcut on the Desktop, right-click on the MBEAT_v4.1.h folder, select "Send to" and then "Desktop (create shortcut)".

4.3. Opening MBEAT

After installing MBEAT and double-clicking on the "MBEAT_v4.1.h" folder, you will be presented with the window in Figure 8. In order to start the application, you will need to double-click on the Microsoft Access file called **MBEAT_v4.1.h.mdb**. <u>**NB:**</u> For users of Access 2007, the Microsoft Access file is called **MBEAT_v4.1.accdb**.
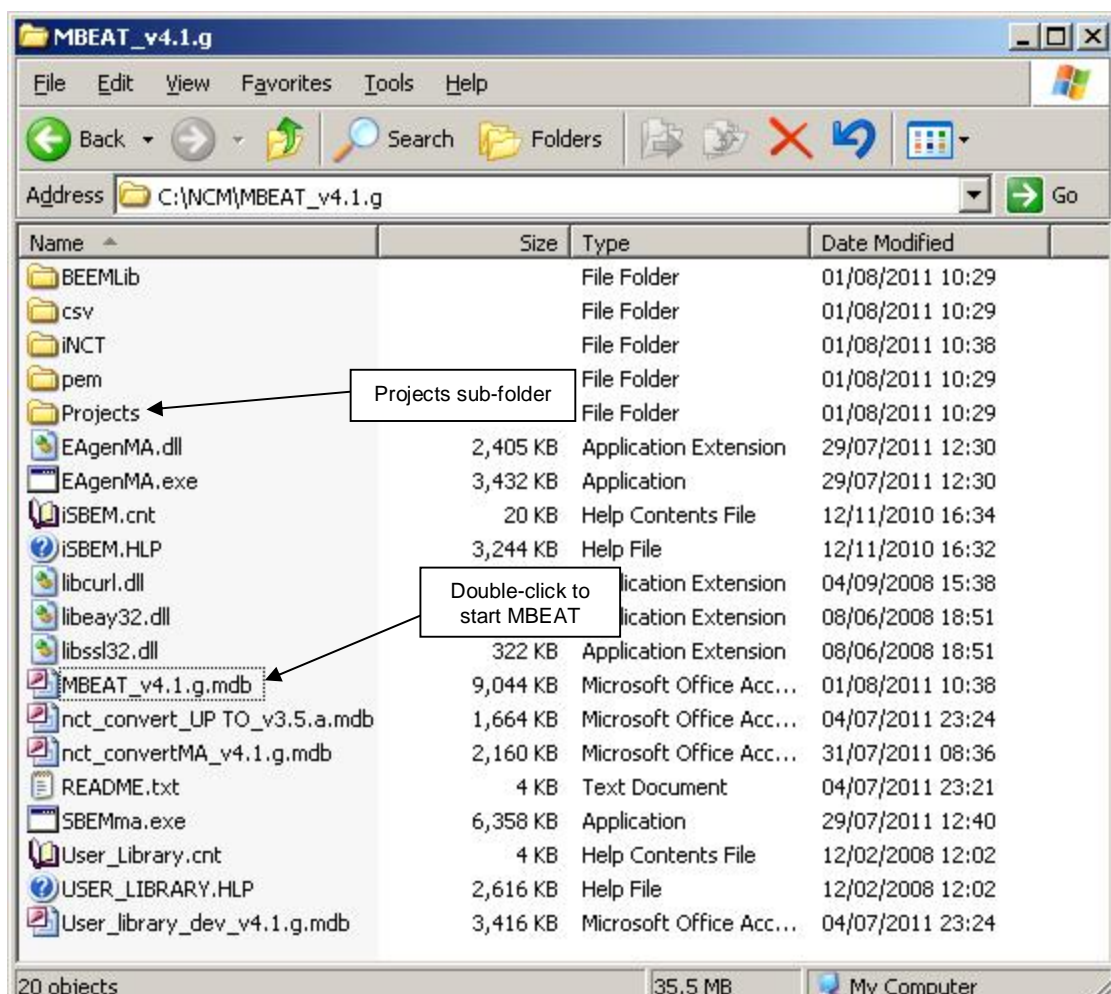
Figure 8: Location of the MBEAT Microsoft Access file and Projects folder

The first time that the application is opened, a dialogue box will appear containing MBEAT's licensing terms and conditions (Figure 9). You will need to accept the terms and conditions before you can proceed. If you tick the "Don't show this message again" box, this window will not appear again on starting the application.
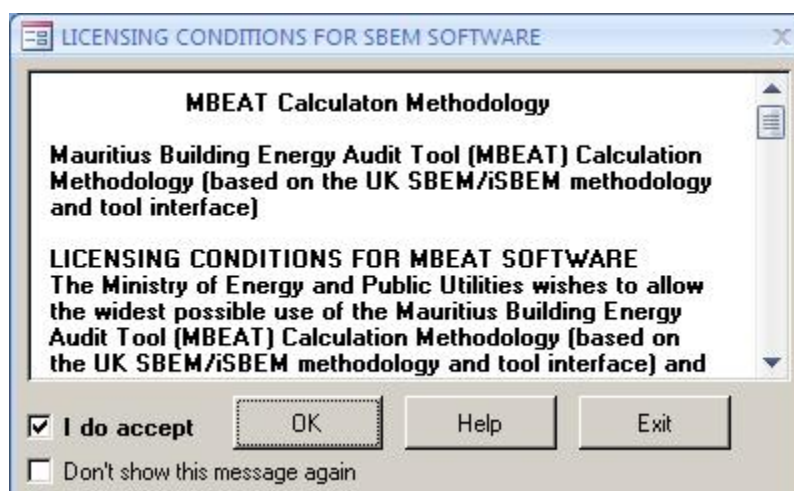
Figure 9: Terms and Conditions dialogue box

4.4.   Creating new and opening existing projects

When the terms and conditions have been accepted, a new window will appear which gives **three** "MBEAT Start-up Options" (Figure 10):
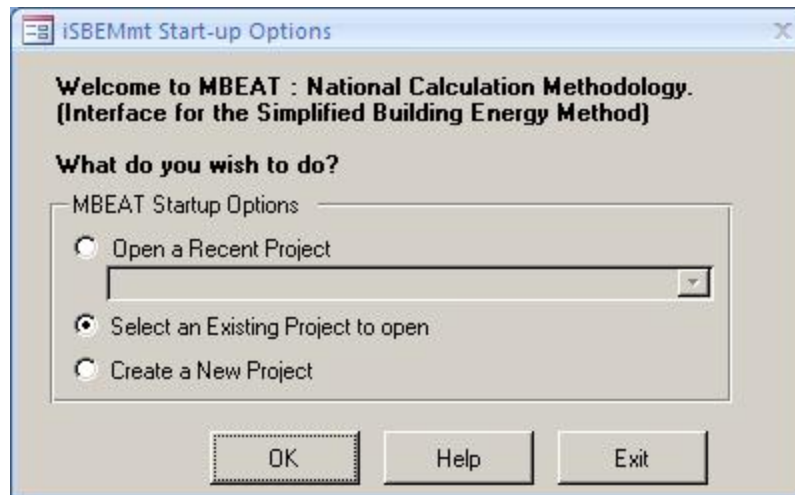
Figure 10: MBEAT Start-up dialogue box

1. **Open Recent Projects** – This option has a drop-down menu which contains the 5 most recently-opened projects.
2. **Select an Existing Project** – Selecting this option and clicking on "OK" opens the "Open File" dialogue box, allowing you to browse through your network/computer to locate a project. It is set to automatically open in the "Projects" sub-folder within the MBEAT_v4.1.h folder.
3. **Create a New Project** – If this option is chosen, the "Save New Project" dialogue box appears, and you need to do the following:
   a. Click on the "Create new folder" button on the top right hand side of the "Save New Project" dialogue box, enter the project's name as the name for the folder, and then click on "Open".
   b. Click into the "File Name" field and enter the project name again and click on "Save". (This folder and project file will be saved to the MBEAT "Projects" folder by default – see Figure 8).
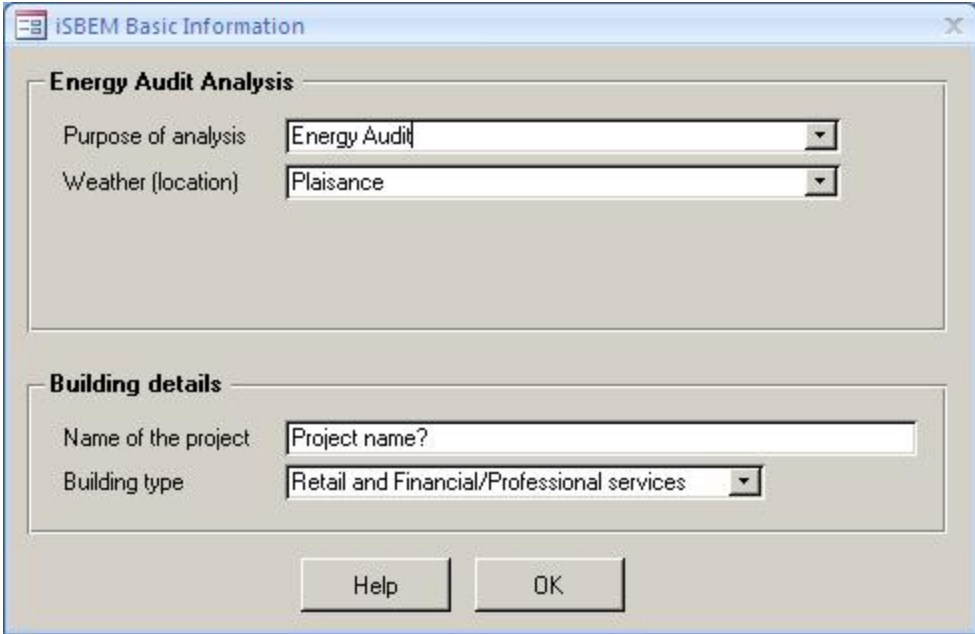
   NB: It is recommended practice to create a sub-folder for each project (inside the Projects folder) in which all the project-related files are saved.

   c. A form then opens which allows you to enter some basic information about the project - see Figure 11. This includes:
      - Purpose of the analysis which will be carried out on the building, e.g., Energy Audit.
      - Audit type – whether 'Assessment of current performance' or 'Assessment of improved performance'.
      - Weather location (pick the closest to your site from the available locations – there are currently 2 locations for Mauritius: Plaisance and Vacoas).
      - Name of the project.
      - Building type - The choice of building type here sets the default building type for the activity areas that you will define later. You will, however, be able to change the building type for each of the activity areas when you come to define them. At

this point, you should choose the building type that most closely defines the majority of the building.

You will be able to edit all this information at a later stage in the *General* form (Section 7.3: General form) if you wish.

NB: The domestic type activities available under the building type "Residential spaces" in MBEAT are to allow the energy calculations for energy audit for a building which contains residential accommodation above a non-domestic space (e.g., a shop or a pub) provided that the residential space can only be accessed from within the non-domestic space, i.e., the residential part is not designed or altered for use as a separate independent dwelling. These are the **only** cases where MBEAT can be used to model domestic areas.

Figure 11: MBEAT Basic Information form

4.5. Closing MBEAT

There are two ways to close MBEAT (circled in Figure 12):

1. Go to the *General* form and click on "Exit MBEAT".

2. Go to the *General* form and click on the cross in the corner of the MBEAT screen (the smaller window inside the main Microsoft Access window).*

****It is <u>not</u> advisable** to exit by clicking the cross in the corner of the main Microsoft Access screen.

What to do if you close the application incorrectly, or if there is a power cut

If you click on the cross in the corner of the main Microsoft Access screen, your work will not be saved to your project file, but stored within a temporary file until the next time you open the interface. When you do open the interface next, you will be presented with the "MBEAT Project Recovery" dialogue box. It asks you whether you want to continue working with the last project which was not closed properly. Click on "Yes", and then, when you are in the *General* form, click on "Save". If you click "No" here, **all** your changes will be lost. If there is a power cut, your work

will be saved into the temporary file as described above, and you should follow the same instructions for recovering your data.

Figure 12: General form showing the correct ways of closing MBEAT

After clicking on either of the 2 options (circled in Figure 12), the MBEAT "END" dialogue box (Figure 13) will open to ask you whether you want to save your changes to the project. The project will be saved to the location determined when you clicked on "Create a New Project" as the project was first entered (the default location was the "Projects" sub-folder within the "MBEAT_v4.1.h" folder).
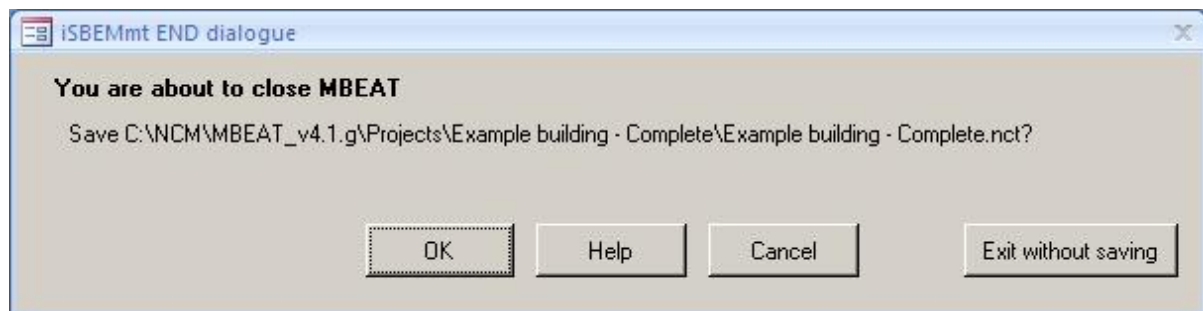
Figure 13: The MBEAT END dialogue box

After you have chosen to save or exit without saving, the MBEAT "END" (Figure 14) dialogue box will open. To exit, click on the button in the centre of the dialogue box.
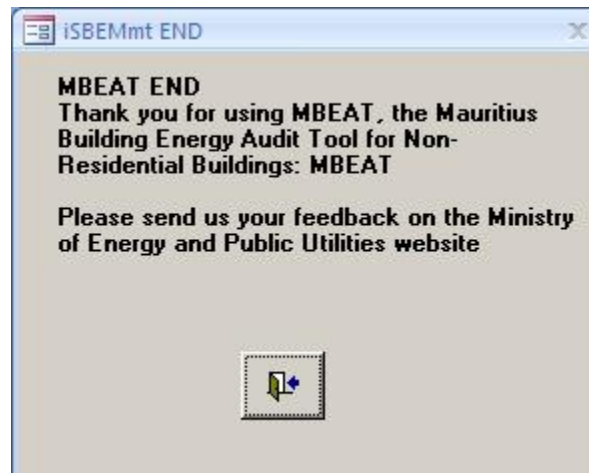
Figure 14: MBEAT END dialogue box

5. TOUR OF MBEAT

The interface consists of a number of screens into which the data for a building needs to be entered in order to model your building. This chapter gives an overview of these screens.

5.1. Introduction to the main forms in MBEAT

The MBEAT opening screen (Figure 15) gives access to the following main forms:
- **General**
- **Project Database**
- **Geometry**
- **Building Services**
- **Ratings**
- **Building Navigation**
- **About MBEAT**

Within each of these forms, there are various tabs and sub-tabs as shown in Figure 15.
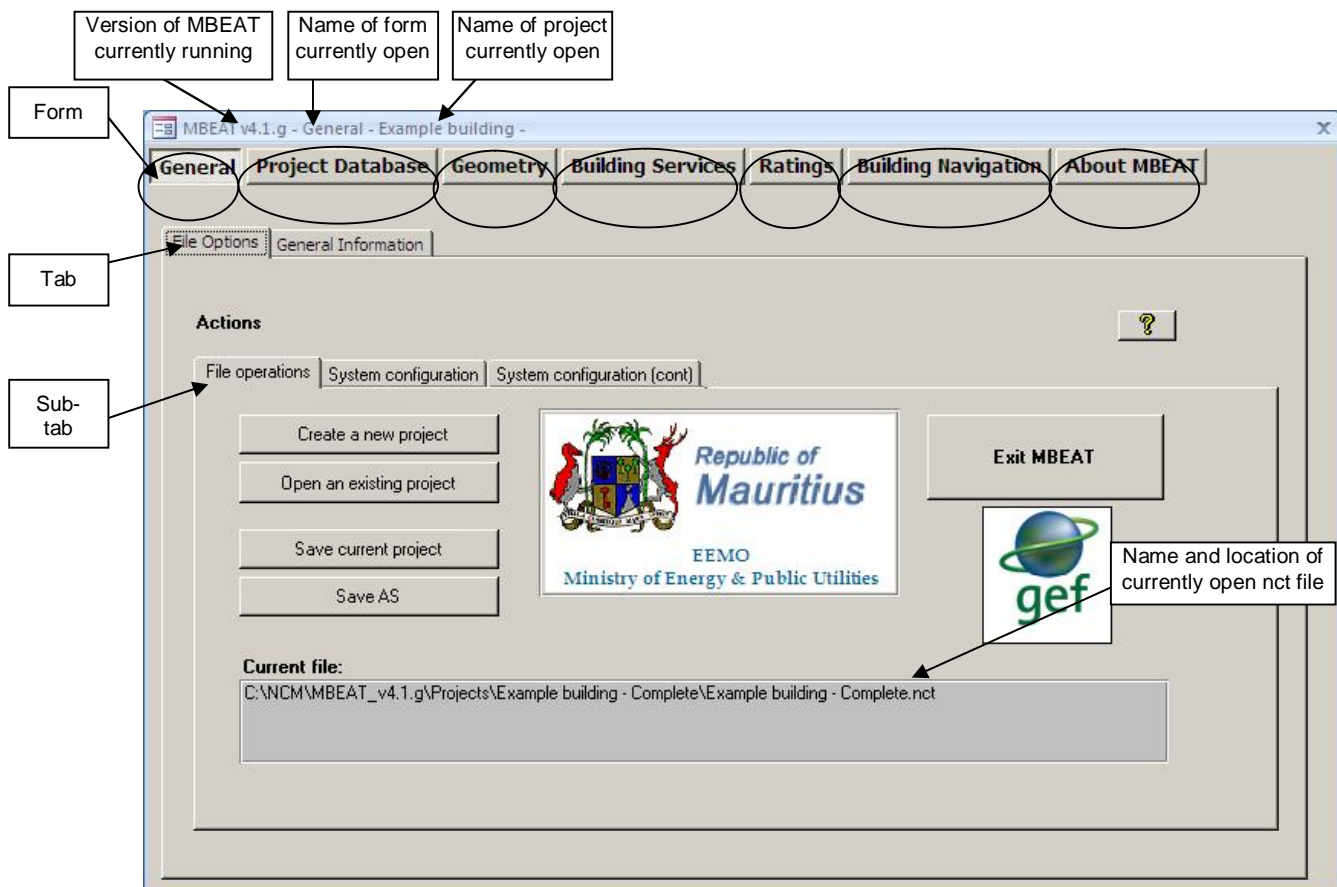
Figure 15: The main forms in MBEAT

As can be seen in Figure 15, the top blue bar of the window displays the version number of MBEAT you are using, the name of the form currently open, and the name of the project. This bar is always visible in all the form, tabs, and sub-tabs of the interface.

Below is a summary of the data which needs to be entered into each form:

General: The *General* form is where projects can be saved and opened. General information relating to the project can also be recorded here, such as the name and address of the project, weather data, and details about the building's owner and energy auditor. This information may have already been entered when the project was first created (see Section 4.4: Creating new and opening existing projects, under 'Create a new project'), but they can be edited here.

Project Database: The *Project Database* form is where the glazing and construction details of your building fabric are entered.

Geometry: The *Geometry* form is where the activity, size, and orientation of the "zones" are entered. Each zone requires a description of the walls, floor, roof/ceiling, doors, and windows which comprise its envelopes.

Building Services: The *Building Services* form is where all the building's systems are described, including: HVAC, HWS, PVS, SES, Wind, and CHP systems. Further information on the lighting and ventilation characteristics specific for each zone is also input through this form.

Ratings: The *Ratings* form is used to carry out the energy performance calculation, access the results, and obtain the Energy Audit report. The only data entry in this form is related to modifying the energy efficiency recommendations for the Energy Audit.

Building Navigation: The *Building Navigation* form provides a hierarchical summary of all the building objects that have been defined, assigned and unassigned, along with key details on some of the objects. There is no data entry in this form.

About MBEAT: The *About MBEAT* form displays the licensing conditions for the software. There is no data entry in this form.

5.2. Hierarchy of forms, tabs, and sub-tabs in MBEAT

Detailed information on each of the forms, tabs, sub-tabs, and sub-forms within them is provided in the sections indicated below:

Form Tab *Sub-tab* *Sub-form*	Section
General	**7.3**
File Options	
File Operations	
System Configuration	
System Configuration (cont.)	
General Information	
Project Details	
Special Considerations	
Building Details	
Energy Auditor Details	
Energy Auditor details	
Owner Details	
Project Database	**7.4**
Constructions for Walls	
General	
Assigned	
Constructions for Roofs	

General *Assigned* **Constructions for Floors** *General* *Assigned* **Constructions for Doors** *General* *Assigned* **Glazing** *General* *Assigned*	
Geometry **Project** *General and geometry* **Zones** *General* *Envelope Summary* *Quick Envelopes* **Envelopes** *General* *Windows Summary* **Doors** *General* **Windows and rooflights** *General*	**7.5**
Building Services **Global & Defaults** *HVAC System Defaults* *Services Management* **HVAC Systems** *General* *Heating* *Cooling* *Systems Adjustments* *Bi-valent Systems* *Zone Summary* **HWS** *General* *Storage & Secondary Circulation* *Assigned* *Bi-valent Systems* **SES** *Collector Parameters* *Solar Storage & Collector Loop* *Auxiliary Energy & Distribution Losses* **PVS** *General* **Wind Generators** *General* **Transpired Solar Collectors** *General* **CHP Generator** *General* **Zones** *HVAC and HWS Systems* *Ventilation* *Ventilation (cont.)* *Exhaust* *Lighting* *Lighting Controls*	**7.6**

Display Lighting
        TSC
   Meters
        General		

Ratings
   Energy Audit
        Building Rating
        Graphic Rating
        Recommendations
        Audit Trail
                Construction
                Geometry
                HVAC & HWS
                Lighting
        Calculation Logs
                SBEMma.log
                EAgenMA.log
        Calculation Errors
                SBEMma.err
                EAgenMA.err
        Supporting Documents
		8.1

Building Navigation
   Selections
   Object Properties
		7.7

About MBEAT		**7.8**

Table 8: Structure of the forms, tabs, and sub-tabs in MBEAT

6. BASIC MBEAT FUNCTIONALITY AND THE HELP MENU

6.1. Basic interface functionality and buttons

Within the *Project Database*, *Geometry*, and *Building Services* forms, you are required to enter information about various aspects of the building. The *Project Database* form requires you to enter the information about the properties of each of the construction and glazing types. The *Geometry* and *Building Services* forms require you to enter details about the zones, their envelope elements, windows, and doors and all of the building services systems found in the building (all these items are shown in Figure 5: Structure of MBEAT objects).

All of these items are 'records' within the interface, and there is a *General* sub-tab**,** like the one shown below (Figure 16), for each, where you can view, add, delete, and edit them.

Within MBEAT, there is an alternative way of entering some types of records, in particular, the envelope elements and windows. These can be entered using the *Quick Envelope* sub-tab. The functionality of this and any other screens in MBEAT will be explained in the relevant sub-section of Chapter 7.

The majority of the buttons and functionality of MBEAT can, however, be demonstrated by the *General* sub-tab (Figure 16).
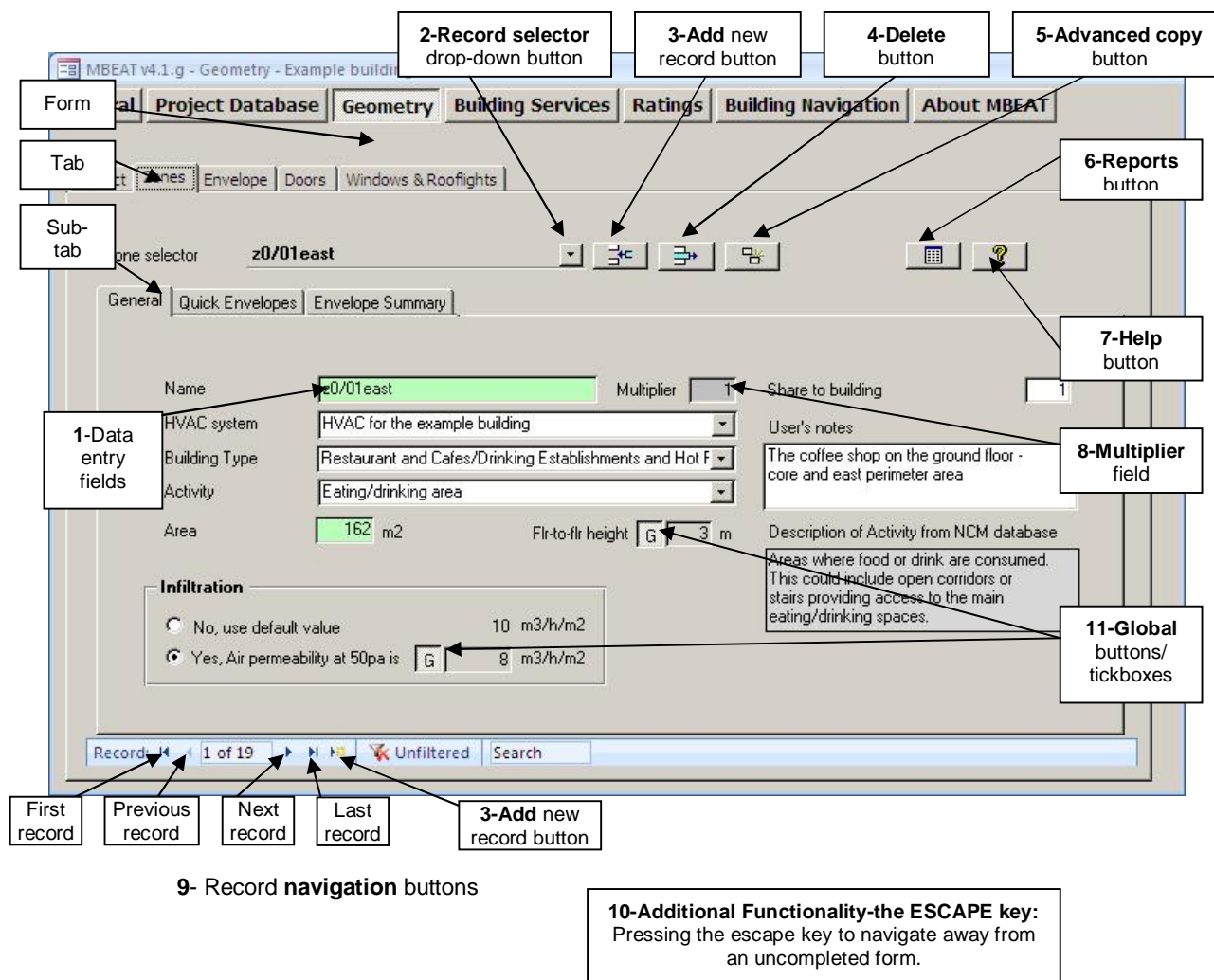
Figure 16: A General sub-tab: basic commands and buttons

1. Data entry fields

The data entry fields in MBEAT require the user to either enter text/numbers or select an option from a drop-down menu. Some of the fields have a green background. These fields are mandatory and <u>must</u> be filled in before proceeding to the next record or navigating away from that screen.

2. Record selector button ▾

Clicking on the record selector drop-down button produces a drop-down list of all of the records in that sub-tab. For example, in the *Project Database* form > *Constructions for Walls* tab, clicking on the record selector drop-down button displays all of the constructions for walls that have already been defined in that project.

To the right of the name of the record, there is further information about the parent building objects for that record. For example, in the *Zones* tab, clicking the record selector button displays all of the zones in the building along with the HVAC system with which each zone is associated (the HVAC system that serves the zone).

Extra features:

"Copy single object" function (this function will be available in future versions of the tool): The first entry in the drop-down list begins with "Choose action or X from the list" where X can be a construction, zone, wall, HVAC system, etc. The only action currently planned to become available is to "Copy a single object". This will allow (when it becomes functional in future versions) the user to copy only the selected object with none of its associated/child objects (To copy the object and all of the associated objects, you will need to use the "Advanced Copy" button, which is discussed below).

3. Add new record button

If you hover over this button with the mouse cursor, the text "Click here to insert a new X" will appear, where X could be a construction object, zone, HVAC system, etc. You can also click on the "Add new record" button at the bottom of the screen. You will then be prompted to enter a name for the record. Once you have done this, press on the **Tab** or **Enter** button on your keyword. You will then be able to start entering the rest of the information necessary for that record.

NB: The name should be entered in the "Name" field. Do **not** try to add a name in the "Record selector" field.

4. Delete record button

If you hover over this button with the mouse cursor, the text "Click here to delete current X" will appear. To delete a record, select the record you want to delete from the drop-down "Record selector" menu, and click on the "Delete" record button. Not only will the record be deleted but any associated sub-objects as well. For example, if you delete an envelope element, any associated windows and doors will also be deleted (If a Microsoft Access message box appears showing "Reserved error" or "No current record", click on "OK" to proceed). A dialogue box will then appear to confirm that you intend to delete the record. Any deletion cannot be undone. It is very important that you determine which associated sub-objects are going to be deleted at the same time. If you are sure you want to delete the record and all its associated records, click on "Yes".

5. Advanced copy button

The "Advanced Copy" button is available in the *Geometry* and *Building Services* forms. By clicking on this button, the selected building object, along with all of its associated sub-objects, are copied. The new record is given a name automatically. For example, if you copied an envelope named X, a new envelope would be created and named "X.1". At the same time, all of its associated objects would also be copied. For example, if an envelope element were copied, any associated windows and doors would also be copied. The copied windows and doors, however, keep the same name as those they were copied from. For a zone, this would mean all of its associated envelope elements, windows, and doors would be copied, and if any HVAC systems were copied, so would every associated zone, along with all of its envelope elements, windows, and doors.

If you need to only copy the selected record and not any of its sub-objects, use the copy single object function found in the record selector menu (this function will be available in future versions of the tool).

6. Reports button

Clicking on the "Reports" button produces two reports: the *Data Summary* report and the *Unassigned Objects* report. These reports are for double-checking the data entered. For more details on these two reports, see Section 7.9: Double-checking the data.

7. Help button

The "Help" button can be found in the top right hand corner of every sub-tab of MBEAT. Clicking on this button opens the Help menu (see Section 6.2: MBEAT Help, for further information).

8. Multiplier field

If there is more than one identical zone, for example, this field allows the user to only define it once and then enter the number of these identical zones that exist in the building. Remember that this would also "multiply" all of its associated envelope elements, windows, and doors during the calculation.

9. Record navigation buttons

These buttons allow you to scroll through the records in that sub-tab quickly.

10. The Escape key – navigating away from incomplete records

Once a new record has been created, MBEAT will not allow you to navigate away from that screen until you have completed all the mandatory fields (all the green fields). MBEAT does not have default values for these fields, and they are needed for MBEAT to carry out its calculations. If you need to navigate away from the screen before it is completed, press the **Escape** key on your keyboard.

11. The Global buttons or tick boxes

Global buttons and tick boxes allow you to use previously defined 'global' values for a variety of parameters. For example, in Figure 16 , the global 'air permeability at 50pa' button is pressed in. This means that the current record (in this case, zone z0/01east) takes the previously defined 'global' air permeability value (this global value is defined in the *Geometry* form > *Project* tab > *General and Geometry* sub-tab – see Table 9: Global parameters).

When the Global button or tick box is not pressed in or ticked, you are able to enter a value specifically for that record. Table 9: Global parameters - shows the global parameters available in MBEAT, where they are defined, and where they are later used.

Parameter	Global value defined:	Location of Global button or tick box
Air permeability	*Geometry* form > *Project* tab > *General and Geometry* sub-tab	*Geometry* form > *Zones* tab > *General* sub-tab
Zone height	*Geometry* form > *Project* tab > *General and Geometry* sub-tab	*Geometry* form > *Zones* tab > *General* sub-tab
Condition of adjoining space for envelope elements	*Project Database* form > *Construction for Walls* tab > *General* sub-tab	*Geometry* form > *Envelope* tab > *General* sub-tab

	Project Database form > *Construction for Floors* tab > *General* sub-tab	*Geometry* form > *Zones* tab > *Quick Envelopes* sub-tab
	Project Database form > *Construction for Roofs* tab > *General* sub-tab	

Table 9: Global parameters

6.2. MBEAT Help

MBEAT Help can be accessed in two ways:

1. By pressing the "Help" button which appears on every sub-tab in the interface as described in Section 6.1. This opens the "Help Topics" window from which you can navigate to the item of interest (see Figure 17).

2. By clicking into the field of interest and pressing the **F1** key on your keyboard. This opens the specific Help entry relating to that particular field in the "Help Entries" window (see Figure 18). From there, you can click either "Contents", "Index", or "Find" to open the "Help Topics" dialogue box.

There are Help entries on each of the fields in the interface, and there is a selection of "How to" entries, such as, how to close MBEAT, how to name the building objects, or how to go about describing a roof. Most of this information can also be found in this User Guide.

Help Topics window (Figure 17)

All of the Help topics are listed in the "Help Topics" window. It contains three screens from which you can navigate to your chosen topic: the "Contents" screen, the "Index" screen, and the "Find" screen.

- The "Contents" screen lists all the entries under the MBEAT form, tab, or sub-tab to which they relate or under the "How to.." menu.
- The "Index" screen lists all the entries in alphabetical order.
- The "Find" screen contains a search facility which brings back all the Help entries which contain, in their contents, a given word or phrase.

Entries listed under the form/tab/sub-tab to which they relate or under the "How to…" menu.

Entries listed in alphabetical order

Find facility – allows the user to search for a given word or phrase in the content of the Help entries.
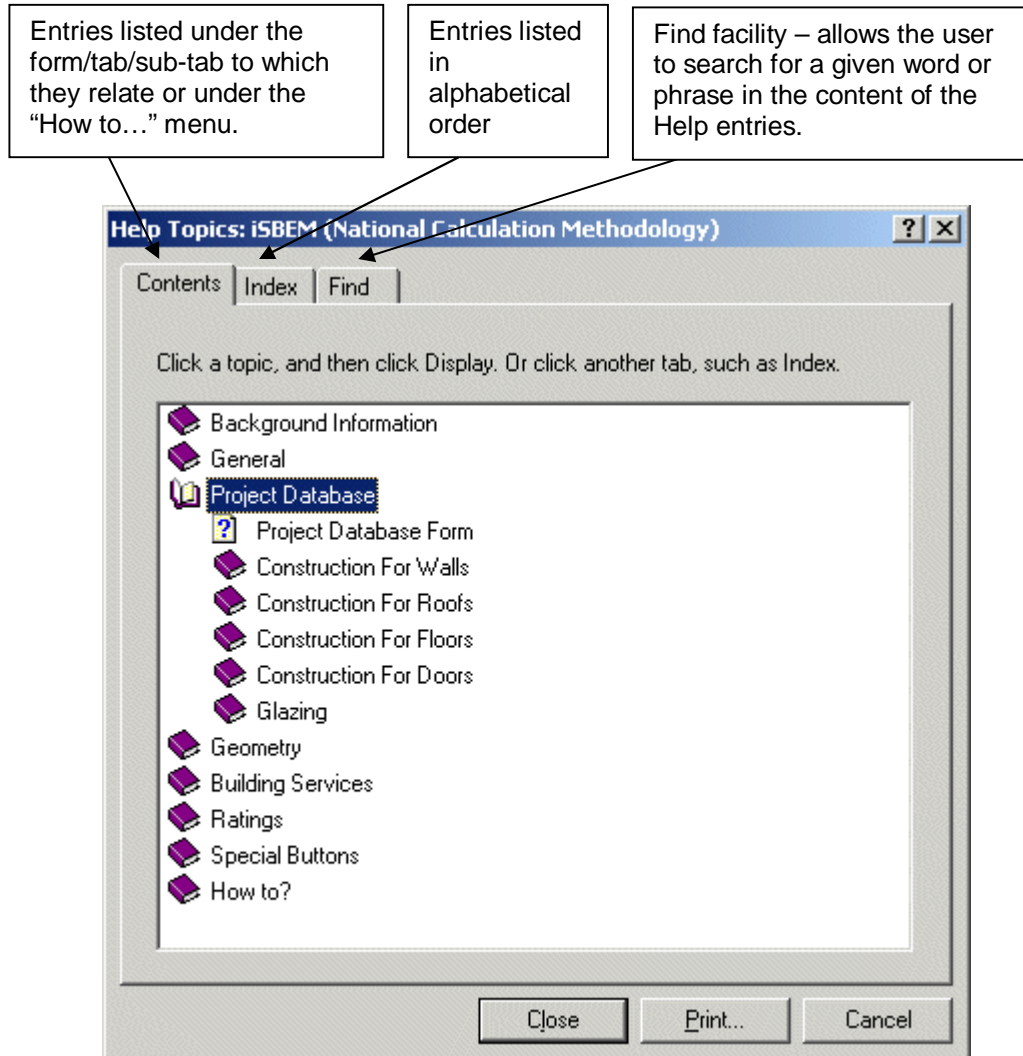
Figure 17: Help Topics window

Help Entries window (Figure 18)

Double-clicking on the item of interest in the "Help Topics" window, or clicking on **F1** on your keyboard, while the cursor is in the relevant field in the interface, opens the "Help Entries" window on the page of interest and closes the "Help Topics" window. Within the "Help Entries" window, it is possible to scroll through the "Help Entries" using the scrolling buttons. Clicking on either the "Contents", "Index", or "Find" buttons opens the "Help Topics" window.
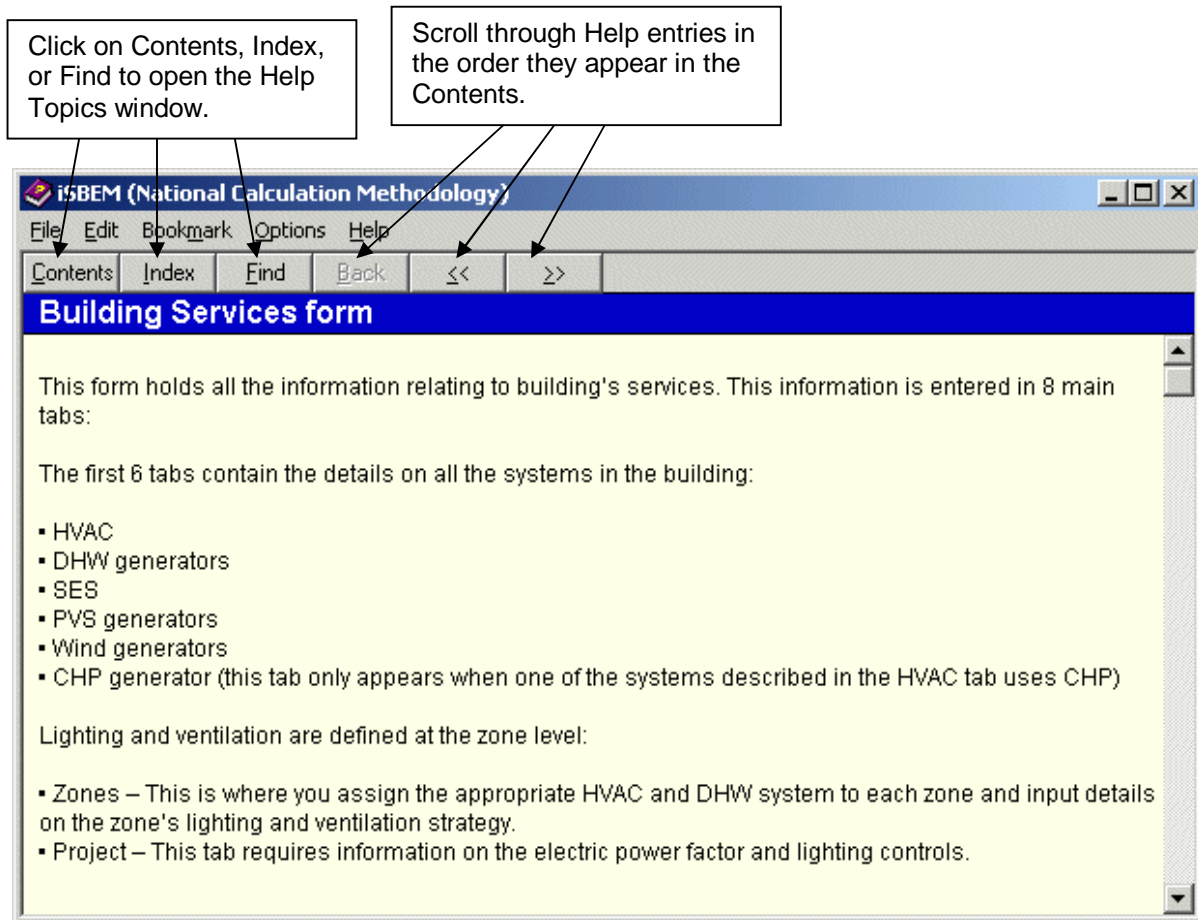
Figure 18: Help Entries window

7. ENTERING A BUILDING INTO MBEAT

This chapter takes you through each of the MBEAT data entry forms consecutively (the *General*, *Project Database*, *Geometry*, and *Building Services* forms), giving guidance on what information is required at each stage.

7.1. Order of data entry

Some items need to be defined before others in MBEAT. For example, the building fabric needs to be defined before the walls, doors, and windows can be fully described. This hierarchy between the different elements defined in MBEAT can be seen in Figure 5: Structure of MBEAT objects. However, there is a degree of flexibility too.

Figure 19 shows which elements need to be entered before others and also gives a suggested order of data entry. It is this order that is followed in the tutorial.
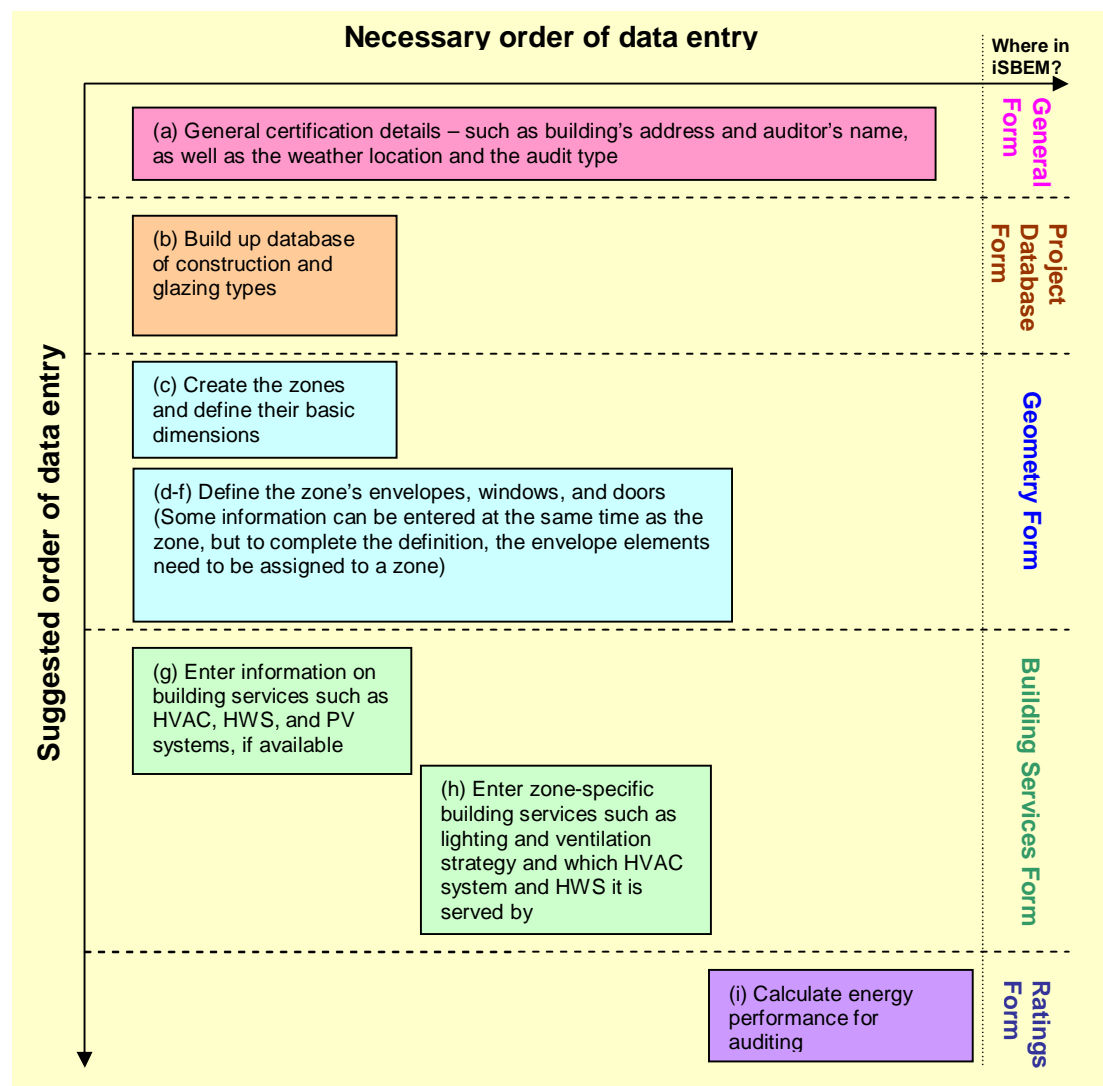
Figure 19: Order of data entry

(The stages, indicated by the letters in Figure 19 (a – i) correspond to the stages described in Section 2.5: Overview of how a building is defined in MBEAT).

7.2. Important note on the default values in MBEAT

In MBEAT, there are default values included for various parameters. For example, there are default seasonal efficiencies for HVAC systems and default constructions for envelope elements so that you can select them when defining the envelopes of a zone when learning how to use the tool. These default values are not generous (i.e., usually pessimistic), should be checked by the user, and, if appropriate, changed or added to.

7.3. General form

The *General* form contains the following tabs:
- **File Options** tab
- **General Information** tab

7.3.1. File Options tab

The *File Options* tab has the following sub-tabs:
- **File Operations** sub-tab.
- **System Configuration** sub-tab.
- **System Configuration (cont.)** sub-tab.

File Operations sub-tab:

This sub-tab contains the options to "Create a New Project", "Open an Existing Project", "Save current project", "Save As" (to save current project under a different name), and "Exit MBEAT" (shown in Figure 20). It also displays in the "Current file" box the name and location of the currently open project file (".nct" file).

Figure 20: The File Options tab in the General form

System Configuration sub-tab:
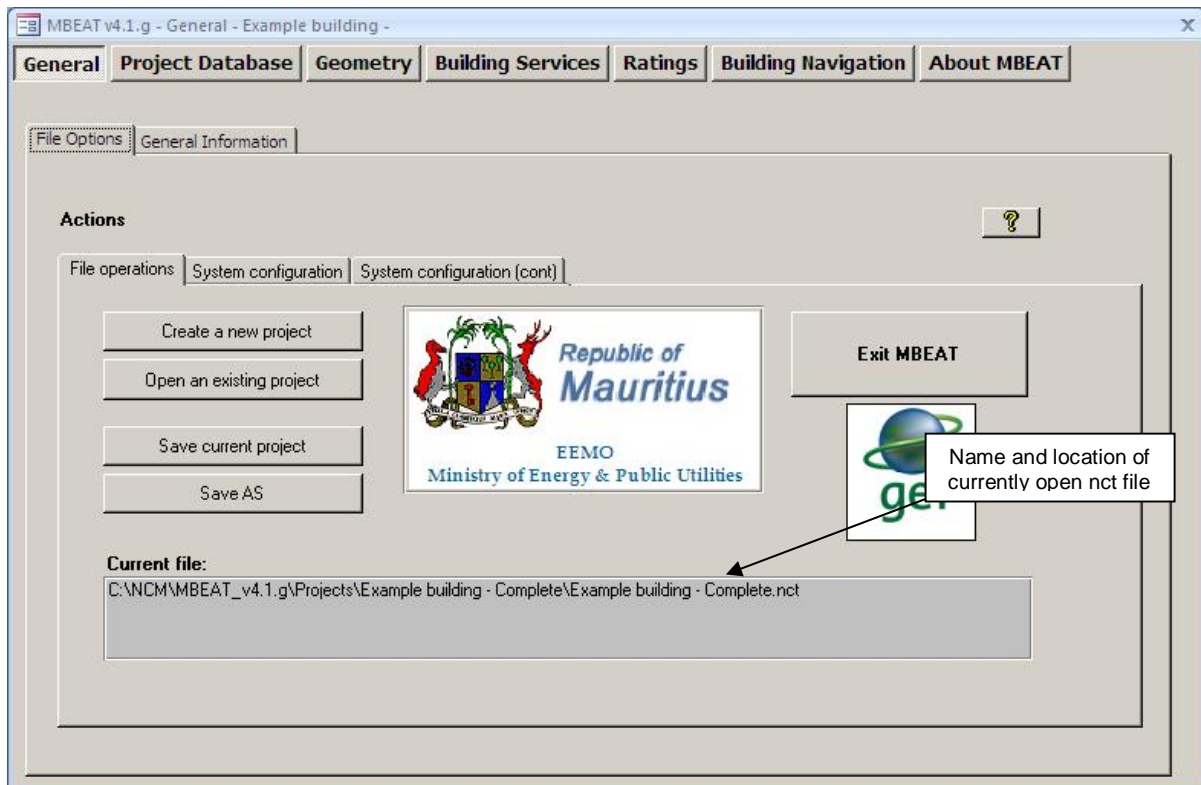
MBEAT creates different output reports (more details can be found in Chapter 8). Two of these reports have the file extension '.htm', i.e., they are in html format. In order for the htm files to be created for you to view (by accessing your web browser, e.g., Microsoft Internet Explorer), MBEAT needs to know the *Program Files* folder path on your computer. The default path (C:\Program Files\), shown in Figure 21, should be fine for most systems. If, however, you have a different configuration on your computer, and the reports are not created, you will need to manually edit the configuration in this tab to reflect the settings on your computer. When you tick the box "Tick to edit current configuration", the "Program Files folder" box will become active and you will be able to input the location appropriate for your computer configuration. If in doubt, contact your IT Department.

MBEAT also needs to know the folder where the projects and the MBEAT output reports will be saved. This is specified by the location of the *Projects* folder. The default path, shown in Figure 21, should be fine for most systems, where [App-Path] is the path where the application MBEAT has been installed on your computer (by default, C:\NCM\MBEAT_v4.1.h). If however, the reports are not created, or you have changed the location where MBEAT is installed by default, you will need to manually edit the configuration in this box "Project Files folder".
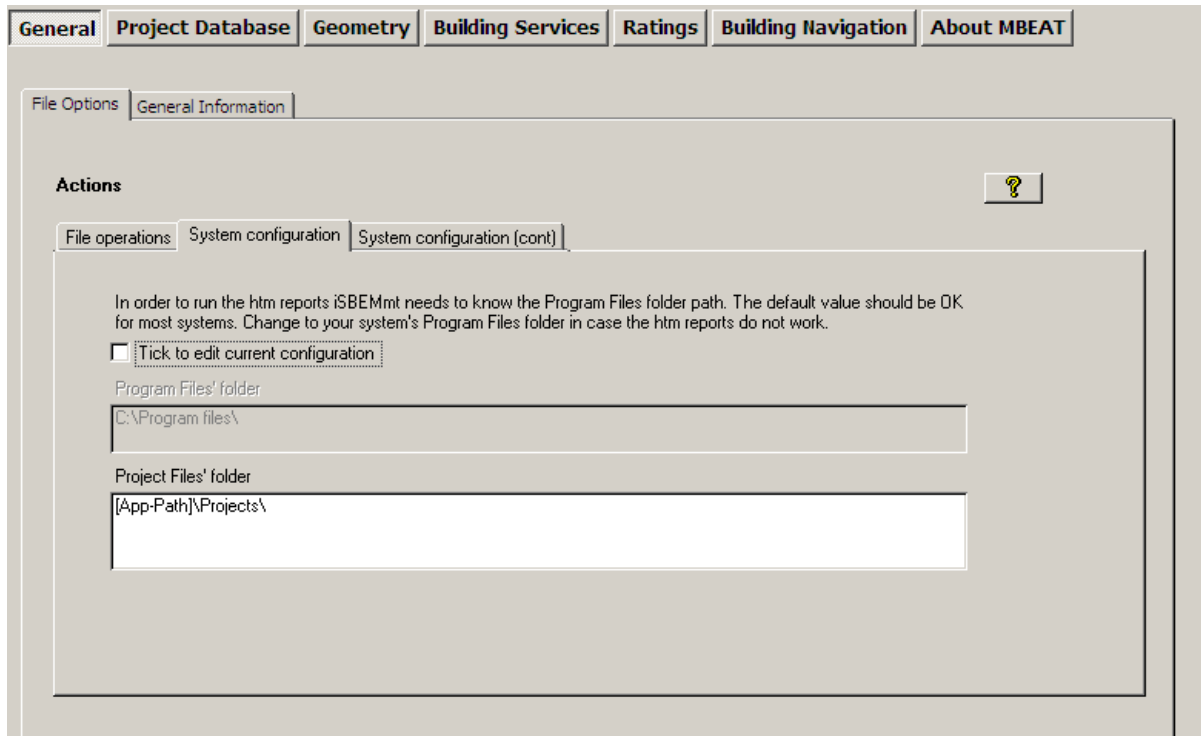
Figure 21: The System Configuration sub-tab

System Configuration (cont.) sub-tab:

This sub-tab (Figure 22) contains tick boxes which users can modify to reflect their preferences while using MBEAT:

1. Tick box which is unticked by default. You need to tick it if you would like MBEAT to generate the *Data Reflection* report (for the actual building) in html format (as well as csv format which is always done) during the calculation, and the relevant access button will appear in the *Ratings* form. If the box remains unticked, then this report will be generated in csv format only (see Section 8.2.2: Data Reflection Report – Actual Building), and the relevant access button in the *Ratings* form will remain invisible.

2. Tick box, which is ticked by default, and should remain ticked if you wish for the contents of the *Building Navigation* form to be refreshed automatically with any changes in the objects properties that might have been performed since the form was last accessed. If you do not wish for the *Building Navigation* form to be refreshed automatically, you should untick this box. There is a button in the *Building Navigation* form which you can click in order to initiate the "refresh" function manually (see Section 7.7: Building Navigation form).

3. Tick box, which is ticked by default, to automatically clear the contents of the *Quick Envelopes* sub-tab once the envelopes have been created (i.e., once the "create envelopes" button has been pressed). You can untick this box if you do not wish for the contents of the tab to be cleared (see Section 7.5.8: Quick Envelopes tab: Short cut to creating envelopes and windows).

4. Tick box, which is ticked by default, to allow the definition of the areas of glazing within envelopes to be input as areas, in m^2, rather than percentages in the *Quick Envelopes* sub-tab. If you wish to define glazing areas using percentages, then you can untick the box (see Section 7.5.8: Quick Envelopes tab: Short cut to creating envelopes and windows).
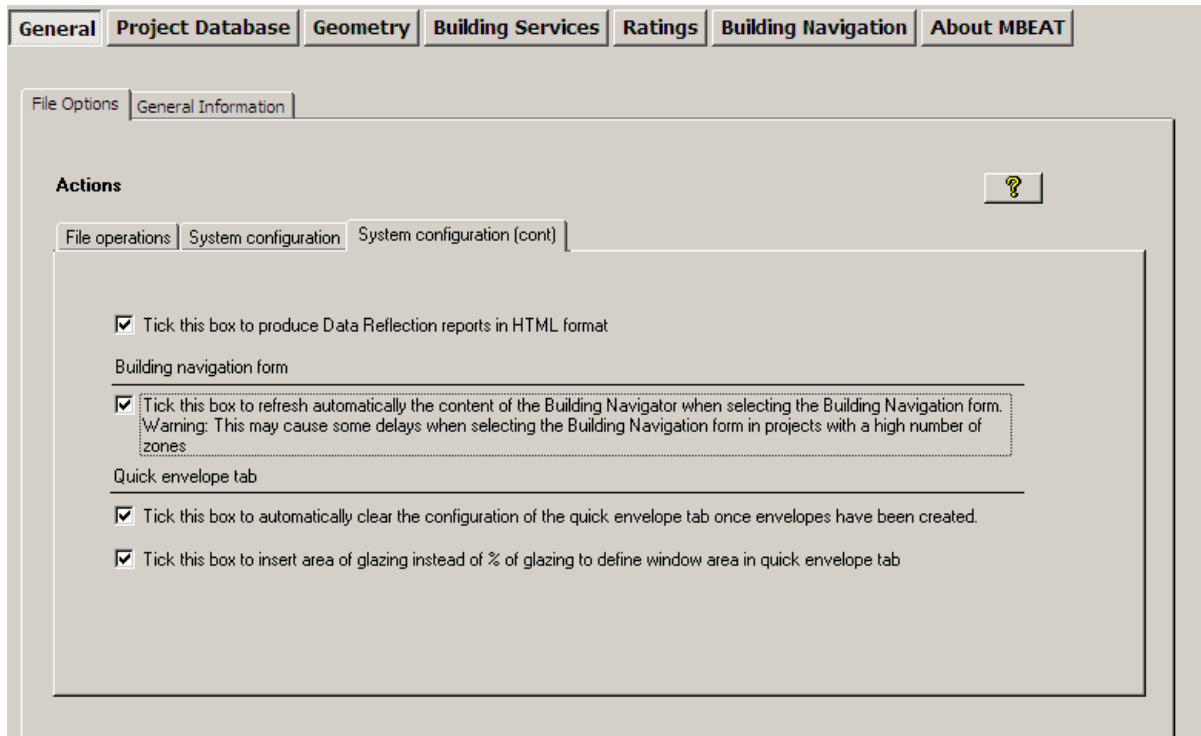
Figure 22: The System Configuration (cont.) sub-tab

7.3.2. General Information tab

The *General Information* tab contains four sub-tabs, as described below, where you can enter as much or as little background information about the project. However, there are also essential parameters to be selected, such as the weather location for the project and the purpose of the analysis. These details can be entered and edited in their respective tabs (see Figure 23). Some of this information may have already been entered when the project was first created (see Section 4.4, under 'Create a new project').

The *General Information* tab contains the following sub-tabs:
- **Project Details** sub-tab.
- **Building Details** sub-tab.
- **Energy Auditor Details** sub-tab.
- **Owner Details** sub-tab.

Figure 23: The General Information tab in the General form

Project Details sub-tab:

In this sub-tab, the following information can be entered (Figure 23):

Energy Audit Parameters

1. Purpose of the analysis – purpose for carrying out a calculation using MBEAT, which currently contains one option: Energy Audit.

2. Audit type - whether 'Assessment of current performance' for modelling the building in its current state or 'Assessment of improved performance' for modelling the building with improvements.

3. Weather location (pick the closest to your site from the available locations – there are 2 locations for Mauritius: Plaisance and Vacoas.

   NB: The chosen weather option should, in most circumstances, be taken as the location from the list which is closest in distance to the site of the proposed building. Where there are particular micro-climate issues that need to be taken into account, the other weather data file may be used if the weather data is more appropriate.

Figure 24: The Building Details sub-tab of the General Information tab in the General form

Building Details sub-tab:

In this sub-tab (Figure 24), the following information can be entered:

Building Details

1. Building type - The choice of building type here sets the default building type for the activity areas that you will define later. You will, however, be able to change the building type for each of the activity areas when you come to define them in the *Geometry* form. At this point, you should choose the building type that most closely defines the majority of the building.

2. Name of the project. **NB:** The text input in this field should not include any double quotes.

3. UPRN - the Unique Property Reference Number (UPRN) of the building.

4. Building address. **NB:** The text input in this field should not include any double quotes.

5. City. **NB:** The text input in this field should not include any double quotes.

6. Post Code. **NB:** The text input in this field should not include any double quotes.

7. Location description - a description of the building location. **NB:** The text input in this field should not include any double quotes.

8. Inspection Date – the date on which the energy auditor inspected the building for the purposes of energy auditing.

9. Tick box to indicate whether the building has a special conservation status (i.e., the building has been identified as being: one of special architectural or historical interest, in a conservation area, in a designated area of special character or appearance, or of traditional construction).

Energy Auditor Details sub-tab:

This sub-tab (Figure 25) contains the sub-form: *Energy Auditor Details.*

Figure 25: The Energy Auditor Details in the General form

Energy Auditor Details sub-form: in this sub-form, the following information can be entered:

1. Name – of the certifier, energy auditor, agent, or qualified/accredited person. **NB:** The text input in this field should not include any double quotes.

2. Address – of the certifier, energy auditor, agent, or qualified/accredited person. **NB:** The text input in this field should not include any double quotes.

3. City – of the certifier, energy auditor, agent, or qualified/accredited person. **NB:** The text input in this field should not include any double quotes.

4. Post Code – of the certifier, energy auditor, agent, or qualified/accredited person. **NB:** The text input in this field should not include any double quotes.

5. Telephone number – of the certifier, energy auditor, agent, or qualified/accredited person.

Clear all – All the information in the *Energy Auditor Details* sub-tab will remain visible in any new project created but can be cleared by pressing the "Clear all" button.

Owner Details sub-tab:

In this sub-tab (Figure 26), the following information can be entered:

Owner of the Building Details

1. Name – of the owner of the building. **NB:** The text input in this field should not include any double quotes.

2. Telephone number – of the owner of the building.

3. Address – of the owner of the building. **NB:** The text input in this field should not include any double quotes.

4. City – of the owner of the building.

5. Post Code – of the owner of the building.

Figure 26: The Owner Details sub-tab of the General Information tab in the General form

7.4. Project Database form

Each type of construction used in the building fabric is defined within the *Project Database* form. Within this form, there are five main tabs (circled in Figure 27):

- **Constructions for Walls** tab
- **Constructions for Roofs** tab
- **Constructions for Floors** tab
- **Constructions for Doors** tab
- **Glazing** tab

In each tab, you need to enter information on each of the different types of construction found in the building. For example, in your building, there may be two glazing types. This is where you enter the details of these types. Later on, during the building's geometry definition, each of these construction/glazing types can be assigned to particular parts of the building, i.e., envelope, door, or window. In other words, you are not defining the walls, doors, or windows of your building at this stage; just the characteristics of the materials used in their construction.

Clicking on the "Check Objects assignment" button produces two reports: the *Unassigned Objects* Report and the *Data Summary* Report. These reports can be used to check the data entered at any stage of inputting a building into the interface. There is a "Reports" button on each tab within the interface so it is not necessary to return to this form to access the reports.

How to double-check the data you have entered is explained at the end of this chapter (see Section 7.9: Double-checking the data).

Notes:

- Constructions for intermediate floors/ceilings are dealt with under the *Constructions for Floors* tab.

- If the space in the roof is unconditioned, the top floor ceiling should be dealt with as a "roof". It should be given the combined thermal performance of the whole construction including the ceiling construction, the void, and the roof construction.

- Only constructions for external doors and windows need to be defined in MBEAT (i.e., ignore doors and windows within envelopes that are **not** adjacent to the exterior).

Figure 27: The Constructions and Glazing tabs in the Project Database form

Each of the main tabs in the *Project Database* form has two sub-tabs: *General* and *Assigned*. The *General* tab is where the information is entered to define your construction types - see the following section on how this is done. The *Assigned* tab contains a list of all the envelope elements (i.e., envelopes, doors, or windows) of the building to which this construction (or glazing) has been "assigned". You cannot edit the list on this screen as it is provided for viewing only (see Figure 28). It reflects your input in the *Geometry* form when assigning envelope elements to constructions.
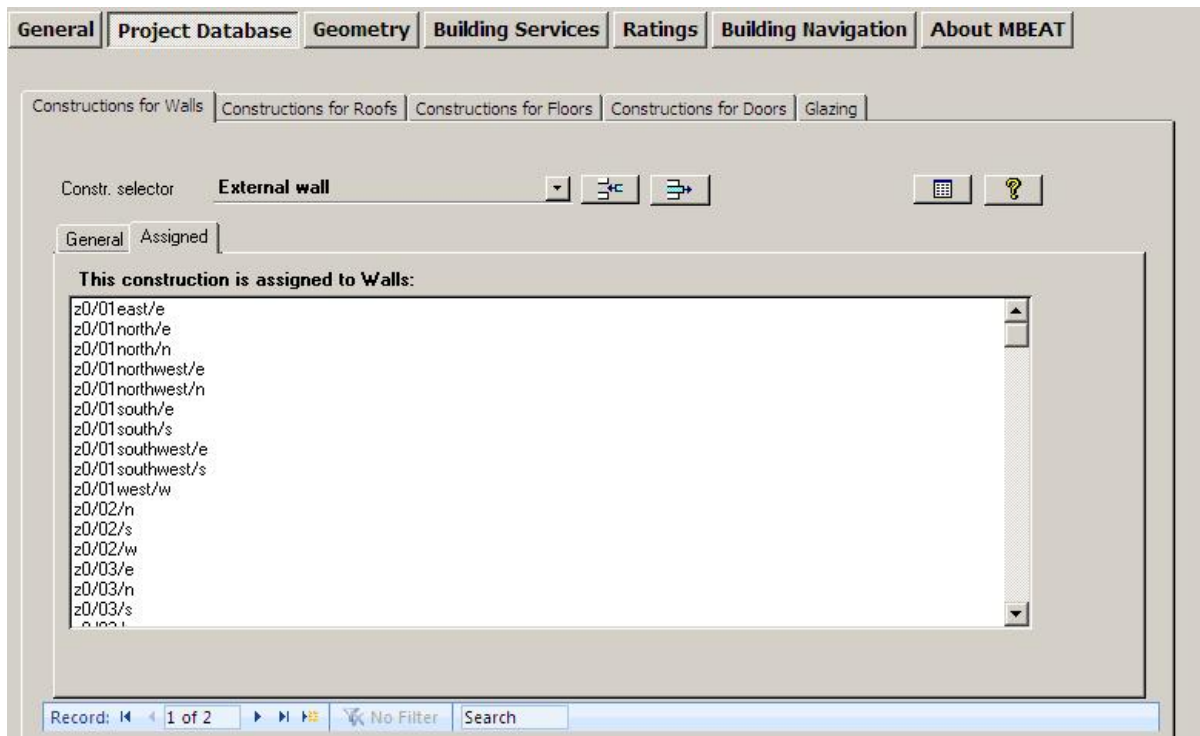
Figure 28: The Assigned sub-tab in the Constructions for Walls tab

7.4.1. Defining construction types

To insert a new type of construction, you must firstly create a new record by clicking on the "Create a new record" button shown in Figure 29. For each new construction, you need to enter the following information:

1. Name - You will be prompted to enter a unique name for your construction (this must be done before you can continue with the construction's definition).

2. Generally used in walls/floors/roofs which connect zones to (for walls, roofs, and floors only) – Here you need to select from the options in the drop-down menu (see Figure 29), which include the options of: Exterior, Strongly ventilated space, Unheated adjoining space, Conditioned adjoining space, Underground, and Same space. This sets the default or 'global' condition of the adjacent space which will appear when you assign this construction for a specific envelope element (see Section 7.5.4: Defining envelope, for details on how this global value is used). This parameter is only required for walls, roofs, and floors, and you can alter it for any individual envelope when defining its geometry.

3. Tick if the construction involves metal cladding (for walls and roofs only) – tick box.

NB: Constructions involving metal cladding are roof or wall systems where metal forms an integral part of the construction, such as metal twin-skin systems where the insulation is located between the metal skins and where the metal skins are typically 0.4 mm to 1.2 mm thick. Metal cladding systems are divided into two broad categories: (a) built-up metal cladding systems involving rail and bracket or z-spacer systems with insulation within the panels, and (b) composite-panel metal cladding systems with insulation inside the panels. If the metal is simply used as an external shield against the weather, such as a rainscreen, this is not, for the purposes of MBEAT calculations, considered as "metal cladding".

4. Description of the construction - MBEAT requires a number of parameters to describe the thermal characteristics of the construction types. These can be introduced into MBEAT in one of two ways:

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i. Import directly from the library - This is the default option. If it is not already selected, you need to click on the "Import one from the library" radio button. Then, in the library drop-down menu(s), choose the construction that most closely matches the one you are trying to define, from your knowledge of what has been found in the building or is specified on drawings or schedules.

ii. Manually introduce the values - Click on the "Introduce my own values" radio button if you wish to enter your own values to define the thermal characteristics of the construction.

For **walls, roofs, floors, and doors,** there are two parameters which need to be entered: the U-value (W/m^2K) and the K_m value (kJ/m^2K). (See below for the description of these parameters). If the user selects a construction type from the construction library, these values are imported automatically from the NCM Construction database.

For **glazing** types, the parameters that need to be entered manually are: the U-value, the total solar transmittance (T-Solar), and the light transmittance (L-Solar). (See below for the description of these parameters). If the user selects a glazing type from the glazing library, these values are imported automatically from the NCM Glazing database.

5. Absorption coefficient - For external **walls and roofs**, enter the proportion of the incident solar radiation that is absorbed by the construction.

NB: Glazed Doors - Doors which are more than 50% glazed should be entered into MBEAT as windows, and their light and solar characteristics should be entered into the *Project Database* form > *Glazing* tab. Doors which are 50% or less glazed can be treated as opaque doors.

U-Value
The U-value is the thermal transmittance of the construction, given in W/m^2K. It can be calculated using the "combined method" given in BS EN ISO 6946 for simple constructions. Constructions such as cladding and steel frame constructions require more complicated calculation procedures, and an appropriate methodology should be followed. For example, the "BRE U-value Calculator" would be appropriate for these construction types. (Guidance on the calculation of U-values for curtain walls can be found in 'The Thermal Assessment of Window Assemblies, Curtain Walling, and Non-traditional Building Envelopes', *Ledbetter, S., et al.*, Centre for Window and Cladding Technology, University of Bath, Bath, March 2006).

NB: In the case of a user-defined U-value for ground floors, the user needs to specify (using a tick-box) whether the U-value entered into MBEAT has been obtained following the guidance specified in section 3.5.2 of "CIBSE Guide - Vol. A - 2007" (and ISO 13370:2007 – *Thermal Performance of Buildings – Heat Transfer via the Ground – Calculation Methods*)[iii], i.e., the U-value has been modified/corrected to account for insulation to counter the heat loss through floors in contact with the ground. If the U-value input by the user has already been modified, then MBEAT will use the U-value as input. Otherwise, MBEAT will make the modification (as a function of the ratio of exposed perimeter to floor area and the thermal resistance of the floor construction), which is always the case when the floor construction is selected from the Library. The user input un-corrected U-value for the ground floor should be the inverse of the resistance of the floor construction only, i.e., before allowing for any ground effect (perimeter to area) or edge insulation.

NB: The calculation of the U-values of rooflight/window systems must include the effect of the bars that form part of the glazing system.
NB: The glazing U-value entered should include the glass, in a vertical inclination, the frame, and any bars that form part of the glazing system. This value is adjusted in MBEAT to produce

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[iii] Further guidance in BR 443:2006 - Conventions for U-value Calculations.

the correct U-value for the window/rooflight inclination (the correction for a horizontal flat roofs is +0.3 to the U-value and for pitched roofs, it is +0.2 to the U-value). However, the value checked for compliance with building regulations is the one input (for vertical inclination) and not the adjusted U-value used within the calculation.

NB: When an nct file is converted from a previous version of MBEAT, the definition of any construction, which was done in the *Project Database* form using either the library in the original nct file, is converted to "introduce my own value" using the U-value and κ_m value which corresponded to the construction selected in the original nct file so that even if the Construction Database is updated between versions (which is likely), the same values from the original selection are used in the converted file, unless the user revises and modifies his construction selections in the converted file.

κ_m (Kappa m) value

The κ_m value is the effective thermal capacity of an element (wall, floor, ceiling, etc), given in kJ/m^2K. As it takes some time for heat to flow into or out of the building fabric, not all the thermal

capacity is useful. The κ_m value represents that part which affects the heating and cooling energy demands. The rules for calculating it can be found in the standard BS EN ISO 13790:2008. In brief, <u>for each construction element</u>: Calculate the contribution of each layer of construction by calculating: density (kg/m^3) * thickness (m) * specific heat capacity ($kJ/(kgK)$). Starting from the layer of the construction closest to the space (i.e., from the interior), add these values together until <u>any one</u> of the following conditions is satisfied:
* the sum of the layers thicknesses has reached 0.1 m,
* you have reached the mid-point of the construction, or
* you have reached an insulating layer (defined, for MBEAT purposes, as having a conductivity of 0.08 W/mK or less).

NB: If the construction contains an air cavity whose conductivity is above 0.08 W/mK, the

contribution of the air cavity needs to be taken into account in the calculation of the κ_m value (although the contribution to the thermal mass of the construction would be very small), i.e., it is not considered as an insulating layer.

T Solar
T Solar is the total solar energy transmittance (*g perp*) defined as the time-averaged ratio of energy passing through the un-shaded element to that incident upon it. T Solar values entered by the user should refer to values for <u>normal incidence</u> of solar radiation. **NB:** External movable devices for solar protection are accounted for later when defining the window in the *Geometry* form, through the shading system options.

L Solar
L Solar (light transmittance) is the amount of visible solar energy that passes through a glazing system, expressed as a fraction of the visible solar energy incident on it. This value will be used for the daylighting calculations. L Solar values entered by the user should refer to values for <u>normal incidence</u> of solar radiation.

NB: Total solar energy transmittance values given by windows manufacturers are usually given for solar radiation perpendicular (normal) to the glazing (*g perp*). However, MBEAT uses monthly calculations and therefore, a value (*g*) averaged over all angles of incidence. MBEAT calculates this value by multiplying (*g perp*) by a correction factor corresponding to the orientation of the glazing and its tilt from the horizontal.

NB: In the Glazing Database, "Uncoated, clear" refers to ordinary clear glass which has no low-emissivity coating and no tint, "Reflectance, low-emissivity" refers to glazing in which at least one glass pane has a low-emissivity coating (such as "Pilkington K" glass or "Optitherm" glass), and "Tinted" refers to glazing where at least one pane is colour-tinted.

NB: For windows or other glazed envelope elements with non-scattering glazing, ISO 9050 and EN410 provide a method to obtain the solar energy transmittance for radiation perpendicular to the glazing. EN 13363-2 and ISO 15099 provide methods of determination of the total solar energy transmittance of glazing equipped with solar protection devices. For more information, see also section 11.4 of the CEN Standard prEN wi 14.

Figure 29: An external wall being defined in the Constructions for Walls tab

Viewing and deleting construction types

To view the construction types that you have in your *Project Database* form, you need to click on the record selector[iv] in each of the four tabs. A drop-down list will then appear showing all of the constructions that have been defined in that project so far. To delete a construction or glazing type, you need to select it using the record selector, and then click on the "Delete record" button.

7.5. Geometry form

Depending on what information you have first, you can start by entering information into either the *Geometry* form or the *Building Services* form.

To define the geometry of your own building, you will need to have followed the instructions on "zoning" given in Chapter 3. (The Example building has been "zoned" for you. Details can be found in Table 22, Figure 90: Ground floor plan, and Figure 91: First floor plan in APPENDIX A:.)

The *Geometry* form contains five main tabs (see Figure 30):

- **Project** tab – This tab requires geometrical information on the whole building rather than on a zone level and is where you can enter global default values for a number of parameters to be used.

[iv] For further descriptions of the various commands in MBEAT, see Chapter 6: BASIC MBEAT FUNCTIONALITY AND THE HELP MENU.

The geometry of **each zone** is then described in the following tabs:

- **Zones** tab
- **Envelopes** tab
- **Doors** tab
- **Windows and rooflights** tab

Figure 30: The Project, Zones, Envelopes, Doors, and Windows & Rooflights tabs in the Geometry form

7.5.1. Summary of how to define the geometry of a building

There are **5** steps to defining the geometry of a building:

1. **Enter building scale information** (total floor area) **and global values** which apply to most zones (such as zone height). This is done in the *Project* tab (Section 7.5.1: Project tab).

Then for **each zone**:

2. **Create the zone** - This is done in the *General* sub-tab of the *Zones* tab (Section 7.5.3: Defining zones).

3. **Create its envelope elements** – There are two ways to create envelope elements (walls, floor, and roof/ceiling):

   a. In the *Envelopes* main tab (Section 7.5.4).

   b. In the *Quick Envelopes* sub-tab of the *Zones* tab (Section 7.5.8).

4. **Create any windows** – There are two ways to do this:

   a. In the *Windows* main tab (Section 7.5.5).

b. In the *Quick Envelope* sub-tab of the *Zones* tab at the same time as creating the envelope element it is part of (Section 7.5.8).

5. **Create any external doors** – In the *Doors* tab (Section 7.5.7).

NB: Internal windows and doors <u>should not</u> be entered into MBEAT.

The tabs in *italics* above are the main tabs of the *Geometry* form (see Figure 30). It is important to understand how to introduce information into these tabs (as well as being able to use the *Quick Envelope* function) as there are some parameters which can only be entered using these tabs. However, once familiar with the basis of the geometry objects, it is likely that you will enter most of your data using the *Quick Envelope* function.

Order of data entry

You need to create the zone <u>before</u> defining its envelope. It is not mandatory to enter all the information about the zone (envelopes, doors, windows) before moving onto the next zone as you can always add or edit this information at a later time. Where possible, however, you should introduce each zone one at a time into the interface.

Description of what is happening in MBEAT

When you create a zone, envelope element, or window, you are creating what is referred to in MBEAT as a 'building object'. These building objects need to be linked together correctly in order to define the geometry of a zone. When you define an envelope element in the *Envelopes* main tab, you will be prompted to link (or assign) it to a zone. Equally, when you define a window in the *Windows & Rooflights* main tab, you are prompted to link it to an envelope element. If you create the envelope element or window in the *Quick Envelope* sub-tab, these links are established automatically. The final stage of defining a zone is to assign it to the appropriate building services systems. This can be done in either the *Geometry* (partly) or *Building Services* form.

Figure 31 below is an example of a simple zone. To define the geometry of this zone, you would need to create the zone, 6 envelope elements, one window, and one door. The south wall door and window would need to be linked to the south wall, which in turn (along with the other 5 envelope elements) would need to be linked to the zone, as shown by the arrows in the diagram below.
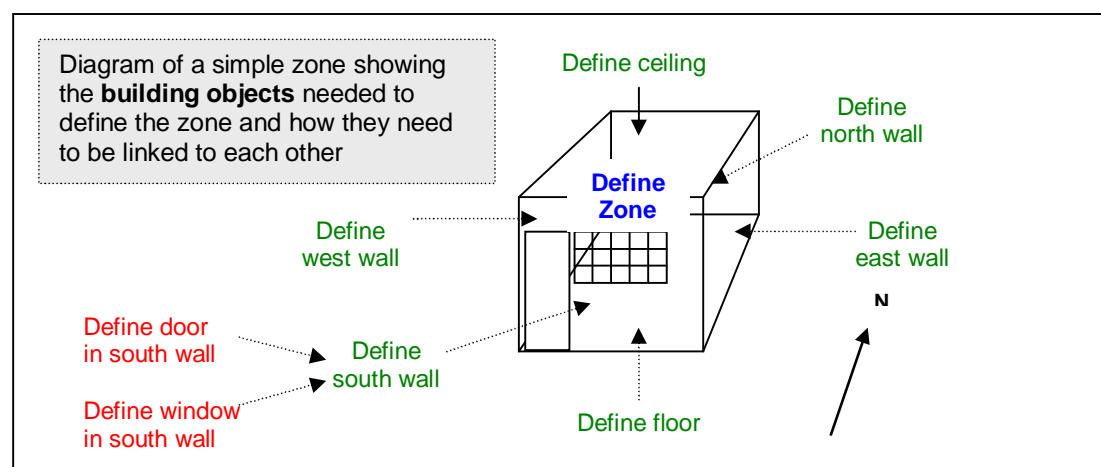

Figure 31: Diagram of building objects needed to define a simple zone

7.5.2. Project tab

Before defining the geometry of each zone, there are several parameters at the building scale which you need to enter, such as the total floor area of the building. You can also enter global[v] values which apply to all or most zones (zone height and air permeability). These parameters are entered into two sub-tabs:

- **General & Geometry** sub-tab

General & Geometry sub-tab:

This sub-tab requires the input of the following information, as shown in Figure 33:

Building Infiltration (Global)

1. Air permeability at 50 pa (m^3/h.m^2) - The value you enter here will be the global or default value assigned to each zone. You can choose later to either use this global value or enter a different value for each zone that you define (see Section 7.5.3: Defining zones). Air permeability is the physical parameter used to quantify the air tightness of the building fabric. It measures the resistance of the building envelope to infiltration. It is defined as the average volume of air (in m^3 per hour) that passes through unit area of the building envelope (in m^2) when subject to an internal to external pressure difference of 50 Pascals. The envelope area of the building is defined as the total area of the floor, walls, and roof separating the interior volume from the outside environment. It is measured with ventilators closed. The user can over-write the default value by manually entering an alternative value.

Building Orientation

2. Building (clockwise) rotation – In degrees from north.

   NB: For example, Figure 32, a rotation of 45 degrees would change north-facing walls to north-east. However, note that the nomenclature in the names of already created envelopes (denoting orientation) would <u>not</u> be changed automatically by the rotation. Also, note that any envelope created <u>after</u> the rotation is performed will still retain the original coordinate system. Hence, this parameter should be changed <u>with caution</u> from the default of zero.

   NB: The "Building rotation" parameter can be used when you want to model a building identical to one you have already modelled in MBEAT before (and therefore have its nct file), but which has a different orientation to the original one. As such, this parameter can be used to rotate the whole building as described in the guidance, provided you do not need to make any further modifications to the geometry of the building.

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[v] For further details on global values, see Section 6.1: Basic interface functionality and buttons.
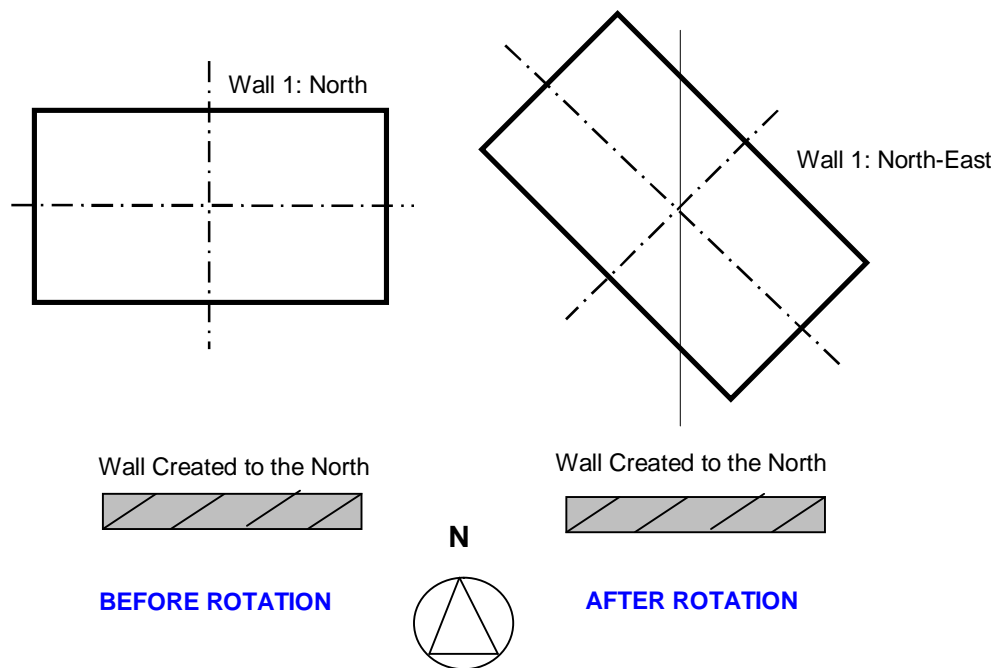
Figure 32: Example of a 45 degree building rotation

NB: The user is no longer required to enter the building height (height to eaves, in m).

Building Details

3. Zone height (Global) – Floor to floor height (floor to soffit for top floor), in m, i.e., including floor void, ceiling void, and floor slab. As with the global building infiltration parameter, the value you enter here will be given as the global or default zone height in each of the zones. You can choose to use this global value or enter a new value for each respective zone (see Section 7.5.3: Defining zones).

   NB: For a zone with a flat roof, the zone height would be from top of floor to top of roof. For a zone with a pitched roof and a flat ceiling underneath it, the zone height would be from top of floor to underside of soffit. For a zone with a sloping roof (i.e., an exposed pitched roof with no flat ceiling underneath it), the zone height would be from top of floor to soffit height. If there is a suspended floor, the zone height would be measured from the floor surface (rather than the slab underneath it).

4. Maximum number of storeys – Number of storeys of the building being modelled. If the building does not have the same number of storeys all over the floor plan, input the maximum number of storeys.

5. Building area – The total building (sum of zone areas) floor area (m^2) – This field is for data entry checking purposes only (i.e., the value entered into this field is not used in any part of the calculation). The user can compare this figure to the figure calculated by MBEAT and reported directly below it as: "Currently the total zone area is…" which is a sum of all the areas of the entered zones. A red warning will appear if these values are not identical. The total zone area calculated by MBEAT takes into consideration the value input in the multiplier parameter for each of the zones.

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Figure 33: General & Geometry sub-tab of Project tab in the Geometry form

7.5.3. Defining zones – Zones tab

The first step in defining the geometry of a zone is to create the zone in the *Zones* tab of the *Geometry* form.

NB: For energy auditing calculations purposes, we recommend that users generally avoid creating more than 100-150 zones in MBEAT. However, the processing time will depend on the total number of objects that need to be processed by MBEAT (not just zones), i.e., zones, envelopes, windows, etc. Hence, creating a project with a very large number of objects will slow down calculation and may cause it to crash.

The *Zones* tab contains four sub-tabs:

- **General** sub-tab: This is where the zones are created and defined. You need to give each zone a unique name, select its building and activity types, and enter its area, height, and infiltration characteristics. You can also specify which HVAC system the zone is served by in this tab (but only if you have already defined the HVAC system in the *Building Services* form or you are using one of the default HVAC systems in MBEAT). (see below).
- **Quick Envelopes** sub-tab: This is one way to define the envelope elements and assign them to the zone as described in Section 7.5.8: Quick Envelopes tab: Short cut to creating envelopes and windows.
- **Envelope Summary** sub-tab: This tab displays a summary of all the envelope elements defined so far in the zone.

General sub-tab:

To create a zone, you will need to click into the *General* sub-tab of the *Zones* tab, add a new record, and enter the following information:

1. Name – Any name can be given to a zone. The only requirement is that it is unique. There are certain recommendations to avoid it becoming complicated since there are so many elements in MBEAT which require naming. See Section 3.5: MBEAT Nomenclature, for guidance on how to name your zones, envelope elements, doors, and windows.

2. Multiplier – Indicate how many zones exactly identical to this one exist in the building (if more than the default of 1). Remember that this would also "multiply" all of its associated envelopes, windows, and doors during the calculation.

3. HVAC System – If you have defined your HVAC systems before defining your zones (i.e., if you have started with the *Building Services* form instead of the *Geometry* form), you can select the HVAC system that serves this zone from the drop-down list. If no HVAC system serves the space (i.e., an unconditioned zone that is intended to remain that way), select 'Zones without HVAC system' (spaces which have no heating or cooling, e.g., plant rooms, storage spaces, exposed circulation spaces). If you have not yet defined your HVAC system, this can be left as 'Unassigned' at this stage. You will be able to assign the zones to an HVAC system later within the *Building Services* form so there is no need to define the HVAC system before continuing. If you leave the zone as unassigned, a red warning will appear in the top right hand corner to let you know how many zones remain unassigned so that you would not proceed with running the calculation before assigning them.

   NB: If a zone is defined as having no heating or cooling, i.e., assigned to 'Zones without HVAC system', but the activity type selected for the zone is one which typically requires conditioning (according to the Activity Database), a red exclamation mark "**!**" will appear next to this parameter as a warning to the user, in case this was done in error. Ultimately, however, the calculation will be carried out using the data input by the user.

   If you do not know the type of the HVAC system in your existing building or its detailed parameters, you should select one of the following default options from the drop-down menu (see Section 7.6: Building Services form):

   - 'Heating only - Electric resistance' - Heat generated by passing an electric current through resistance wire. Assumed to be electric central heating system with warm air distribution. Fan storage heaters and electric fan converters should be input by defining an HVAC system in the *Building Services* form > *HVAC Systems* tab > *General* sub-tab and selecting the system type "Other local room heater - fanned". If you do not know the heating method (i.e., whether a heated-only building uses electricity or a fuel-based heating system), you should select electric resistance heating as your default.

   - 'Heating only - Other systems' - Assumed to be a wet radiator system with heat generated by fuel combustion. Pumps assumed to be powered by grid-supplied electricity. If you know the fuel type used by the heating system, you can define it in the *Building Services* form > *Global and Defaults* tab > *HVAC System Defaults* sub-tab (see Section 7.6.1: Global and Defaults tab).

   - 'Heating and mechanical cooling' - Assumed to be a constant volume air system with terminal reheat and fixed fresh air. Fans and pumps assumed to be powered by grid-supplied electricity. If you know the fuel types used by the heating and cooling generators, you can define them in the *Building Services* form > *Global and Defaults* tab > *HVAC System Defaults* sub-tab (see Section 7.6.1: Global and Defaults tab).

NB: The default HVAC systems are representative of existing rather than new buildings and should only be used if you do not know the type of the HVAC system in your building or its detailed parameters as the default efficiencies assumed by MBEAT for them are quite pessimistic and cannot be edited by the user.

NB: See note in Section 7.6.9: Defining the zone specific building services, regarding indirectly conditioned spaces.

4. Building type – The default for this field is the building type that was selected when creating the project (this information is recorded in the *General Information* tab in the *General* form). However, it can be changed for any particular zone, if appropriate (see note below).

5. Activity type – A building can be divided into a number of activity areas. For example, in an office building, there may be a reception, open plan office, some cellular offices, a tea room, and some toilets. When you choose your building type and activity area, you are setting a number of default parameters which the tool uses to calculate the energy consumption. These parameters include temperature set points, heat gains from people and equipment, required illuminance level, and fresh air requirements amongst others. Each building type has a number of different activity areas to choose from. The description of the activity area, as it appears in the NCM Activity Database, is displayed in a box at the right-hand side of the sub-tab. For more information on building types and activity areas, please refer to the NCM Activity Database.

NB: It is not a problem in MBEAT to introduce activities from building types other than the default building type introduced at the beginning of an MBEAT project. For example, an office may have activities from the "Office" building type (e.g., office area, reception, eating/drinking area, etc...) but may also have atypical activities which are not included in the office building type, e.g., a shop, in which case the user would need to use a "Retail" building activity such as a sales area or similar. The building type does not need to be the same for all activities in a project. It is intended to be a default for the project in MBEAT and provides a 'filter' on the many activities available in the database, making it easier for users to find and make a choice of activity for each zone. Generally, activities from the default building type should be used, but if there is nothing suitable available, another building type could be used.

NB: The domestic type activities available under the building type "Residential spaces" in MBEAT are to allow the energy calculations for the generation of one energy audit for a building which contains residential accommodation above a non-domestic space (e.g., a shop or a pub) provided that the residential space can only be accessed from within the non-domestic space, i.e., the residential part is not designed or altered for use as a separate independent dwelling. These are the **only** cases where MBEAT can be used to model domestic areas.

6. Area - Floor area of the zone, in m^2, calculated using the internal horizontal dimensions between the internal surfaces of the external zone walls and half-way through the thickness of the internal zone walls (see Section 3.4: Measurement and other conventions, and Figure 7). This parameter is used to multiply area-related parameters in the databases. The area basis needs to be consistent with that for Operational Ratings.

NB: If the zone has any virtual boundaries created due to the zoning rules on daylight access, you need to consider the area of the zone as that delimited by the 'line' created by that virtual boundary (the virtual boundary itself is not entered into MBEAT).

NB: Where there is an unheated, unoccupied roof space (i.e., between a pitched roof and a flat ceiling) above an activity area, it should not be treated as a separate unheated zone. Instead, the void should be considered as part of the construction when calculating the U-value between the occupied activity area and the outside (i.e., the top floor ceiling should be defined as a 'roof' and given the combined thermal performance of the whole construction including the ceiling construction, the void, and the roof construction). If the roof space is occupied (heated), then it becomes a normal activity area. If surfaces of the room are not rectilinear, for example, if a pitched roof is exposed to the inside of the conditioned zone (i.e., there is no flat ceiling underneath it), then the roof area will be that of the inner surface area of the roof as "seen" by the heat flux.

7. Zone height – Floor to floor height (floor to soffit for the top floor), in m, i.e., including floor void, ceiling void, and floor slab, is used for calculating the length of the wall-to-wall junctions and radiant and temperature gradient corrections. Either enter you own figure into the box, or click on the Global button (G). Pressing the Global button brings the global default value, which you previously defined in the *Projects* tab, into the field.

NB: For a zone with a flat roof, the zone height would be from top of floor to top of roof. For a zone with a pitched roof and a flat ceiling underneath it, the zone height would be from top of floor to underside of soffit. For a zone with a sloping roof (i.e., an exposed pitched roof with no flat ceiling underneath it), the zone height would be from top of floor to soffit height. If there is a suspended floor, the zone height would be measured from the floor surface (rather than the slab underneath it).

Infiltration

8. Air permeability at 50pa, in $m^3/h.m^2$ - Similar to the zone height, you have the option to either enter you own value or use the global value which you previously defined in the *Projects* tab by clicking on the "Global" button. Otherwise, a default value (visible in the interface) will be used by the software. Air permeability is the physical parameter used to quantify the air tightness of the building fabric. It measures the resistance of the building envelope to infiltration. It is defined as the average volume of air (in m^3 per hour) that passes through unit area of the building envelope (in m^2) when subject to an internal to external pressure difference of 50 Pascals. The envelope area of the building is defined as the total area of the floor, walls, and roof separating the interior volume from the outside environment. It is measured with ventilators closed.

9. Share to building – A ratio indicating the proportion of the zone that should be associated with the project being assessed, e.g., a proportion of a reception area that is shared with other businesses. The default value is 1, which indicates that the whole of the zone is associated with the project being modelled.

10. User's notes – This box is provided for the user to fill in, at their discretion, any details (description) about the zone that are not covered by the other fields. MBEAT does not process the data entered in this field.

Figure 34 shows a zone being defined.

Figure 34: A zone being defined in the General sub-tab of the Zones tab in the Geometry form

At the top right hand side of the *Zones* tab, a message (in red text) will appear indicating how many zones have not yet been assigned to HVAC systems. To see a list of all the zones which

have not yet been assigned, click on the "Reports" button to access the *Unassigned Objects* report (for more details about the Objects reports, see Section 7.9: Double-checking the data).

Notes on viewing/deleting/copying zones

To **view** the zones that you have created, you need to click on the record selector in the *Zones* tab. A drop-down list will then appear showing all of the zones that you have defined in that project so far. To the right of the zone's name will be the HVAC system which that zone has been assigned to. If a zone has not yet been assigned to an HVAC system, it will say "Unassigned".

To **delete** a zone (along with all its associated envelope elements, doors, and windows), you need to select it using the record selector, and then click on the "Delete record" button.

If you press the **copy** button, you will copy the selected zone along with all of the envelope elements, doors, and windows that have been created and linked to it. The new zone will be automatically named for you - it will be the "name of copied zone**.1**". Once it has been created, you can change its name. However, the names of the copied envelope elements, doors, and windows will still have the same names as those they were copied from. The following sections will explain how to rename and edit the envelope elements, doors, and windows. (There will be an option to just copy the zone by itself, without its child objects, in future versions of the tool.)

Envelope Summary sub-tab:

The envelope elements of a zone can be viewed in the *Envelope Summary* sub-tab of the *Zones* tab, shown in Figure 35, (see Section 7.5.4: Defining envelopes – Envelope tab for details on how the envelopes for each zone are created). Depending on which radio button is selected in the 'Show Objects' section, you can choose to either view only the envelopes attached to the zone or view the zone's envelopes as well as any windows or doors assigned to the envelopes. The zone's envelopes are listed in the left hand side window in terms of their names and types of envelope (<w> for wall, <f> for floor/ceiling, and <r> for roof). If any of the envelopes, windows, or doors, are highlighted in the left hand side window, more details about that object appear in the 'Selected objects properties' window, such as its area, construction, and the condition of the space it connects the zone to. Also included in the details is the ID number given by MBEAT to this envelope. This ID number can be used to locate this particular envelope quickly, using the "Go to ID" field in the *Envelope* tab, should any editing of its parameters be required (see Section 7.5.4: Defining envelopes – Envelope tab and Figure 36).
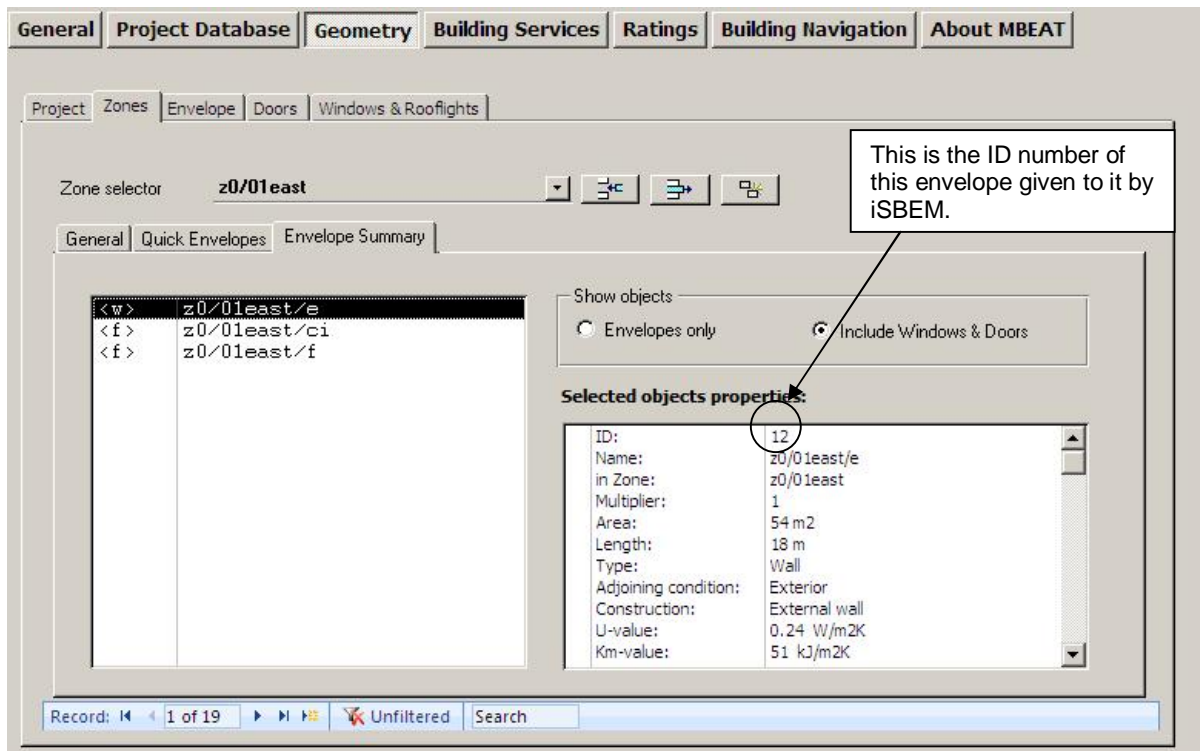
Figure 35: Envelope Summary sub-tab

NB: the *Quick Envelope* function will be explained in Section 7.5.8: Quick Envelopes tab: Short cut to creating envelopes and windows.

7.5.4. Defining envelopes – Envelope tab

The second stage of defining the geometry of a zone is to define its envelopes (walls, floor, and ceiling/roof). There are two ways of doing this:

1. In the *Envelopes* tab – Where you can create the envelope elements and define all of their parameters. This method is explained below.

2. In the *Quick Envelopes* sub-tab of the *Zones* tab - Where you can create and define the basic parameters for the envelope elements and windows. This is explained in Section 7.5.8. There are some parameters, however, for both envelope elements and windows which can only be defined in their main tabs. These tabs will, therefore, be explained first.

The main *Envelope* tab, shown in Figure 36, contains two sub-tabs:

General sub-tab: This is where you can create and define the envelope elements in terms of name, area, orientation, construction type, and what type of space it is connected to.

Window & Door Summary sub-tab: This tab displays a summary of the windows and doors present in each envelope element.

General sub-tab:

For each envelope element, you will need to click into the *General* sub-tab of the *Envelope* tab, create a new record, and add the following information:

3. Name – Similar to the naming of the zones (see Section 3.5 for more information).

4. Multiplier – Indicates how many envelope elements identical to this one exist in the selected zone. Remember that this would also "multiply" all of its associated windows and doors during the calculation.

5. Zone – Here you need to select the zone from the drop-down list (of zones defined so far) which this envelope element is part of.

6. Type of envelope – Choose between wall, floor or ceiling, and roof. If you select 'roof' or 'floor or ceiling', the following parameter becomes active:

   i. Pitch[vi] – You need to enter the pitch angle, in degrees, from the horizontal.

   If you select 'wall', the following parameter becomes active:

   i. Perimeter – You need to enter the perimeter length, in m. This is the horizontal dimension of the wall. Limits for this horizontal dimension are defined by the type of the adjacent walls (usually at right angles to the vertical envelope element in question). If the adjacent wall is external or a perimeter wall, the limit will be the internal side of the adjacent wall. If the adjacent wall is internal, the limit will be half-way through its thickness.

7. Connects space to (sometimes referred to as "adjacent condition") – Here you need to select what conditions apply on the other side of the wall/floor or ceiling/roof. If you click the 'Global' button, the condition associated with the type of construction selected below (as has been defined in the *Project Database* form) will be inserted as the default. If this is not appropriate, you can un-click the Global button and select between: Conditioned adjoining space, External, Strongly ventilated, Underground, Unheated space, or Same space (see Table 10).

Option	Brief Description
Exterior	For an envelope separating the considered zone from the outside air or water.
Strongly ventilated spaces	For an envelope separating the considered zone from a space provided with one or more permanent openings (i.e., that cannot be closed), with a capacity for the supply of fresh air and extract of inside air, determined according to section 5.3 of NEN 1087, of at least 3×10^{-3} m^3/s per m^2 useable area.
Unheated adjoining space	For an envelope separating the considered zone from an unheated adjoining space, other than meant under 'Strongly ventilated spaces'.
Conditioned adjoining space	For an envelope separating the considered zone from another conditioned zone.
Underground	For an envelope separating the considered zone from the ground.
Same space	For constructions representing the internal envelopes that separate contiguous zones which have been merged into one zone, i.e., the envelope is "contained" within the merged zone.

Table 10: Options for 'Connects space to' field for envelopes

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[vi] A pitched roof has a pitch greater than 10 deg (If the roof's pitch is 10 deg or less, it can be considered flat). If the pitch is greater than 70 deg, it can be considered a wall.

8. Construction – Here you need to select the type of construction for the envelope. When you click the drop-down menu to the right of the construction field, you will be presented with all the constructions of that type (type of envelope defined above) that you have defined in the *Project Database* form, as well as a default construction (For e.g., if this is a wall, then all the constructions you previously defined in the *Project Database* form > *Constructions for walls* tab will be visible). Select one of these. If you need another construction type, you will need to go back to the *Project Database* form and create it first.

9. Area – This is the area of envelope element <u>inclusive</u> of any windows and doors, in m^2. This value is used to calculate the fabric heat loss so this is the area to which the U-value is applied (the areas of windows and doors will be deducted within the calculation when necessary). For floors and flat roofs/ceilings, the envelope area is calculated in the same manner as the zone area (see Section 7.5.3: Defining zones and Section 3.4: Measurement and other conventions). The area for an exposed pitched roof (i.e., without an internal horizontal ceiling) will be that of the inner surface area of the roof. For vertical envelopes (i.e., walls), the area is calculated as follows:

Area of vertical envelope element = h * w, where:

h = floor to floor height (floor to soffit on top floor), in m, i.e., including floor void, ceiling void, and floor slab, and

w = horizontal dimension of the wall. Limits for this horizontal dimension are defined by the type of the adjacent walls (usually at right angles to the vertical envelope element in question). If the adjacent wall is <u>external or a perimeter wall</u>, the limit will be the internal side of the adjacent wall. Otherwise, the limit will be half-way through its thickness.

NB: If surfaces of the room are not rectilinear, for example, if a pitched roof is exposed to the inside of the conditioned zone (i.e., there is no flat ceiling underneath it), then the roof area will be that of the inner surface area of the roof as "seen" by the heat flux.

NB: During the calculation, if the area of the wall input is found to be less than the total area of windows and doors defined within it, MBEAT will increase the area of the wall to fit the areas of all the defined openings in it. The corresponding wall in the notional building will similarly have the increased area. Therefore, you should always ensure that you double-check the figures you input for your model geometry in MBEAT before running the calculation.

10. Orientation – Here you need to select from the drop-down menu whether the element faces north, north-east, east, etc., or is horizontal.

11. Tick box to indicate if there is a transpired solar collector on this envelope. This tick box becomes active only if a transpired solar collector object has been defined in the *Building Services* form of this project, and if this envelope is a wall. If the box is ticked, the following two parameters become active:
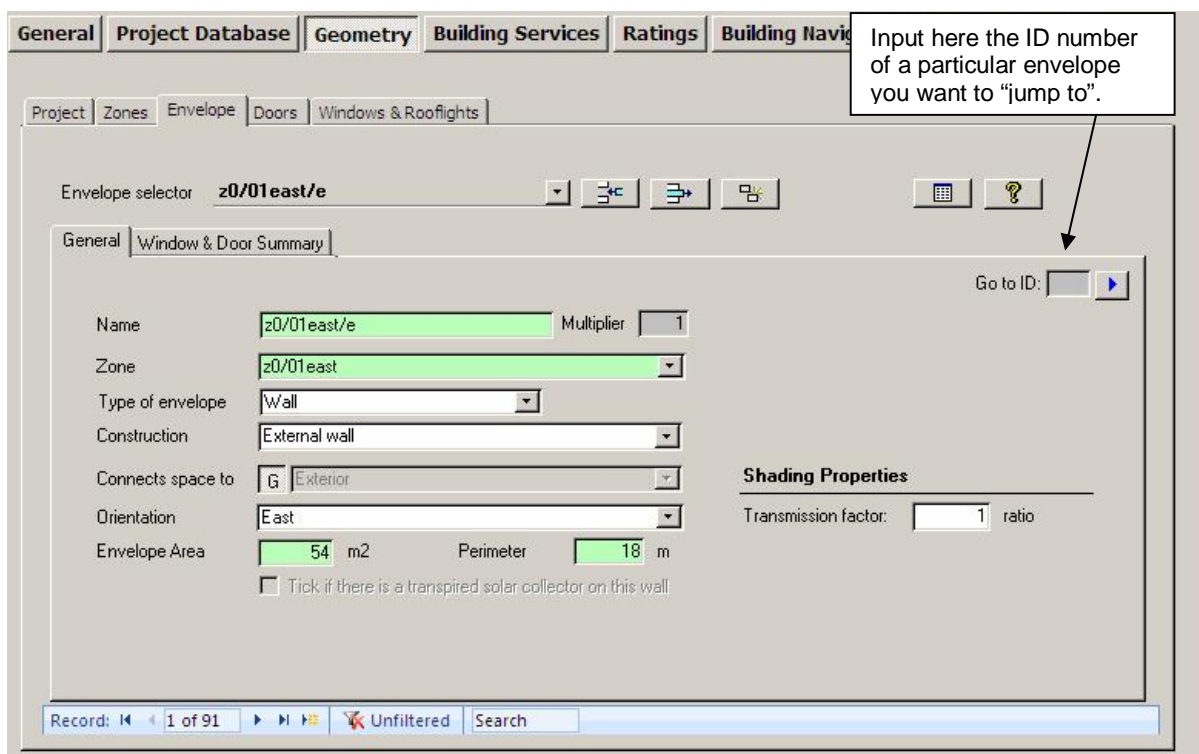
     i. A drop-down menu to select the name of the transpired solar collector, already defined in the *Building Services* form, which is installed on the exterior of this wall.

     ii. Area of the transpired solar collector, in m^2, which is installed on the exterior of this wall.

12. Transmission factor – This is the fraction of solar energy that can be transmitted through that specific wall after accounting for shading from overhangs compared to a wall that is unshaded by overhangs. A value of 1 means that the wall is not shaded by an overhang. (For details on how to calculate the transmission factor, see Section 7.5.6: Transmission correction factors.) This parameter is visible only if the type of envelope is set to be a wall.

13. Go to ID – this parameter can be used to quickly 'jump to' a particular envelope. The ID number of an envelope is visible among the envelope details displayed in the *Envelope Summary* sub-tab of the zone to which this envelope belongs. For example, if while reviewing the details in the *Envelope Summary* sub-tab, an error was detected in the description of a particular envelope, you can make a note of its ID number (Figure 35), go to the *Envelope* tab, type the ID number in the box, and press the arrow key ▶. This will take you to the *General* sub-tab of that particular envelope where you can correct the error (see Envelope Summary sub-tab in section 7.5.3: Defining zones – Zones tab).

Figure 36 shows a wall being defined.

Figure 36: A wall being defined in the General sub-tab of the Envelope tab in the Geometry form

At the top right hand side of the *Envelope* tab, a message appears if any of the envelope elements have not yet been assigned to a zone. To see a list of all the envelope elements which have not been assigned to zones, click the Reports button (for more details about the Objects reports, see Section 7.9: Double-checking the data).

Viewing, deleting, and copying envelope elements in the Envelope main tab

To **view** the envelope element that you have created, you need to click on the record selector in the main *Envelope* tab. A drop-down list will then appear showing all of the envelope elements that you have defined in that project so far. To the right of the envelope's name will be the zone which that envelope element is part of, followed by the HVAC system which the zone has been assigned to. If the zone has not been assigned to an HVAC system, it will say "Unassigned".

Note that the first line in the drop-down box reads "*Select action or wall from the list*". This refers to actions that will be available in future versions of the tool, for example, sorting by zone or copying only part of the envelope (for example, copying a wall without its windows).

To **delete** an envelope element (and any associated windows or doors), you need to select it using the record selector and then click on the "Delete Record" button.

If you press the "Copy Record" button, you will **copy** the selected envelope element along with any windows and doors that have been created and linked to it. The new envelope will be automatically named for you - it will be the "name of copied envelope**.1**". Once it has been created, you can change its name. (The names of the copied windows and doors associated with the envelope, however, will have the same name as those they were copied from - the following section will explain how to rename and edit the windows).

Windows & Doors Summary sub-tab:

The windows and doors assigned to an envelope element can be viewed in the *Window & Door Summary* sub-tab of the *Envelope* tab, shown in Figure 37, (see Section 7.5.5: Defining windows, for details on creating windows and rooflights and Section 7.5.7: Defining doors, for details on creating doors). Depending on which radio button is selected in the 'Objects' section, you can choose to either view only the windows and rooflights attached to the envelope, view only the doors, or view the envelope's windows and rooflights as well as any doors. The envelope's windows and/or doors are then listed in the left hand side window in terms of their names and types (<wi> for window and <d> for door). If any of the windows or doors are highlighted in the left hand side window, more details about that object appear in the 'Selected objects properties' window, such as its area and construction.
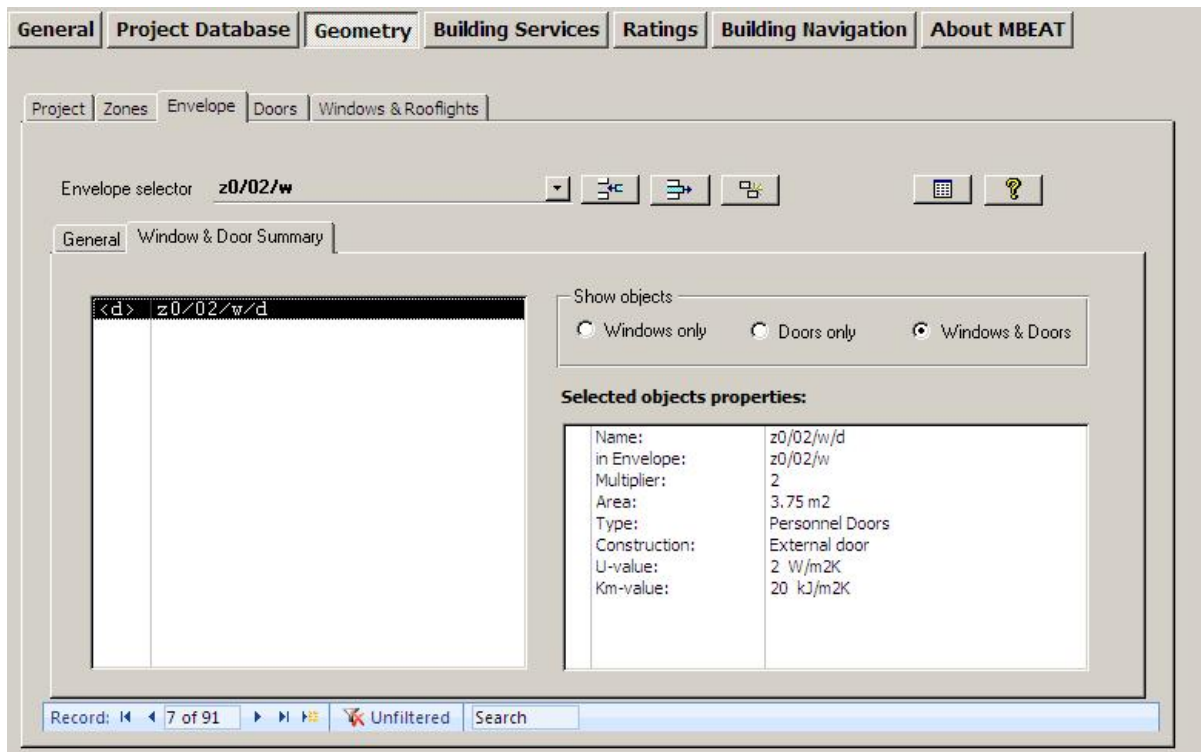
Figure 37: Windows & Doors Summary sub-tab

NB: the *Quick Envelope* function is explained in Section 7.5.8: Quick Envelopes tab: Short cut to creating envelopes and windows.)

7.5.5. Defining windows and rooflights – Windows & Rooflights tab

For each envelope element in the building, you need to define the type and amount of glazing it contains, if any. If there is more than <u>one</u> window/rooflight of the same glazing type, area, shading type, etc. in one wall/roof, you can define only one of them and use the multiplier field to define how many of them exist in the wall/roof. The principal way to define the windows is in the main *Windows & Rooflights* tab. Rooflights are considered in the same way as windows in MBEAT.

There is only one sub-tab in the *Windows & Rooflights* tab:

- **General** sub-tab.

General sub-tab:

This is where you need to enter the window name, assign it to an envelope element, enter the glazing type, area, shading system, and transmission factor, etc.

NB: Internal windows and doors should not be entered into MBEAT.

For each window, you will need to create a new record and add the following information:

1. Name – As before, the name must be unique and should indicate which wall it is to be attached to (see Section 3.5: MBEAT Nomenclature, for more information) for easier reference.

2. Multiplier – Indicate how many windows identical to this one exist in the selected envelope element.

3. In Envelope – Here, you need to select from the drop-down box, which envelope element this window is in (be it a wall or a roof).

4. Glazing type – Here, you need to select the type of glazing. When you click on the drop-down menu to the right of the glazing field, you will be presented with all the glazing types that you already defined in the *Project Database* form, as well as a default glazing.

5. Area – Area of the structural opening in the wall/roof including the frame, in m^2.

   NB: If the wall/roof is fully glazed, then the area of the window will be equal to the area of the wall/roof.

   NB: If a wall/roof contains a row/array of identical windows/rooflights, you can input the area of only <u>one</u> window/rooflight and use the "multiplier" field to define the number of identical windows/rooflights that exist in the same wall/roof.

   NB: During the calculation, if the area of the wall input is found to be less than the total area of the windows and doors defined within it, MBEAT will increase the area of the wall to fit the areas of all the defined openings in it. The corresponding wall in the notional building will similarly have the increased area. Therefore, you should always ensure that you double-check the figures you input for your model geometry in MBEAT before running the calculation.

6. Surface area ratio – This is the "developed area to projected area" ratio for the window or rooflight. The developed area is the total area of the glass plus the frame, and the projected area is the area of the opening in the wall/roof. Therefore, for domed or conical rooflights, for example, this ratio would be larger than 1, and for typical windows and flat rooflights, the value is 1. It cannot have a value which is less than 1. The default values are 1 for windows and 1.3 for rooflights.

7. Area ratio covered – This is the ratio of the roof area covered by an array of rooflights to the total area of the rooflight glazing (see Figure 38 for example). This parameter is active only if the envelope to which this window belongs has been defined as a roof, i.e., the window is in fact a rooflight. **NB**: This parameter is used by MBEAT to determine the area of the zone which is daylit by the array of rooflights for automatic daylight zoning sub-division (see Lighting (Controls) sub-tab in Section 7.6.9: Defining the zone specific building services- Zones tab). If the user is doing the daylight zoning manually, the "Area ratio covered" parameter is not relevant. If the calculated value for this parameter is larger than the maximum of 4, then the user can either enter the value as 4 or do the daylight subdivision manually for the zone containing this array of rooflights.

8. Display window tick box – Tick this box if the window being defined is for display purposes (e.g., a shop front window).

9. Frame factor – This is the ratio of the window or rooflight area which is occupied by the frame to the total window or rooflight area. The default value is 0.1 for a window (i.e., 10% of the total area is occupied by the frame and 90% by the glazing) and 0.3 for a rooflight. It cannot have a value which is less than 0 or which is larger than 1.

10. Aspect ratio – This is the ratio of the window's height to its width. The default value is 0.7.

11. Shading position – Here, you need to select from the drop-down menu whether the window has: external, internal, or no moveable solar shading device. This is used (together with the next 2 parameters) to calculate the reduction factor due to shading devices, which reduce the amount of solar heat gains entering the zone through the glazing. If the option selected is <u>not</u> "None (no shading)", the following 2 parameters become active:

    a. Shading colour – Here, you need to select from the drop-down menu the colour of the moveable solar shading device (see corresponding properties used by the calculation in Table 11).

b. Shading translucency – Here, you need to select from the drop-down menu the degree of translucency of the moveable solar shading device (see corresponding properties used by the calculation in Table 11).

12. Transmission factor – This is the fraction of solar energy transmitted through that specific window after accounting for shading from overhangs and fins. (For details on how to calculate the transmission factor, see Section 7.5.6: Transmission correction factors.)

NB: Doors which are more than 50% glazed should be entered into MBEAT as windows, and their light and solar characteristics should be entered into the *Project Database* form > *Glazing* tab. Doors which are 50% or less glazed can be treated as opaque doors.

Transmittance $\tau_{e,B}$		Reflectance $\rho_{e,B}$			
		white	pastel	dark	black
Opaque	0,0	0,7	0,5	0,3	0,1
Medium translucent	0,2	0,6	0,4	0,2	0,1
High translucent	0,4	0,4	0,3	0,2	0,1

Table 11: Data for typical solar protection devices

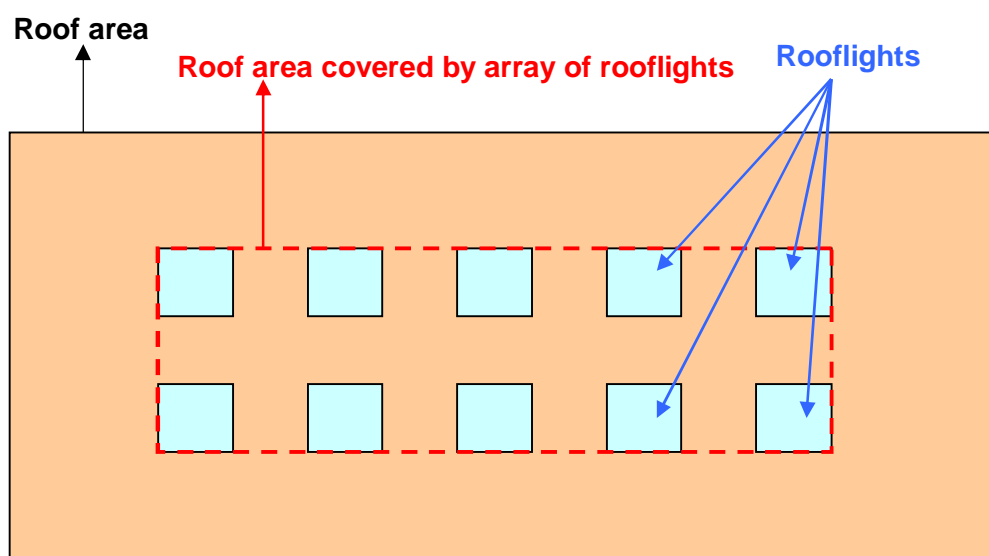**Figure 38: Area ratio covered for the definition of rooflights**

Example (Figure 38):
Roof area covered by array of rooflights = 9 m x 3 m = 27 m^2.
Total area of rooflight glazing = 10 x 1 m^2 = 10 m^2
Area ratio covered for the example in the diagram = 27 m^2 / 10 m^2 = **2.7**

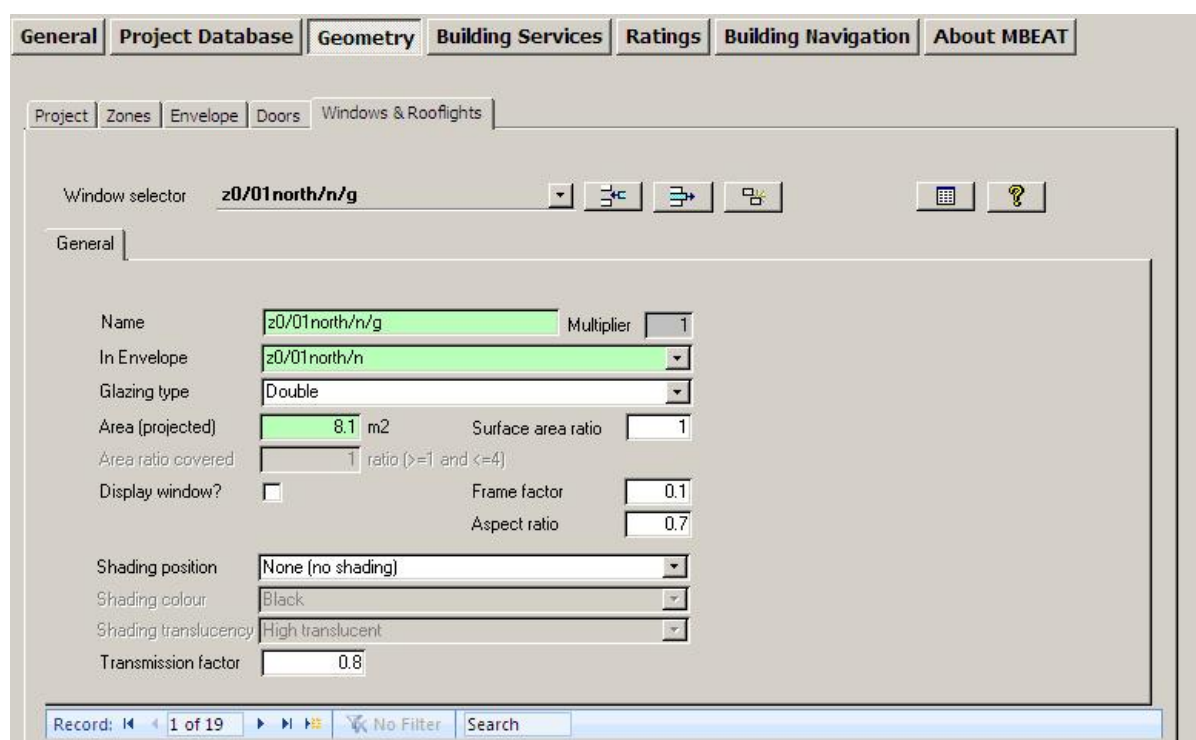Figure 39 shows a window being defined.

Figure 39: A window being defined in the General sub-tab of the Windows & Rooflights tab in the Geometry form

At the top right hand side of the *Windows* tab, a message will appear indicating how many windows have not yet been assigned to an envelope element. To see a list of all the windows which have not been assigned to envelope elements, click on the Reports button (for more details about the Objects reports, see Section 7.9: Double-checking the data).

Viewing, deleting, and copying windows in the Windows & Rooflights tab

To **view** the windows that you have created, you need to click on the record selector in the main windows tab. A drop-down list will then appear showing all of the windows that you have defined in that project. To the right of the window's name will be the names of the envelope element which that window is part of, followed by the name of the zone to which the envelope belongs.

Note that the first line in the drop-down box reads "*Select action or window from the list*". This refers to actions that will be available in future versions of the tool, for example, sorting by envelope element.

To **delete** a window, you need to select it using the record selector, and then click on the "Delete Record" button.

If you press the "Copy Record" button, you will **copy** the selected window. The new window will be automatically named for you – it will be the "name of copied window**.1**". Once it has been created, you can change its name.

7.5.6. Transmission correction factors

The transmission factor for windows can be calculated from[vii]:

[vii] The source of the shading calculation due to fins and overhangs is the CEN standard "EN 13790: Energy performance of buildings — Calculation of energy use for space heating and cooling".

$TS = Fo\ Fi$

where

Fo is the partial shading correction factor for overhangs, and
Fi is the partial shading correction factor for fins.

A transmission factor of 1 refers to 100% of solar energy transmitted, i.e., no shading from fins or overhangs.

NB: The effect of shading from the horizon (e.g., the ground, trees, and other buildings) is not considered for the calculations carried out by MBEAT.

Shading from overhangs and fins

The shading from overhangs and fins depends on the overhang or fin angle, latitude, orientation, and local climate. Seasonal shading correction factors for typical climates are given in Table 12 and Table 13.

a) Vertical section   b) Horizontal section

Key
α overhang angle
β fin angle
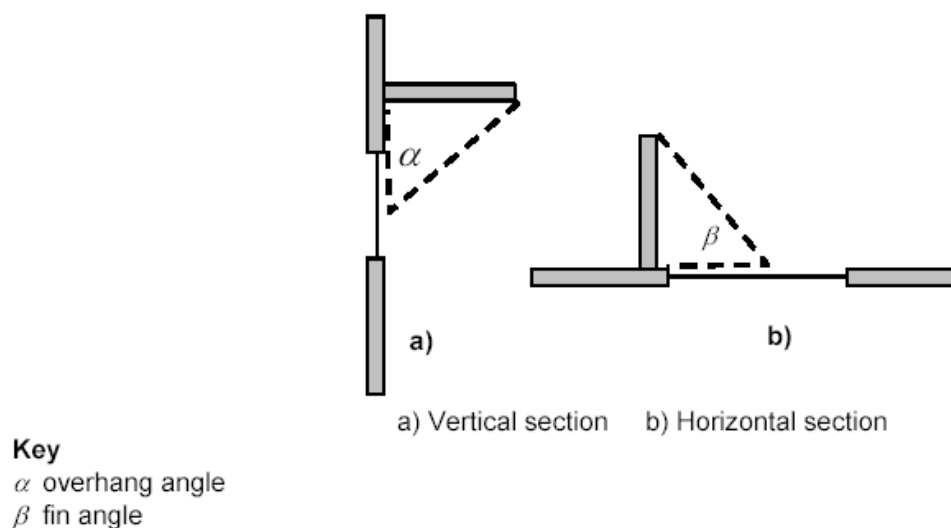
Figure 40: Shading from overhangs and fins

NB: For the purposes of this calculation, the angles alpha and beta, indicated by the dashed lines in Figure 40, are taken between the plane of the window and the overhang or fin shadow line at mid-window.

Overhang angle	20° S lat.		
	N	E/W	S
0°	1	1	1
30°	0.84	0.85	0.92
45°	0.60	0.70	0.80
60°	0.31	0.49	0.66

Table 12: Partial shading correction factor for overhang, Fo

Fin angle	20° S lat.		
	N	E/W	S
0°	1	1	1
30°	0.94	0.95	1

45°	0.83	0.87	1
60°	0.71	0.77	1

Table 13: Partial shading correction factor for fins, Ff

7.5.7. Defining doors – Doors tab

Only a zone's **external** doors need to be defined in MBEAT.

The *Doors* tab contains one sub-tab:

- **General** sub-tab

General sub-tab:

This is where you need to enter the name of the door, assign it to an envelope element, and enter its area, its construction type, and what type of door it is. If there is a number of doors in the same wall with the same area, construction, type, etc., then you can define only one door and use the multiplier field to denote the number of identical doors that exist in the wall.

NB: Internal windows and doors should not be entered into MBEAT.

For each door, you will need to create a new record and add the following information:

1. Name – As before, the name must be unique and should indicate which wall it is to be attached to (see Section 3.5: MBEAT Nomenclature, for more information) for easier reference.

2. Multiplier – Indicate how many doors identical to this one exist in the selected envelope element.

3. In Envelope – Here, you need to select which element this door is part of from a drop-down box of the envelopes already created.

4. Type – Here, you need to select between: Personnel Doors, High Usage Entrance Doors, and Vehicle Access Doors.

5. Construction type – Here, you need to select the type of construction. When you click on the drop-down menu to the right of the construction field, you will be presented with all the constructions for doors that you defined in the *Project Database* form, as well as a default construction.

6. Area – Specifies the area of the door including the frame, in m^2, i.e., the area of the structural opening in the wall.

   NB: If an external wall contains a row/array of identical doors, you should input the area of only <u>one</u> door and use the "multiplier" field to define the number of identical doors that exist in the same wall.

   NB: During the calculation, if the area of the wall input is found to be less than the total area of windows and doors defined within it, MBEAT will increase the area of the wall to fit the areas of all the defined openings in it. The corresponding wall in the notional building will similarly have the increased area. Therefore, you should always ensure that you double-check the figures you input for your model geometry in MBEAT before running the calculation.

NB: Doors which are more than 50% glazed should be entered into MBEAT as windows, and their light and solar characteristics should be entered into the *Project Database* form > *Glazing* tab. Doors which are 50% or less glazed can be treated as opaque doors.

Figure 41 shows a door being defined. In this example, two doors of 3.75 m^2 in area each have been entered.

Figure 41: A Door being defined in the Doors tab

7.5.8. Quick Envelopes tab: Short cut to creating envelopes and windows

The *Quick Envelopes* sub-tab provides an alternative way of introducing the envelope elements and windows without having to assign them manually to a zone or envelope element, respectively.

The information required is a selection of the parameters required in the main *Envelope* and *Windows & Rooflights* tabs.

Envelopes elements and windows are created as follows:

The zone to which the envelopes and windows are to be assigned is defined by the zone selected using the record selector.

The type (wall, floor/ceiling, or roof) and orientation of the envelope element is defined by which row you enter your information into. The first eight rows are for creating walls with orientations S, SE, E, NE, N, NW, W, and SW, and the last three rows are for ceilings, floors, and roofs.

There are then the following fields that need to be filled in for each envelope element:

1. Construction type (choose between a default construction and the constructions that you already defined in the *Project Database* form).
2. Adjacent condition – Here you have 2 options:
   a. Leave the "Global" button pressed in and hence apply the global default adjacency condition that was associated with the selected construction in the *Project Database* form (see Section 7.4.1: Defining construction types) or
   b. Un-depress the "Global" button and select a condition from the drop-down menu (choose between: Exterior, Strongly ventilated spaces, Unheated adjoining space, Conditioned adjoining space, Underground, or Same space).

3. Area of the envelope (calculated as described in section 7.5.4: Defining envelopes – Envelope tab), in m^2.

4. Perimeter length (L), in m, if the envelope is a wall. **NB:** If this box is left blank, MBEAT will calculate the perimeter length using the input envelope area and assuming the height of the envelope to be the same as the height defined for the zone. However, if the envelope being defined does not have the same height as that defined for the zone, the user needs to input the perimeter length manually.

5. Pitch angle, in degrees, if the envelope is a roof.

If that envelope element has any windows or glazed areas, you need to fill in the following remaining fields:

6. Area of the window or rooflight, including the frame, in m^2. If you wish to define windows or rooflights (including the frames) using percentages of the envelope areas (as was the case in previous versions of MBEAT), then you need to untick the relevant box in the *General* form > *File Options* tab > *System Configuration (cont.)* sub-tab (see Section 7.3.1: File Options tab). The box is ticked by default.

   NB: Internal windows and doors should not be entered into MBEAT.

   NB: If the wall/roof is fully glazed, then the area of the window will be equal to, i.e. 100% of, the area of the wall/roof.

   NB: If a wall/roof contains a row/array of identical windows/rooflights, you should input the area of only <u>one</u> window/rooflight and use the "multiplier" field to define the number of identical windows/rooflights that exist in the same wall/roof.

NB: During the calculation, if the area of the wall input is found to be less than the total area of windows and doors defined within it, MBEAT will increase the area of the wall to fit the areas of all the defined openings in it. The corresponding wall in the notional building will similarly have the increased area. Therefore, you should always ensure that you double-check the figures you input for your model geometry in MBEAT before running the calculation.

7. Glazing type (choose between a default glazing type and the glazing types that you defined in the *Project Database* form).

8. Disp? – Indicate whether it is a display window or not (as defined in ADL2A).

Once the information is entered, click on the **"Create Envelopes"** button to create the envelopes. Once the button has been clicked and the envelopes have been created, the contents of the *Quick Envelopes* tab will be automatically cleared. If you do not wish for the contents of the tab to be cleared after the creation of the envelopes (for e.g., so you can re-use them), then you need to untick the relevant box in the *General* form > *File Options* tab > *System Configuration (cont.)* sub-tab (see Section 7.3.1: File Options tab). The box is ticked by default.

To **view** the envelopes and windows that you have created, go to the *Envelopes Summary* sub-tab (in the *Zones* tab) and the *Windows Summary* sub-tab (in the *Envelope* tab). All the envelopes and windows will be available for **editing** in the main *Envelope* and *Windows* tabs.

NB: Doors which are more than 50% glazed should be entered into MBEAT as windows, and their light and solar characteristics should be entered into the *Project Database* form > *Glazing* tab. Doors which are 50% or less glazed can be treated as opaque doors.

The parameters that you cannot define in the Quick Envelopes sub-tab include:

- Shading position - If the window or rooflight has anything but the default for this parameter (which is "None (no shading)"), then you will need to go to the *Windows & Rooflights* main tab, select the window in question using the record selector, and change the details manually.

- Transmission factor for windows - If the window or rooflight has anything but the default for this parameter (which is 1), then you will need to go to the *Windows & Rooflights*

main tab, select the window in question using the record selector, and change the details manually.

- Surface area ratio – If the window or rooflight has anything but the default (which is 1 for windows and 1.3 for rooflights) for this parameter, you will need to go to the *Windows & Rooflights* main tab, select the window in question using the record selector, and change the details manually.

- Frame factor – If the window or rooflight has anything but the default (which is 0.1 for windows and 0.3 for rooflights) for this parameter, you will need to go to the *Windows & Rooflights* main tab, select the window in question using the record selector, and change the details manually.

- Aspect ratio – If the window or rooflight has anything but the default (which is 0.7) for this parameter, you will need to go to the *Windows & Rooflights* main tab, select the window in question using the record selector, and change the details manually.

- Area ratio covered – If the rooflight definition has anything but the default value (which is 1) for this parameter, you will need to go to the *Windows & Rooflights* main tab, select the window in question using the record selector, and change the details manually.

Introducing a second envelope element with the same orientation:

If your zone has, for example, a second west-facing wall with a different construction or adjacent to a different condition on the other side, you would need to create one west wall, click on the "Clear all" button to remove the information about the first west wall, enter the information about the second west wall, and then click on "Create envelopes" again. The tool would then add the second west wall to the already created envelopes.

Naming of the envelope elements and windows created in the Quick Envelopes tabs:

The names are created automatically as described in Chapter 3.

Figure 42 shows a wall and a window being defined in the *Quick Envelopes* tab. The example wall is a 15 m^2, external, 5 m perimeter, south-facing wall, constructed from an External Wall specification that had previously been defined in the *Project Database* form. It has a 7.5 m^2 window with glazing of a type previously defined in the *Project Database* form, and it is not a display window.

Figure 42: The Quick Envelopes sub-tab

7.5.9. Using the reports to double-check the data entry

In addition to the summary sub-tabs already discussed in the previous sections, MBEAT produces two *Objects* reports which can be used to double-check the data you have entered. For details on these two reports, see Section 7.9: Double-checking the data.

7.6. Building Services form

This form holds all the information relating to the building services. This information is entered into the following main tabs (these are circled in Figure 43):

- **Global and Defaults** tab – This tab contains some default information on HVAC systems if no or little information is known about the systems in the actual building. It also requires information on the electric power factor and lighting controls for the whole building.
- **HVAC systems** tab - This tab requires information on the HVAC systems in the building.
- **HWS** tab - This tab requires information on the hot water systems in the building.
- **SES** tab - This tab requires information on any solar energy systems connected to the hot water systems in the building, if applicable.
- **PVS** tab – This tab requires information on any photovoltaic systems connected to the building, if applicable.

- **Wind generators** tab – This tab requires information on any wind generators connected to the building, if applicable.
- **CHP generator** tab (this tab only appears when one of the HVAC systems described in the *HVAC Systems* tab is specified as using CHP) – This tab requires information on any combined cooling, heating, and power generators connected to the building.
- **Transpired solar collectors** tab – This tab requires information on any transpired solar collectors connected to the building, if applicable.
- **Zones** tab – This is where you assign the appropriate HVAC system and HWS to each zone and input details on the zones' lighting and specific ventilation strategy.
- **Meters** tab – This is where you input the metered data for your building.

Figure 43: The tabs in the Building Services form

7.6.1. Global and Defaults tab

In this tab, there are the following sub-tabs:

- **HVAC System Defaults** sub-tab
- **Services Management Services** sub-tab

HVAC System Defaults sub-tab:

If no HVAC system serves the space (i.e., an unconditioned zone), you should select the option 'Zones without HVAC system' as the HVAC system for that zone in the *Geometry* form > *Zones* tab > *General* sub-tab or the *Building Services* form > *Zones* tab > *HVAC & HW System* sub-tab (spaces which have no heating or cooling, e.g., plant rooms, storage spaces, exposed circulation spaces.). If you do not know the type of the HVAC system in your existing building or its detailed parameters, you should instead select one of the following default options from the drop-down menu (see Section 7.5.3: Defining zones – Zones tab):

- 'Heating only - Electric resistance' - Heat generated by passing an electric current through resistance wire. Assumed to be an electric central heating system with warm air distribution. Fan storage heaters and electric fan converters should be input by defining an HVAC system in the *Building Services* form > *HVAC Systems* tab > *General* sub-tab and selecting the system type "Other local room heater - fanned". If you do not know the heating method (i.e., whether a heated-only building uses electricity or a fuel-based heating system), you should select electric resistance heating as your system.

- 'Heating only - Other systems' - Assumed to be a wet radiator system where heat is generated by fuel combustion. Pumps assumed to be powered by grid-supplied electricity. If you know the fuel type used by the heating system, you can define it in this sub-tab (Figure 43).

- 'Heating and mechanical cooling' - Assumed to be a constant volume air system with terminal reheat and fixed fresh air. Fans and pumps assumed to be powered by grid-supplied electricity. If you know the fuel types used by the heating and cooling generators, you can define them in this sub-tab (Figure 43).

NB: The default HVAC systems are representative of existing rather than new buildings and should only be used if you do not know the type of the HVAC system in your building or its detailed parameters as the default efficiencies assumed by MBEAT for these systems are quite pessimistic, and they cannot be edited by the user.

Services Management sub-tab:

In this sub-tab, you need to enter details about the electrical power factor and the management scores for the building as shown in Figure 44:

Building Details

1. Electric power factor – This is a measure of the actual electric power consumption to that usually measured by the electric metre (results from the voltage and current variations being out of phase). Select from: '<0.9', '0.9-0.95', and '>0.95'.

Management Scores

2. Current management score – This is the score for the current quality of energy management in the building. This is a round figure on a scale from 0 to 100 (inclusive), where 0 is the poorest (lowest) score and 100 is the highest (best) score.

3. Improved management score – This is the potential score if the quality of energy management in the building were improved. This is a round figure on a scale from 0 to 100 (inclusive), where 0 is the poorest (lowest) score and 100 is the highest (best) score.

Figure 44: Services Management sub-tab of the Global and Defaults tab in the Building Services form

7.6.2. Defining HVAC Systems – HVAC Systems tab

Overview of how to model HVAC Systems

The building's HVAC system(s) is defined within the first five sub-tabs of the *HVAC systems* tab.

- **General** sub-tab: This is where you select the system type, give it a unique name, and enter some basic system details for each HVAC system in the building.
- **Heating** sub-tab: This is where you can further define the heat generator efficiency.
- **Cooling** sub-tab: This is where you can further define the cold generator efficiency.
- **Systems Adjustments** sub-tab: This is where details on air leakage and specific fan power can be entered.
- **Bi-valent Systems** sub-tab: This is where you can define bi-valent systems for HVAC.
- **Zone Summary** sub-tab: This tab displays a summary of the zones assigned to each HVAC system, along with the zones' envelopes, windows, and doors.

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The *System type* selected in the *General* sub-tab automatically brings with it some assumptions. For example, whether mechanical ventilation is an integral part of the system and the degree of local time and temperature control that is (or can be) provided. The majority of system types used in non-domestic buildings can be found in the system type drop-down box. However, there are a few systems which require further guidance, such as:

- VRF with natural ventilation – Select 'Split or multi-split system', and then adjust the efficiencies in the *Heating* and *Cooling* sub-tabs to values suitable for the VRF.

- VRF with mechanical ventilation – Select 'Split or multi-split system', and then adjust the efficiencies in the *Heating* and *Cooling* sub-tabs to values suitable for the VRF, and define mechanical ventilation at zone level.

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- If 'Chilled ceiling' is selected, the default assumption is that there is displacement ventilation.
  - Chilled ceiling with no mechanical ventilation – Select 'Chilled ceilings or passive chilled beams and displacement ventilation', and then set the specific fan power to zero.
  - Chilled ceiling with mixing ventilation – Select 'Chilled ceilings or passive chilled beams and displacement ventilation', and then use twice the actual specific fan power in order to capture the effect of the higher ventilation rate.
- If your HVAC system is a high velocity forced-convection air heating (induction nozzle system), which does the job of mixing the air in the zone in a similar manner to destratification fans, then you can model this in MBEAT by first selecting the appropriate HVAC system type (flued or unflued) and then ticking the box relating to destratification fans (in the *Building Services* form > *Zones* tab > *HVAC & HW System* sub-tab) in the zones served by that system. The system should follow the flow rate guidelines given for destratification systems shown below. You will then need to justify this to Building Control using the necessary documentation for your system's functions.

NB: Destratification may be achieved by several means, for each of which minimum flow rates should be ensured. (Where destratification and heating is provided by the same system, higher flow rates may be needed to avoid excessive air supply temperatures):

- Cased fans installed at high level. The volume of air handled by the fans should be at least equivalent to two room volumes per hour. Total air movement will be higher than this because additional airflow will be induced.

- Open blade "sweep fans". In this case, air speeds will be lower and the volume of air handled should be at least the equivalent of 6 room volumes per hour.

- High velocity induction nozzles with a temperature rise through the heater of at least 45˚C. The volume of primary air from the nozzles should be at least equivalent to 0.15 room volumes per hour. Total air movement will be significantly higher because of the additional airflow induced by the nozzles.

The system type, along with the further details entered in the remaining HVAC sub-tabs, allow MBEAT to calculate the System Seasonal Efficiency for heating (SSEFF), the System Seasonal Energy Efficiency Ratio for cooling (SSEER), and the Auxiliary Energy.

SSEFF – The System Seasonal Efficiency for heating takes account of the seasonal efficiency of the heat generator, thermal losses and gains to and from pipework and ductwork, and duct leakage. It does not include the energy used by fans and pumps. The combined heating demand of all zones served by a particular system divided by its SSEFF gives the energy consumption of the heating system (For example, a boiler or boilers).

SSEER – The System Seasonal Energy Efficiency Ratio for cooling takes account of the seasonal efficiency of the cold generator, thermal losses and gains to and from pipework and ductwork, and duct leakage. It does not include the energy used by fans and pumps. The combined cooling demand of all the zones served by a particular system divided by its SSEER gives the energy consumption of the cooling system (For example, a chiller).

Auxiliary Energy – This is applied to the total floor area conditioned by a particular system. It depends on the duration of occupation and operation in the zones served, and it covers the energy used by fans, pumps, and controls. The calculation depends on the HVAC system type selected, as well as on other information provided by the user on the SFP, duct and AHU leakage, and control provision.

If no HVAC system serves the space (i.e., an unconditioned zone), you should select the option 'Zones without HVAC system' as the HVAC system for that zone in the *Geometry* form > *Zones* tab > *General* sub-tab or the *Building Services* form > *Zones* tab > *HVAC & HW System* sub-tab (spaces which have no heating or cooling, e.g., plant rooms, storage spaces, exposed circulation spaces). If you do not know the type of the HVAC system in your existing building or its detailed

parameters, you should instead select one of the following default options from the drop-down menu (see Section 7.5.3: Defining zones – Zones tab):

- 'Heating only - Electric resistance' - Heat generated by passing an electric current through resistance wire. Assumed to be electric central heating system with warm air distribution. Fan storage heaters and electric fan converters should be input by defining an HVAC system in the *Building Services* form > *HVAC systems* tab > *General* sub-tab and selecting the system type "Other local room heater - fanned" (see below). If you do not know the heating method (i.e., whether a heated-only building uses electricity or a fuel-based heating system), you should select electric resistance heating as your default.

- 'Heating only - Other systems' - Assumed to be a wet radiator system with heat generated by fuel combustion. Pumps assumed to be powered by grid-supplied electricity. If you know the fuel type used by the heating system, you can define it in this sub-tab (Figure 43).

- 'Heating and mechanical cooling' - Assumed to be a constant volume air system with terminal reheat and fixed fresh air. Fans and pumps assumed to be powered by grid-supplied electricity. If you know the fuel types used by the heating and cooling generators, you can define them in this sub-tab (Figure 43).

NB: The default HVAC systems in MBEAT are representative of existing rather than new buildings and should only be used if you do not know the type of the HVAC system in your building or its detailed parameters as the default efficiencies assumed by MBEAT for these systems are quite pessimistic, and they cannot be edited by the user.

General sub-tab:

The *General* sub-tab is shown in Figure 45. For each HVAC system in your building, you will need to create a new record and add the following information:

1. Name – A unique name must be given to each HVAC system.

2. System type – Here, you can currently choose between 26 system types (11 heating only systems and 15 heating and cooling systems), including, for e.g., VAV (variable air volume), fan coil, dual duct, and central heating with water distribution (see Table 15 for brief definitions of the system types). If the type selected is a 'heating and cooling" system, then the following parameter becomes active:

   a. A tick box to indicate whether this HVAC system is actually used in this project to provide cooling only. If the box is ticked, SBEM will disregard the heating feature of this HVAC. Otherwise, heating and cooling are assumed to be provided by this system.

NB: In order to ensure adequate ventilation for maintaining the concentration of CO_2 below 0.5% in spaces served by <u>unflued</u> heating appliances[viii], the zonal ventilation option for these spaces should be set to 'mechanical' (See section 7.6.9: Defining the zone specific building services).

NB: In order to define "Variable refrigerant flow" (VRF) systems and "Split or multi-split system with ventilation" systems in MBEAT, users should select the system type option "Split or multi-split system" and input a suitable efficiency. This simplifies the HVAC system options (multisplit can be used for VRF as VRF is a type of split/multisplit system) and removes ventilation from HVAC systems where the ventilation is not an integral part of the system heating/cooling strategy. If these systems are accompanied by mechanical ventilation, mechanical ventilation should be defined at zone level with a suitable ventilation SFP.

NB: See note after *System Adjustments* sub-tab, regarding specific fan power for fan coil systems.

[viii] For details, please refer to BS 5925:1991: Code of Practice for Ventilation Principles and Designing for Natural Ventilation.

NB: See note in Section 7.6.9: Defining the zone specific building services, regarding defining high velocity forced-convection warm air heaters.

NB: If there is **more than one type of HVAC system in a space** with each system clearly meant to service a particular part of the space, e.g., one servicing the facade perimeter area and another servicing the core area, then the space should be divided into 2 separate zones in MBEAT (each served by its corresponding HVAC system) even if there is no physical separation between the 2 zones (e.g., a wall). However, if heating is provided in the same zone by two, or more, different types of heat sources, for e.g., a heat pump in a split system and an LPG boiler in a wet system, you need to define the parameters of the different heat generators sharing the heating load in the *Bi-valent systems* sub-tab. On the other hand, if a zone is served by, for e.g., an LPG-fired wet system for heating and an electric split system for cooling only, then the systems can be approximated in MBEAT by defining your HVAC system type as "split or multisplit", the heat source as "LTHW boiler", and fuel type as "LPG", and then define the appropriate seasonal efficiency for the heating and energy efficiency ratio for the cooling. MBEAT will use LPG for the heating and grid-supplied electricity for the cooling. If applicable, you then need to define the mechanical ventilation at zone level (for all the zones served by this system) with a suitable ventilation SFP, and heat recovery.

If you change the HVAC system type defined in your project from one that provides mechanical ventilation to one that does not (or vice versa), you <u>must</u> re-visit the *Ventilation* **sub-tab of the** *Zones* **tab in the** *Building Services* **form <u>for all the zones served by this HVAC System</u> in order for all ventilation-related parameters to be updated by the tool. You may also wish to re-define the local ventilation in these zones following the change in the HVAC type** (see Section 7.6.9: Defining the zone specific building services-Zones tab).

Heating system:

3. Heat source – Depending on the system type selected, a selection of heat sources is offered. For example, if 'Single-duct VAV' is selected, you need to choose between: LTHW boiler, MTHW boiler, HTHW boiler, Direct or storage electric heater, Heat pump: air source, and Heat pump: ground or water source.

4. Fuel type – Depending on your selected heat source, you will be given a selection of heating fuel types to choose from, for e.g., LPG, Fuel Oil, Grid-supplied electricity.

5. Tick if this system also uses CHP (tick box) – This tick box appears if the system type selected can use CHP. If it is ticked, a new tab appears, *CHP generator*, where further details are required to describe the CHP generator. If the box is not ticked, the tab does not appear.

Cooling system:

6. Generator type - If appropriate to your choice of system, you will be given the option to select a cooling generator type from the drop-down list: Air cooled chiller, Water cooled chiller, Remote condenser chiller, Heat pump (gas/oil), or Heat pump (electric).

Ventilation:

7. Heat recovery – Depending on the system type, this ventilation characteristic needs to be selected from: No heat recovery, Plate heat exchanger (Recuperator), Heat pipes, Thermal wheel, and Run around coil (see Table 14).

Option	Brief Definition
No heat recovery	No heat recovery system
Plate heat exchanger (Recuperator)	Recuperators usually take the form of air-to-air plate heat exchangers
Heat pipes	The heat-pipe is a passive heat exchanger of which there are two main types: • horizontal - in which a wick within the tubes transfers liquid by capillary action

	• vertical - in which heat from the warmer lower duct is transferred to the cold upper duct by means of a phase change in the refrigerant.
Thermal wheel	A thermal wheel comprises a cylinder packed with a suitable heat transfer medium that rotates slowly within an airtight casing which bridges the ducts between which heat is to be transferred.
Run around coil	Finned air-to-water heat exchangers are installed in the ducts between which the heat is to be transferred. A pumped water or water/glycol (for freeze protection) circuit is used to transfer heat from the warm extract air to the cooler supply air (or vice versa in summer)

Table 14: Definitions of heat recovery options in MBEAT

8. Heat recovery seasonal efficiency - This parameter is active if a heat recovery system is selected, i.e., the previous parameter is <u>not</u> set to 'No heat recovery'. If you know the heat recovery efficiency, it can be introduced manually into the interface. Otherwise, a default value, corresponding to the selected heat recovery system type, will be used by MBEAT.

9. Tick box to denote whether the heat recovery system efficiency is variable - This parameter is active if a heat recovery system is selected above.

NB: If the SFP was calculated or measured for a mechanical ventilation system that already included heat recovery, then that is the value you enter into MBEAT. If the SFP was calculated or measured for a mechanical ventilation system before a heat recovery system was added on, then you need to add 0.15 to the SFP for a thermal wheel system and 0.3 for any of the other heat recovery options in MBEAT, to account for the additional resistance.

Figure 45: HVAC system definition, General sub-tab

System Type in MBEAT	Brief Definition
Central heating using water: radiators	Central heat generator(s) with water distribution and radiators

Central heating using water: convectors	Central heat generator(s) with water distribution and convectors
Central heating using water: floor heating	Central heat generator(s) with water distribution and floor heating
Central heating with air distribution	Central heat generator(s) with air distribution
Other local room heater - fanned	Includes gas fires, gas convectors, direct electric heaters, electric storage heaters that are provided with fans. Larger units above about 10kW such as "cabinet heaters" or "unit heaters" should be classed as "forced convection air-heaters"
Other local room heater - unfanned	Includes gas fires, gas convectors, direct electric heaters, electric storage heaters that do not have fans
Unflued radiant heater	Luminous or non-luminous overhead radiant heater without flue. Includes electric overhead radiant heaters
Flued radiant heater	Luminous or non-luminous overhead radiant heater with flue
Multiburner radiant heaters	Overhead multiburner radiant heater
Flued forced-convection air heaters	May have fan to assist transportation of combustion air and/or combustion products.
Unflued forced-convection air heaters	"Direct" gas heaters. Note that provision for adequate ventilation must be provided
Single-duct VAV	An all-air system in which the volume of supply air is modulated to match the cooling demand. May have reheat capability. Assumed to also provide heating, possibly also with separate perimeter heating system
Dual-duct VAV	A VAV system with separate supply of hot and cold air. Assumed to also provide heating, possibly also with separate perimeter heating system
Indoor packaged cabinet (VAV)	Local cooling/heating unit. May supply air directly into room, into under floor void, or into ceiling void. May have terminal units with variable local recirculation rate. May have electrical trim heater. Volume of air handled is sufficient to handle all the cooling load. Assumed to also provide heating, possibly also with separate perimeter heating system
Fan coil systems	Local fanned terminal units in ceiling, on wall or on floor, with a central chilled water supply. Systems may be 2-pipe, 3-pipe or 4-pipe, changeover or non-changeover - no distinction is made here. Assumed to also provide heating. Zonal ventilation is no longer available for fan coil units. Ventilation for this HVAC type is defined at HVAC level.
Induction system	Air is supplied from a central unit, commonly at high pressure. This induces a secondary airflow within the terminal unit to achieve an acceptable delivery temperature. Final heating or cooling is provided by heat exchangers within the terminal. Systems may be 2-pipe, 3-pipe or 4-pipe, changeover or non-changeover - no distinction is made here. Assumed to also provide heating.

Constant volume system (fixed fresh air rate)	An all-air system in which the volume of supply air is fixed. Assumed to also provide heating, possibly also with separate perimeter heating system. If provided with local reheat capability, use the "Terminal reheat (constant volume)" system. This category includes packaged rooftop units.
Constant volume system (variable fresh air rate)	Constant volume system in which the proportion of fresh air can be varied to limit chiller operation ("free cooling economiser").
Multizone (hot deck/cold deck)	A central air handling unit has separate hot and cold decks. Mixing takes place at the Air handling unit and air is supplied to each zone through a single duct per zone. Assumed to also provide heating, possibly also with separate perimeter heating system.
Terminal reheat (constant volume)	Cooled air is supplied centrally and reheated locally to the desired supply temperature for each zone. Assumed to also provide heating, possibly also with separate perimeter heating system.
Dual duct (constant volume)	Hot and cold air are distributed separately - commonly at high pressure - and locally mixed to provide the desired supply temperature for each zone. Assumed to also provide heating, possibly also with separate perimeter heating system.
Chilled ceilings or passive chilled beams and displacement ventilation	The combination of a chilled ceiling (or passive chilled beam) system with a separate low-level, low volume supply of cooled ventilation air. Heating assumed to be by separate LTHW system. The default assumption is that there is displacement ventilation.
Active chilled beams	Chilled beams which include the provision of cooled air from a central source, typically operating as an induction system. May include local fans. Heating assumed to be by separate LTHW system.
Water loop heat pump	Local heat pumps are served by a common water circuit to or from which they can reject or extract heat. Central cooling and heating plant provides the net heat or cooling input to this circuit. Assumed to also provide heating.
Split or multi-split system	Combination of outdoor and indoor units connected by refrigerant pipe work. No mechanical ventilation system. Use this category also for ducted split systems and window/wall units. *The SEER/SCoP should include the power consumption for compressors, controls, as well as fans and pumps within the air-conditioning units.*
Single room cooling system	Integral units without ducting, such as wall or window units. Ducted units should be defined as constant or variable volume air systems, as appropriate. *The SEER/SCoP should include the power consumption for compressors, controls, as well as fans and pumps within the air-conditioning units.*

Table 15: Definitions of HVAC type options in MBEAT

Heating sub-tab:

Once you have entered the basic information on each HVAC system into the *General* sub-tab, there are a few more details on the heating efficiency which can be entered, if they are known. You will see that the 'Heat Source' and 'Fuel Type' fields that were completed in the *General* tab also appear in this tab (they can be edited in either tab).

First, you need to select the HVAC system with the record selector, and then the following information can be entered:

Heating System

1. Heat source – Depending on the system type selected, a selection of heat sources is offered. For example, if 'Single-duct VAV' is selected, you need to choose between: LTHW boiler, MTHW boiler, HTHW boiler, Direct or storage electric heater, Heat pump: air source, and Heat pump: ground or water source.

2. Fuel type – Depending on your selected heat source, you will be given a selection of heating fuel types to choose from, for e.g., LPG, Fuel Oil, Grid-supplied electricity.

3. Effective heat generating seasonal efficiency - If you know the effective heat generating seasonal efficiency for the heat generator, it can be introduced manually into the interface. Otherwise, a (conservative) default value will be used by MBEAT.

   NB: The Effective Heat Generating Seasonal Efficiency is calculated by adding the Heating Efficiency Credits, where applicable for additional controls and other measures that go beyond the required minimum controls package, to the Heat Generator Seasonal Efficiency. The Heat Generator Seasonal Efficiency is the ratio of the useful heat output to the energy input over the heating season.

Convention: Electric room heaters

Any form of fanned or unfanned electric 'room heater' whether panel, bar, convector, or storage heater shall have a user-input heat generating seasonal efficiency of 1 (i.e., 100% efficiency).

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1. Generator radiant efficiency (this parameter is active if the HVAC system chosen is a radiant system) - It refers to the ratio of radiant heat output to energy input. If you know the generator's radiant efficiency, it can be introduced manually into the interface. Otherwise, a default value will be used by MBEAT.

Figure 46 shows a heating system being defined.

Figure 46: HVAC systems definition, Heating sub-tab

Cooling sub-tab:

In addition to the information entered in the *General* sub-tab, you can define the power rating and efficiency of the cooling system. If they are not known, default values will be used by the software. The information is entered as follows:

Cooling System

1. Generator type - If appropriate to your choice of system, you will be given the option to select a cooling generator type from the drop-down list: Air cooled chiller, Water cooled chiller, Remote condenser chiller, Heat pump (gas/oil), or Heat pump (electric).

2. Generator kW – This is the cooling generator's nominal electrical power, and if applicable, it needs to be selected from: Up to 100kW, 101 to 500kW, 501 to 750kW, and 751 to 3.5MW. This field is not active if the cooling generator type selected is Heat pump (gas/oil), or Heat pump (electric). The selected value (in addition to the option selected for the ECA parameter below) determines the default energy efficiency ratio used by the calculation if no efficiency value is input by the user.

3. Fuel type – Depending on your selected cooling generator type, you will be given a selection of cooling fuel types to choose from, for e.g., LPG, Biogas, Fuel Oil, or Grid-supplied electricity.

4. Seasonal energy efficiency ratio - If you know the seasonal energy efficiency ratio (SEER) for the cooling generator, it can be introduced manually into the interface. Otherwise, a default value will be used by MBEAT. (Guidance on the calculation of the seasonal energy efficiency ratio can be found in the Non-Domestic HVAC Guide published by DCLG.)

5. Nominal energy efficiency ratio - If you know the nominal energy efficiency ratio (EER) for the cooling generator, it can be introduced manually into the interface. Otherwise, a default value will be used by MBEAT for compliance checking. (Guidance on the nominal energy efficiency ratio can be found in the Non-Domestic HVAC Guide published by DCLG.)

NB: The cooling generator seasonal energy efficiency ratio is the value used within MBEAT to calculate the cooling energy while the cooling generator nominal energy efficiency ratio is the value displayed in the BRUKL output document for compliance checking against the limiting standards from the HVAC compliance Guide.

6. Tick box to indicate if the HVAC system uses a mixed-mode cooling operation.

Figure 47 shows a cooling system being defined.

Figure 47: HVAC systems definition: Cooling sub-tab

System Adjustments sub-tab:

The *System Adjustments* sub-tab (Figure 48) allows the user to specify other system properties, such as, the air leakage associated with the ducts or the air handling unit (AHU) and the specific fan power (SFP). If this information is not known, default values will be used by the software. **NB:** These default values reflect past practices and may not be compliant with the current Building Regulations.

The information is entered as follows:

Ductwork and AHU Leakage

1. Ductwork leakage – If the ductwork has been tested or design targets set for the building, the appropriate CEN classification for air leakage can be entered by clicking on the radio button "Yes, it meets the CEN leakage classification below" and choosing from the drop-down list between: Worse than Class A, Class A, Class B, Class C, or Class D. Different classes refer to the maximum air leakage obtained for the HVAC ductwork at different test conditions.

2. AHU leakage – Similarly, if the AHU has been tested or design targets set for the building, click on the appropriate radio button and choose from the drop-down list between: Class L1, Class L2, Class L3, or Worse than Class L3.

Specific Fan Power for the System

3. Specific Fan Power (SFP) – The SFP of an air distribution system is defined as the sum of the design total circuit-watts, including all losses through switchgear and controls such as inverters, of the fans in the system that supply air and extract it back outdoor (i.e. the sum of the total circuit-watts of supply and extract fans), divided by the design air flow rate through the system. For further details on the SFP and how it is calculated, see the Non-Domestic HVAC Compliance Guide. If the SFP for the system is known, it can be entered manually. Otherwise, the software will insert a default (conservative) value.

NB: If the SFP was calculated or measured for a mechanical ventilation system that already included heat recovery, then that is the value you should enter into MBEAT. If the SFP was calculated or measured for a mechanical ventilation system before a heat recovery system was added on, then you need to add 0.15 to the SFP for a thermal wheel system, and 0.3 for any of the other heat recovery options in MBEAT, to account for the additional resistance.

NB: If the HVAC system selected is 'Fan coil systems' or 'Indoor packaged cabinet (VAV)', the SFP input here should be for the central plant, and then the SFP for the terminal units can be input in the *Building Services* form > *Zones* tab > *Ventilation (cont.)* sub-tab for all the zones served by this HVAC system.

If the type of HVAC system selected in the *General* sub-tab is one where variable speed pumping can be applicable, the following parameters become active:

Pumps

4. A radio button to indicate whether there is constant speed pumping or variable speed pumping for, depending on the HVAC system type selected, a LTHW boiler or both a LTHW boiler and a chilled water (CHW) generator. If there is indeed variable speed pumping for this system, then the following parameter becomes active:

   a. Type – You need to select the type of variable speed control for the pumps from the options available in the drop-down menu.

Figure 48: HVAC systems definition: System Adjustments sub-tab

Bi-valent Systems sub-tab:

A bivalent heating system is one in which the heating is supplied by two (or more) different types of heat sources. An example could be an electric heat pump with an LPG boiler for backup. As such, in addition to the heat source, seasonal efficiency, and fuel type of the primary heat generator you have already defined in the *General* and *Heating* sub-tabs, in the *Bi-valent Systems* sub-tab, you can also define additional/secondary heat generator(s) that share the total heating load with the primary heat generator (see Figure 49). For <u>each</u> additional heat generator, the following parameters need to be input:

1. Heat source of additional heat generator

2. Fuel type of the additional heat generator

3. Effective heat generating seasonal efficiency of the additional heat generator.

4. Proportion, in %, of the heating load that the additional heat generator provides.

Figure 49: HVAC systems definition: Bi-valent Systems sub-tab

Zone Summary sub-tab:

The names of the zones assigned to the HVAC system can be viewed in the *Zone Summary* sub-tab of the *HVAC Systems* tab, shown in Figure 50. The zones are listed in the left hand side window, and if any of the zones are highlighted, more details about that zone appear in the 'Zone's properties' window. For example, details such as the zone's area and activity are displayed.
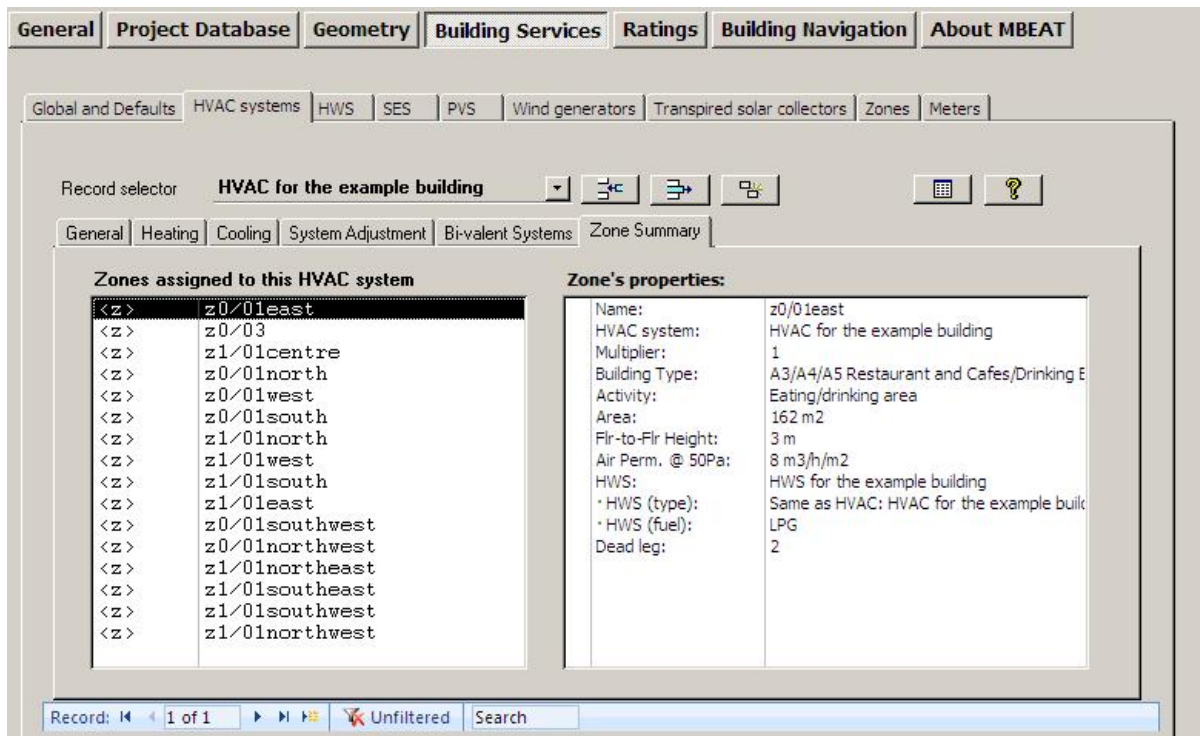
Figure 50: HVAC systems tab: Zone Summary sub-tab

7.6.3. Defining HWS – HWS tab

The *HWS* tab has four sub-tabs:

- **General** sub-tab: This is where the Hot Water System generator, fuel type, and efficiency are defined. (The HW system needs to be defined here before it can be assigned to any zones).
- **Storage & Secondary Circulation** sub-tab: This is where the data on the hot water storage and secondary circulation, if applicable, are defined.
- **Assigned** sub-tab: This tab shows which zones each HWS is assigned to serve.
- **Bi-valent Systems** sub-tab: This is where you can define bi-valent systems for water heating. This sub-tab becomes visible only if the hot water is <u>not</u> provided by the HVAC system.

General sub-tab:

A HWS is defined by the following information:

1. Name – This needs to be a unique name.

    NB: Note that the 'Multiplier' field no longer exists for HWS.

2. Generator type – Select from: Dedicated HWS boiler, Stand-alone water heater, Instantaneous HWS only, Instantaneous combi, Heat pump, or any of this project's HVAC systems previously defined in the *HVAC Systems* tab.

3. Fuel type – Depending on the generator type selected, a list of fuel types is available. For example, if "Instantaneous combi" is selected, you need to choose between: LPG, Biogas, and Fuel Oil. If one of the project's HVAC systems is chosen as the generator type, this field is not enabled as the fuel type would have been previously defined in the *HVAC Systems* tab.

4. Effective heat generating seasonal efficiency - If you know the effective heat generating seasonal efficiency for the HWS generator, it can be introduced manually into the interface. Otherwise, a default value will be used by MBEAT. (This field is inactive if the HWS Generator type selected is 'Same as HVAC').

NB: The Effective Heat Generating Seasonal Efficiency is calculated by adding the Heating Efficiency Credits, where applicable for additional controls and other measures that go beyond the required minimum controls package, to the Heat Generator Seasonal Efficiency. The Heat Generator Seasonal Efficiency is the ratio of the useful heat output to the energy input over the heating season.

NB: Where there is no hot water demand in the building, users should select the option "Zone with access to cold water only" when assigning the HWS to each zone in Section 7.6.9: Defining the zone specific building services- Zones tab.

Figure 51 shows a HWS generator being defined.

Figure 51: Defining a HWS in the General sub-tab

Storage & Secondary Circulation sub-tab:

In this sub-tab (Figure 52), you can enter the following information:

1. Is the system a storage system? – Tick if yes.

2. If the above tick box, regarding the a storage system, is ticked, the following fields become active:

    Either (depending on the selected radio button)

    a. Storage volume (volume of the HWS cylinder) in litres.

    b. Insulation type (on the HWS storage cylinder) – selected from the drop-down menu. If the option selected is <u>not</u> "Uninsulated", then the following parameter becomes active:

        i. Insulation thickness (on the HWS storage cylinder) in mm.

or

  c. Storage losses in MJ/month.

  d. Does the system have secondary circulation? (tick box)

    i. If the secondary circulation tick box is ticked, default values will be assumed for heat losses per metre run (W/m), pump power (kW), and secondary pipework length (m). You can insert specific values if you know them.

    ii. Tick box if there is time control on the secondary circulation.

NB: If the above two boxes regarding a HWS storage volume and secondary circulation are activated but no values are entered by the user for the relevant parameters, the default values used in the MBEAT calculation will be displayed within the interface <u>after</u> the calculation has been run. However, these calculated defaults would be quite pessimistic, and users are advised to enter their own values instead.

NB: If a solar energy system is connected to a HWS, then hot water storage is expected to exist.

NB: If the provision of hot water in any area/zone of the building consists of a combination of HWS generators that do not work simultaneously (such as an additional generator for backup to ensure continuity of hot water supply in a hospital), then the storage volume entered into MBEAT for the HWS should refer to the maximum storage volume that can be used at any given time during the year. The same applies to storage losses. For example, if two identical HWS generators with independent storage are installed to provide a hospital with HWS but one generator and storage are only used in case there is a failure in the primary one, you would input into MBEAT the volume and storage losses associated with only one of the systems.

NB: <u>Modelling trace heating in MBEAT:</u> As an approximation, it can be considered that the energy used by trace heating is equivalent to that used by a secondary circulation. You can tick the box in the *Building Services* form > *HWS* tab > *General* sub-tab to indicate that there is a secondary circulation and then leave the rest of the secondary circulation related fields blank to be calculated by MBEAT. You can also leave the deadleg at the default of 0 m.

Figure 52: HW Storage and Secondary Circulation sub-tab

Bi-valent Systems sub-tab:

This sub-tab becomes active only if the generator type in the *General* sub-tab is not defined as 'Same as HVAC'. It allows the user to define a bi-valent water heating system, i.e., a system in which the heating is supplied by two (or more) different types of heat sources. As such, in addition to the generator type, fuel type, and seasonal efficiency, of the primary heat generator for water heating you have already defined in the *General* sub-tab, in the *Bi-valent Systems* sub-tab, you can also define additional heat generators that share the total water heating load with the primary heat generator (see Figure 49). For each additional heat generator, the following parameters need to be input:

1. Generator type of the additional heat generator

2. Fuel type of the additional heat generator

3. Effective heat generating seasonal efficiency of the additional heat generator.

4. Proportion, in %, of the water heating load that the additional heat generator provides.

To **delete** a generator type, click here to highlight and click the "Delete" button on your keyboard.

Figure 53: HW Bi-valent Systems sub-tab

Assigned sub-tab:

The zones assigned to the HWS can be viewed in the *Assigned* sub-tab of the *HWS* tab, shown in Figure 54.
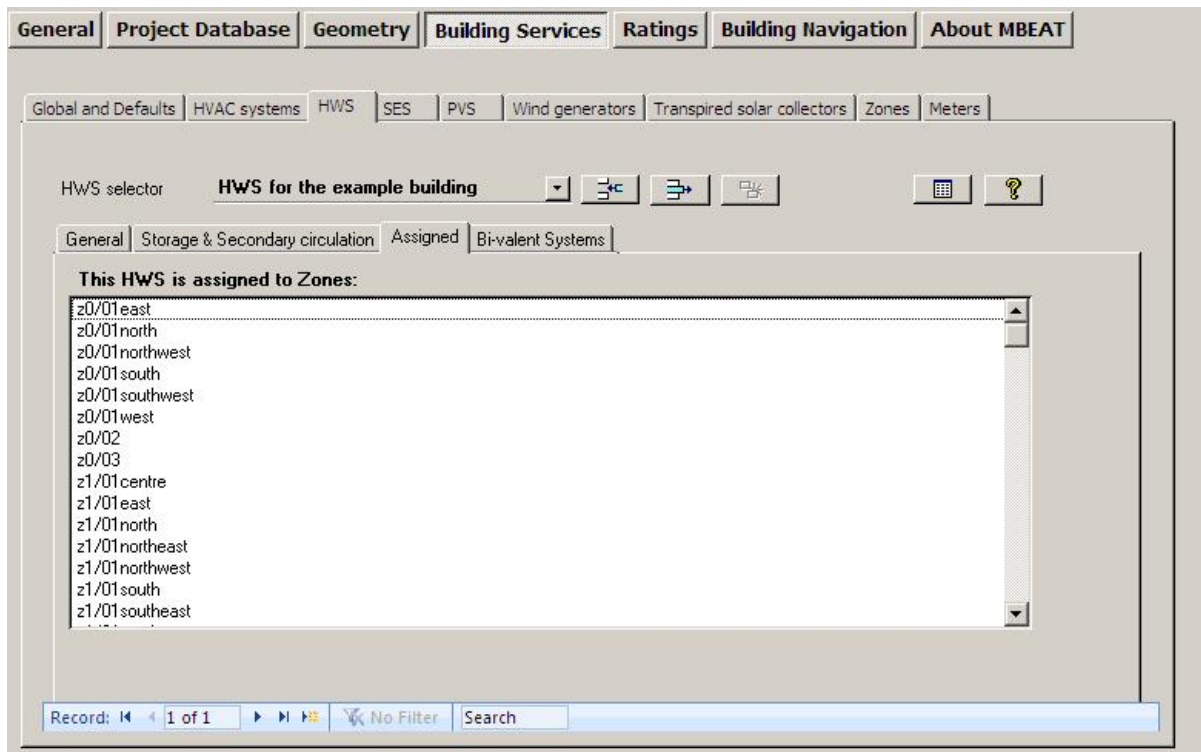
Figure 54: The Assigned sub-tab shows Zones to which the HWS has been assigned

7.6.4. Defining Solar Energy Systems (SES) – SES tab

There are three sub-tabs in the *SES* tab:

- **Collector Parameters** sub-tab
- **Solar Storage & Collector Loop** sub-tab
- **Auxiliary Energy & Distribution Losses** sub-tab

NB: The overall performance of solar thermal systems depends on how the hot water system is used, e.g., daily draw-off patterns and the use of other water heating devices such as a back-up boiler or an immersion heater. The procedure followed in MBEAT is not suitable for detailed design for a particular case. It is intended to give a representative value of the solar contribution to water heating over a range of users. The calculation methodology implemented in MBEAT is based on the f-chart method and has been adopted from the standards EN 151316-4-3:2007 *Heating systems in buildings – Method for calculation of system energy requirements and system efficiencies – Part 4-3: Heat generation systems, thermal solar systems*.

Collector Parameters sub-tab:

The parameters required to define an SES in this sub-tab (see Figure 55) are:

1. Name – Give it a unique name.

2. Multiplier – Indicate how many SES systems identical to this one are associated with the selected HWS.

3. In HWS - Select the HWS that this SES connects to, i.e., serves.

NB: It is important to assign the SES to the relevant hot water system. The drop-down list contains all the hot water systems that you have already defined in the *HWS* tab. If the SES is

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not assigned to the HWS, it will not be linked to the building, and any solar contribution to the hot water demand will not be accounted in the calculation.

NB: If a solar energy system is connected to a HWS, then hot water storage is expected to exist.

4. Area – Aperture area of solar collector(s), in m^2. It refers to the solar collector maximum projected area through which un-concentrated solar radiation enters the collector. The collector aperture area should not be confused with the collector gross area which refers to the projected area of the complete collector.

5. Orientation - Select from the drop-down list: S, SE, SW, E, W, NE, NW, or N. The orientation and inclination of the solar collectors are needed for MBEAT to calculate the solar radiation at the solar collector surface.

6. Inclination – Select from the drop-down list from between $0\text{-}90^o$ in 15° intervals. The inclination of the solar panels is in degrees from the horizontal where 0 stands for a horizontal surface and 90 for a vertical surface. The orientation and inclination of the solar collectors are needed for MBEAT to calculate the solar radiation at the solar collector surface.

7. Do you know the collector performance parameters according to EN 12975-2? – The preferred source of performance data for solar collectors is from a test on the collector concerned according to EN 12975-2: *Thermal solar systems and components – Solar collectors – Part 2: Test methods*. If test data are not available (e.g., for an existing installations), then the default values should be used by selecting:

- No, use the default values from – you then need to select the collector type from the drop-down menu, and MBEAT will use the corresponding default values as shown in Table 16.

Collector type in drop-down menu	h_0	a_1	a_2	IAM
Unglazed	0.9	20	0	1
Flat plate	0.75	6	0	0.94
Evacuated tube	0.65	3	0	0.97

Table 16: Default solar collector performance parameters

On the other hand, if the performance parameters are known, then you should select:

- Yes, the values are – you then need to enter the following parameters which will become active:

a) η_0 – (sigma-zero) the zero-loss collector efficiency factor from the collector test standards EN 12975-2 and related to the aperture area.

b) a_1 – the collector heat loss coefficient, in W/m^2K, from the collector test standards EN 12975-2 and related to the aperture area.

c) a_2 – the temperature dependence of the heat loss coefficient, in W/m^2K, from the collector test standards EN 12975-2 and related to the aperture area.

d) IAM – the incidence angle modifier (IAM) of the collector from the collector test standard EN 12975-2 when the test angle of incidence between it and the direct solar radiation for the test condition is 50°.

Figure 55: Defining a Solar Energy System in the Collector Parameters sub-tab

Solar Storage & Collector Loop sub-tab:

The parameters required to define an SES in this sub-tab (see Figure 57) are:

1. Solar storage volume - refers to the dedicated solar storage volume, in litres, and it should be calculated according to the arrangements for solar pre-heating as indicated in the schematic in Figure 56 and the guidance below:

   - in the case of one or more separate pre-heat tanks, such as arrangements a) or c) in Figure 56, the solar storage volume is the volume of the pre-heat tank(s).

   - in the case of a combined cylinder, such as arrangement b) in Figure 56, the solar storage volume is the volume between the bottom of the lowest back-up element (electric element or heat exchanger) to the lowest element of the solar primary.

   - in the case of a thermal store (hot water only) where (only) the solar coil is within the thermal store, the solar storage volume is the volume of the dedicated thermal storage.

   - in the case of a direct system, such as arrangement d) in Figure 56, the solar volume should be calculated as 0.3 times the volume of the cylinder.

NB: The schematic examples reflected in the Figure 56 are unlikely to represent all types of commercial solar thermal installations. Where necessary, and for more complex systems, an accredited dynamic simulation tool can be used.

NB: The dedicated solar volume of a solar thermal installation varies depending on the control and timing strategy of the of the back-up system. To optimise the performance of the solar thermal system, the back-up system should be prevented from operating during and prior to the period of the day where the solar radiation is strong enough to contribute to the hot water requirements. Where it can be demonstrated that the dedicated solar volume should be calculated following a different approach to the guidelines given here, alternative calculations can be used as long as they are in agreement with the UK Micro Certification Scheme standards

in effect at that time. The detail and justifications of the calculations undertaken will need to be submitted to the Building Control officer.

a) With separate solar cylinder

b) With a twin-coil cylinder

c) Combi boiler

d) Direct system
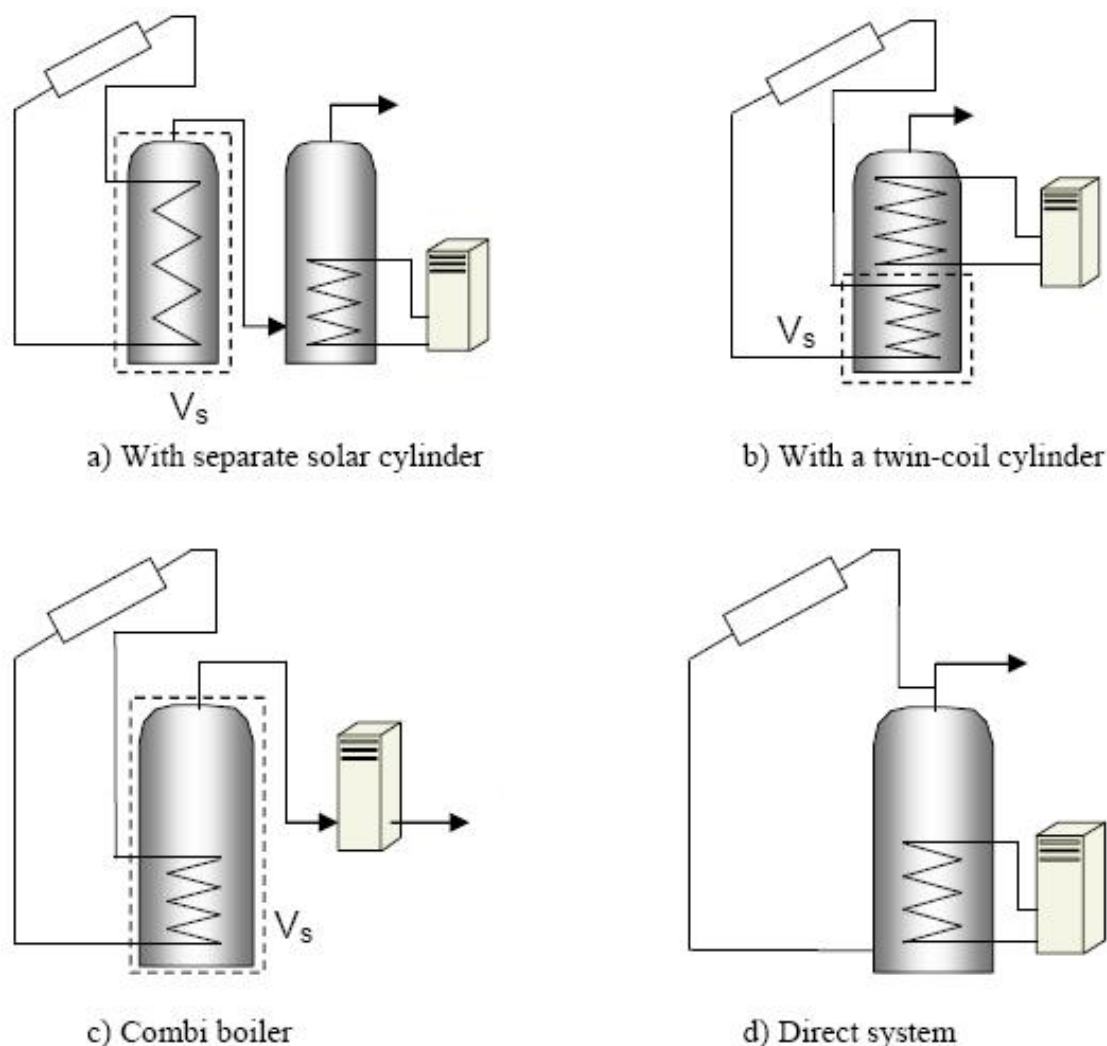
V_s (indicated by the dashed line) is the dedicated solar storage volume.

Figure 56: Schematic examples of arrangements for solar pre-heating (*These schematics are not intended to show safety measures or devices needed to make the systems safe.*) – Adapted from SAP2005

2. Solar pre-heating type – you need to select an option from the drop-down menu as follows:

   - Separate solar cylinder - when there is one or more dedicated solar storage vessels that are heated with the solar collectors only and that do not contain any other heating sources, i.e., the solar energy system has a storage cylinder that is independent of that for the hot water system storage.

   - Combined cylinder - the solar storage is combined in a hot water cylinder with one or more back-up sources, i.e., the solar energy system shares the same storage vessel with the hot water system.

   If the solar pre-heating type selected is 'Separate solar cylinder', then the following parameter becomes active:

a. Insulation type (on the solar storage cylinder) – selected from the drop-down menu. If the option selected is <u>not</u> "Uninsulated", then the following parameter becomes active:

    i. Insulation thickness (on the solar storage cylinder) in mm.

3. Do you know the heat transfer rate of the heat exchanger(s) in the collector loop? – you need to select one of the following options:

- There is no heat exchanger - For solar thermal direct systems in which the solar primary transmission fluid and the consumed water are the same, i.e., arrangement d) in Figure 56, you should select this option. Otherwise, for indirect systems where the primary circuit fluid is different to that of the secondary side of the system, there will be one or more heat exchangers in the storage vessel, and you should selected one of the other two options below.

- No, use the default value.

- Yes, the value is – you need to input the heat transfer rate, in W/K, in the box that will become active. For small systems, the heat transfer rate of the heat exchanger in the solar loop can be obtained from test results according to the standards EN 12975-3 - *Performance characterisation of stores for solar heating systems*. For large systems, the value can be taken from the heat exchanger performance data sheet provided by the manufacturer. For systems with more than one heat exchanger, using an intermediary or tertiary arrangement such as with a thermal store, an equivalent heat transfer rate can be input by the user (alternatively, dynamic simulation compliance tools can be used).

NB: The solar collector loop refers to all elements located between the solar collector and the point where the back-up heating source supplies the hot water system with energy.

4. Do you know the overall heat loss coefficient of all pipes in the collector loop? – you need to select one of the following options:

- No, use the default value.

- Yes, the value is – you need to input the heat loss coefficient, in W/K, in the box that will become active. This is the overall heat loss coefficient of all pipes in the solar loop, including pipes between collectors and array pipes between the collector array and the solar storage tank(s). If the pipe and insulation for the solar loop are known, the overall heat loss coefficient of all the pipes in the solar loop can be calculated accordingly (see for instance *John A. Duffie and William A. Beckman: Solar Engineering of Thermal Process. Wiley-Interscience ed., 1991*).

Figure 57: Defining a Solar Energy System in the Solar Storage & Collector Loop sub-tab

Auxiliary Energy & Distribution Losses sub-tab:

The parameters required to define an SES in this sub-tab (see Figure 58) are:

1. Are the distribution pipes between the solar energy system and the back-up system insulated? – you need to select either yes or no. If there are pipes between the solar thermal system and the back-up heating system, this parameter is used to estimate the thermal losses of the distribution between the solar thermal system and back-up heater. This parameter becomes active only if the "Solar pre-heating type" parameter in the *Solar Storage & Collector Loop* sub-tab has been set to 'Separate solar cylinder'.

2. Circulation system – you need to select one option from the drop-down menu. If the option selected is 'forced circulation system with no PV', then the following parameter becomes active:

    a. Do you know the nominal power of the pumps? – you need to select one of the following options:

        • No, use the default value.

        • Yes, the value is – you need to input the nominal power, in W, in the box that will become active.

    NB: The auxiliary energy consumption required by the circulation pumps in the solar system is calculated according to the type of circulation system. For thermosiphon systems and forced circulation systems assisted with photovoltaics, the auxiliary energy consumption is zero. For forced circulation systems that require grid-electricity for the circulation pump in the solar loop, the user needs to enter the nominal input power of the pumps, which is the power stated on the pumps label. For a multi-stage pump, the power corresponding to the typical operation mode should be chosen. The annual operation time of the pump used for the calculation is in accordance to the EN 12976 standards.

Figure 58: Defining a Solar Energy System in the Auxiliary Energy & Distribution Losses sub-tab

7.6.5. Defining a Photovoltaic system (PVS) – PVS tab

MBEAT allows the user to define a PVS installed on the building in order to provide a percentage of the electrical demand of the building (see Figure 59) by displacing grid-supplied electricity. There is only one sub-tab in the *PVS* tab:

- **General** sub-tab

General sub-tab:

The definition of a PVS requires:

1. Name – Give it a unique name

2. Multiplier – Indicate how many PVS identical to this one exist in the building.

3. Type – Choose from the drop-down list the type of modules used in your PV system.

4. Area – Area of the photovoltaic panel (m^2) excluding the supporting construction.

5. Orientation - Select from the drop-down list: S, SE, SW, E, W, NE, NW, or N. The orientation and inclination of the PV modules are needed by MBEAT to calculate the solar radiation at the module surface.

6. Inclination – Select from the drop-down list from 0°-90° in 15° intervals. The inclination of the photovoltaic panels is in degrees from the horizontal where 0 stands for a horizontal surface and 90 for a vertical surface. The orientation and inclination of the PV modules are needed by MBEAT to calculate the solar radiation at the module surface.

7. Overshading – Select from the drop-down list the level of over-shading of the PV array. The over-shading level refers to the percentage of the sky that is blocked by obstacles (see Table 17). It should be assessed taking into account the inclination of the panels.

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8. Ventilation strategy – Select from the drop-down list the ventilation strategy for the PV array, aided by the definitions in Table 18.

Level of over-shading	% of sky blocked by obstacles
None or very little	<20%
Modest	20-60%
Significant	60-80%
Heavy	>80%

Table 17: PV array over-shading levels

Ventilation Strategy	Definition
Strongly ventilated or forced ventilated modules	It refers to those situations where there is no thermal interaction between the PV module and the surface where it is mounted. This could apply for instance to stand-alone system mounted on a flat roof.
Ventilated modules	There is an air gap between the PV module and the surface where they are mounted. This would apply to roof slope systems where a suitable air gap between the PV module and the roof has been allowed for.
Unventilated modules	There is no air gap between the PV modules and the surface where it is mounted

Table 18: PV array ventilation strategy definitions

Figure 59: Defining a PVS

7.6.6. Defining a wind generator – Wind Generators tab

MBEAT allows the user to define a wind turbine connected to the building in this tab. The electricity produced by the wind turbine can displace the grid-supplied electricity used within the building. There is only one sub-tab in the *Wind Generators* tab:

- **General** sub-tab

General sub-tab:

The parameters needed to define a wind generator are (see Figure 60):

1. Name – Give it a unique name.

2. Multiplier – Indicate how many wind generators identical to this one are connected to the building.

3. Terrain type – This indicates the type of terrain where the wind turbine is located. Select from: Smooth flat country (no obstacles), Farm land with boundary hedges, Suburban or industrial area, and Urban with average building height > 15m.

4. Radio button to indicate whether the wind turbine has a horizontal axis or not. If it is a horizontal axis turbine, you are asked to enter:

    - Diameter – Wind turbine rotor diameter, in m. MBEAT will use the entered diameter to calculate the area swept by the rotor blades.

    If the wind turbine does not have a horizontal axis, e.g., it is a vertical axis wind turbine, then you are instead asked to enter:

    - Area – area swept by the rotor blades, in m^2.

    NB: The swept area of a wind turbine is used to calculate the area of air intercepted by the turbine rotor. For axial horizontal wind turbines, you can enter the rotor diameter, D, in m, and the swept area, A, is automatically calculated by MBEAT as the area of the circle delineated by the turbine's blades, and it is calculated as: $A = p \cdot \dfrac{D^2}{4}$ For any other type of wind turbines, including vertical axis wind turbines, you need to enter the area swept by the rotor, in m^2. Contact the turbine manufacturer if in any doubt.

5. Hub height – The wind turbine hub height, in m.

    NB: The height of the turbine is used to adjust the wind speed values (obtained from the weather database) during the calculation. For axial horizontal wind turbines, this corresponds to the turbine hub height measured from the ground. For other rotor types, including vertical axis wind turbines, use the geometric centre of the turbine rotor.

6. Power – The wind turbine rated power (electrical power delivered at rated wind speed), in kW.

Figure 60: Defining a wind generator

7.6.7. Defining a CHP generator – CHP Generator tab

This tab only appears if one of the HVAC systems, defined in the *HVAC Systems* tab, is specified to use a Combined Heating and Power (CHP) generator for provision of hot water, space heating, and electrical power, or a Combined Cooling, Heating, and Power (CCHP) generator for provision of hot water, space cooling, space heating, and electrical energy (i.e., the relevant box is ticked).

There is only one sub-tab in the *CHP Generator* tab:

- **General** sub-tab

General sub-tab:

The parameters required to describe the CHP generator in MBEAT are (see Figure 61):

1. Fuel type – Select from: LPG, Biogas, Fuel Oil, Diesel, Kerosene, and Biomass.

2. Heat efficiency – the seasonal thermal efficiency of the CCHP generator, defined as the total annual useful heat supplied by the generator divided by the total annual fuel energy input to the generator (using the gross calorific value).

3. Electrical efficiency - it is calculated as the total annual electric power output by the CHP divided by the total annual fuel energy input (using the gross calorific value).

NB: Values for the heat and electrical efficiencies are entered as ratios into MBEAT, not as percentages. For instance, a 30% electrical efficiency should be entered as 0.3 into MBEAT.

NB: The heat to power ratio is automatically calculated by MBEAT as the heat efficiency divided by the electrical efficiency of the CHP.

4. CHPQA Quality Index - an indicator of the energy efficiency and environmental performance of a CHP scheme relative to the generation of the same amounts of heat and power by separate alternative means.

   NB: The Quality Index (QI) provides a means of assessing the quality of CHP Schemes. In MBEAT, it is currently used for reporting purposes only, i.e., it is not used in the calculations.

5. Proportion of the building's space heating demand supplied by the CHP plant - (%). This average monthly value needs to be calculated through a detailed analysis of the building's space heating demand values and patterns. Note that he CHP unit is normally sized below the peak heating demand of the building and will also be out of service at particular times for maintenance purposes.

6. Proportion of the building's hot water demand supplied by the CHP plant - (%).This average monthly value needs to be calculated through a detailed analysis of the building's water heating demand values and patterns. Note that he CHP unit is normally sized below the peak heating demand of the building and will also be out of service at particular times for maintenance purposes.

   NB: The CHP can provide a proportion of the building's hot water only if the HWS generator is set to be the same as the HVAC system to which the CHP is connected.

7. Tick box to indicate whether this is a trigeneration system (i.e., it provides cooling, heating, and power) or not (i.e., it provides heating and power). If the box is ticked, the following fields become active:

   a. Proportion of the building's space cooling demand supplied by the CHP plant - (%).

   b. Chiller efficiency - the seasonal chiller efficiency of the generator, defined as the cooling demand divided by the cooling energy for the generator.

   NB: The CHP can provide a proportion of the building's cooling demand only if the HVAC system, to which the CHP is connected, provides cooling.

NB: MBEAT is not a design tool. The values of the parameters entered in the *CHP Generator* sub-tab need to have come from a previous detailed analysis.

Figure 61: Defining a CHP generator: CHP Generator tab

7.6.8. Defining a Transpired Solar Collector – Transpired Solar Collectors tab

There is only one sub-tab in the *Transpired Solar Collectors* (TSC) tab:

- **General** sub-tab

General sub-tab:

The parameters required to describe a transpired solar collector system in MBEAT are (see Figure 62):

1. Name – Give it a unique name.

2. Type – Select from Standard operation, High temperature rise, and High air volume.

3. Operation – Type of operation of the TSC system. Select from Constant flow and Variable flow.

4. Control type – Select from Only manual and Automatic.

5. Absorptivity – Select from Very high, High, Good, Moderate, and Low.

6. Shading factor - the shading correction (reduction) factor for the TSC system. A value of 1 means the TSC system is unshaded.

7. Tick box to indicate if the transpired solar collector is provided with an independent fan. If the box is ticked, the following parameter becomes active:

    a. Supply specific fan power, in W/(l/s), for the TSC system.

8. Design air flow rate, in m^3/s, for the TSC system.

9. Refresh button – clicking on this button will update the following 2 values, which are visible but cannot be edited by the user in this sub-tab. They are calculated by MBEAT based on parameters input by the user in other sub-tabs as follows:

a) Area – The total area of the TSC system. This is calculated by MBEAT as the sum of the areas input by the user in the "TSC area" field in the *Geometry* form > *Envelope* tab > *General* sub-tab, i.e., the total area of the TSC installed on the exterior of the building's envelopes.

b) % Assigned – The total percentage of the pre-heated air provided by the TSC system that has been assigned to zones in the building. This is calculated by MBEAT as the sum of the percentages input by the user in the "% supply" field in the *Building Services* form > *Zones* tab > *TSC* sub-tab. If this total exceeds 100%, the value is displayed with a red background to warn users to revise their input in the *Zones* tab.

Figure 62: Defining a transpired solar collector: Transpired Solar Collectors tab

7.6.9. Defining the zone specific building services- Zones tab

The zone definition is not completed within the *Zones* tab in the *Geometry* form. Some zone parameters (related to building services) are defined within the *Building Services* form, under the *Zones* tab. There are eight sub-tabs in the *Zones* tab:

- **HVAC and HWS Systems** sub-tab: This is where you assign the HVAC system and HWS which serve each zone.
- **Ventilation** sub-tab: This is where you define the local ventilation type and characteristics for each zone.
- **Ventilation (cont)** sub-tab: This is where you provide more data on the ventilation and heat recovery in the zone.
- **Exhaust** sub-tab: This is where you define an exhaust system in a zone.

- **Lighting** sub-tab: This is where you enter details about the general lighting characteristics for each zone.
- **Lighting Controls** sub-tab: This is where you enter details about the lighting controls for each zone.
- **Display Lighting** sub-tab: This is where you enter details about display lighting characteristics and controls for each zone.
- **TSC** sub-tab: This is where you assign the transpired solar collector that serves the zone, if applicable.

HVAC and HWS Systems sub-tab:

The sub-tab is used to specify the HVAC system and HWS for each zone. The following information is required:

HVAC System Parameters

1. HVAC Systems – Here you need to select from the drop-down list (of systems you have already defined in the *HVAC Systems* tab or the default systems) the HVAC system which serves the zone. If no HVAC system serves the space (i.e., an unconditioned zone), select 'Zones without HVAC system' (spaces which have no heating or cooling and will remain unconditioned, e.g., plant rooms, storage spaces, exposed circulation spaces).

   NB: If a zone is defined as having no heating or cooling, i.e., assigned to 'Zones without HVAC system', but the activity type selected for the zone is one which typically requires conditioning (according to the NCM Activity Database), a red exclamation mark "!" will appear next to this parameter as a warning to the user, in case this was done in error. Ultimately, however, the calculation will be carried out using the data input by the user.

   If you do not know the type of the HVAC system in your existing building or its detailed parameters, you should select one of the following default options from the drop-down menu:

   - 'Heating only - Electric resistance' - Heat generated by passing an electric current through resistance wire. Assumed to be an electric central heating system with warm air distribution. Fan storage heaters and electric fan converters should be input by defining an HVAC system in the *Building Services* form > *HVAC Systems* tab > *General* sub-tab and selecting the system type "Other local room heater - fanned". If you do not know the heating method (i.e., whether a heated-only building uses electricity or a fuel-based heating system), you should select electric resistance heating as your default.

   - 'Heating only - Other systems' - Assumed to be a wet radiator system with heat generated by fuel combustion. Pumps assumed to be powered by grid-supplied electricity. If you know the fuel type used by the heating system, you can define it in the *Building Services* form > *Global and Defaults* tab > *HVAC System Defaults* sub-tab (see Section 7.6.1: Global and Defaults tab).

   - 'Heating and mechanical cooling' - Assumed to be a constant volume air system with terminal reheat and fixed fresh air. Fans and pumps assumed to be powered by grid-supplied electricity. If you know the fuel types used by the heating and cooling generators, you can define them in the *Building Services* form > *Global and Defaults* tab > *HVAC System Defaults* sub-tab (see Section 7.6.1: Global and Defaults tab).

NB: The default HVAC systems are representative of existing rather than new buildings and should only be used if you do not know the type of the HVAC system in your building or its detailed parameters as the default efficiencies assumed by MBEAT for them are quite pessimistic, and they cannot be edited by the user.

NB: <u>Indirectly heated spaces</u> - For spaces such as corridors or access areas, which are not serviced by an HVAC system (i.e., have no direct supply of heating or cooling) but are likely to be indirectly conditioned by the surrounding areas due to the high level of interaction with those spaces (allowing the heated air to move freely from the directly conditioned spaces to the indirectly conditioned ones), they should be considered heated or conditioned (indirectly) by the same HVAC system that supplies the most important surrounding area. In this case, you should assign the HVAC system of the main adjacent space to that indirectly conditioned zone also (although the space is not directly conditioned, the energy to overcome any losses from or gains to it is still required via the conditioned zone and therefore has to be included in the calculation). An example of this would be an open corridor (to heated offices) or a stairwell next and open to offices, i.e., which might have a few envelope elements but is mostly open to the surrounding conditioned areas and which is not directly conditioned but is conditioned through the movement of air (and heat) from the adjacent offices into the corridor. Furthermore, envelope elements between a (directly) conditioned space and an indirectly conditioned space should be labelled as adjacent to a "conditioned adjoining space" and <u>not</u> to an "unheated adjoining space". On the other hand, if a zone is unheated and totally enclosed thus heated air cannot freely move from a heated zone into it, such as a plant room, a store room, or a toilet, you are advised to define it in MBEAT as "Zones without HVAC".

NB: If there is **more than one type of HVAC system in a space** with each system clearly meant to service a particular part of the space, e.g., one servicing the facade perimeter area and another servicing the core area, then the space should be divided into 2 separate zones in MBEAT (each served by its corresponding HVAC system) even if there is no physical separation (i.e., a wall) between the 2 zones. However, if heating is provided in a zone by two, or more, different types of heat sources, for e.g., a heat pump in a split system and an LPG boiler in a wet system, you need to define the parameters of the different heat generators sharing the heating load, as described in the guidance on the bivalent calculation in Section 7.6.2: Defining HVAC Systems – HVAC Systems tab. On the other hand, if a zone is served by, for e.g., an LPG-fired wet system for heating and an electric split system for cooling, then the systems can be approximated in MBEAT by defining your HVAC system type as "split or multisplit", the heat source as "LTHW boiler", and fuel type as "LPG", and then define the appropriate seasonal efficiency for the heating and energy efficiency ratio for the cooling. MBEAT will use LPG for the heating and grid-supplied electricity for the cooling. If applicable, you then need to define the mechanical ventilation at zone level (for all the zones served by this system) with a suitable ventilation SFP, and heat recovery.

2. Are there destratification fans in the zone? (Tick box) - Destratification fans provide additional air recirculation in the zone to ensure even temperature distribution (while these would help reduce heating loads, they would increase auxiliary energy loads).

NB: Destratification may be achieved by several means, for each of which minimum flow rates should be ensured. (Where destratification and heating is provided by the same system, higher flow rates may be needed to avoid excessive air supply temperatures):

- Cased fans installed at high level. The volume of air handled by the fans should be at least equivalent to two room volumes per hour. Total air movement will be higher than this because additional airflow will be induced.

- Open blade "sweep fans". In this case, air speeds will be lower and the volume of air handled should be at least the equivalent of 6 room volumes per hour.

- High velocity induction nozzles with a temperature rise through the heater of at least 45ºC. The volume of primary air from the nozzles should be at least equivalent to 0.15 room volumes per hour. Total air movement will be significantly higher because of the additional airflow induced by the nozzles.

NB: If your HVAC system is a high velocity forced-convection air heating (induction nozzle system), which does the job of mixing the air in the zone in a similar manner to destratification fans, then you can model this in MBEAT by first selecting the appropriate HVAC system type (flued or unflued) and then ticking the above box relating to destratification fans in the zones served by that system. The system should follow the flow rate guidelines given for

destratification systems shown above. You will then need to justify this to Building Control using the necessary documentation for your system's functions.

Hot Water System

3. HWS - A HWS needs to be selected for:

    1. All occupied zones - Depending on the activity and building type selected for the zone, a standard hot water demand is assumed in the NCM Activity Database. For example, there is a demand assumed to arise from the occupants of an office for activities such as washing hands and washing up cups. This demand is associated with the office rather than the toilet or tea room. Thus, the demand from each space needs to be assigned to a HWS even if the system itself is not present in the space. If there is more than one HWS serving the building, the HWS that needs to be specified for a zone should be the generator which accounts for the majority of its demand. A HWS needs to be assigned to every zone defined in MBEAT.

    2. Any space with a deadleg within it – As described above, hot water demand is associated with occupied spaces rather than the spaces. However, if there is a deadleg within the zone, it needs to be associated with the appropriate system, through the zone it serves.

    NB: Where there is no hot water demand in the building, users should select the option "Zone with access to cold water only" when assigning the HWS to each zone.

4. Deadleg length in this zone – Length, in m, of the draw-off pipe to the outlet in the space (only used for zones where the water is drawn off, such as toilets and tea rooms). This parameter is used to determine the additional volume of water to be heated because the cold water in the deadleg has to be drawn off before hot water is obtained. This assumes that the hot water system circulation maintains hot water up to the boundary of the zone, or that the pipe runs from circulation or storage vessel within the zone.

NB: Modelling trace heating in MBEAT: As an approximation, it can be considered that the energy used by trace heating is equivalent to that used by a secondary circulation. You can tick the box in the *Building Services* form > *HWS* tab > *General* sub-tab to indicate that there is a secondary circulation and then leave the rest of the secondary circulation related fields blank to be calculated by MBEAT. You can also leave the deadleg at the default of 0 m.

Lighting System

5. Lighting System – This field will become active in future versions of the tool and will enable the user to select a lighting system for the zone from a previously defined list of systems, similar to that for HVAC systems and HWS.

Figure 63 shows a zone's HVAC, HWS, and lighting characteristics being defined.

Figure 63: Selecting a zone's HVAC, HWS, and lighting systems

Ventilation sub-tab:

This sub-tab is used to specify the type of ventilation system specific for each zone. The following information is required:

Zonal Ventilation Type

1. Zonal ventilation type – A mechanical ventilation system separate from the heating or cooling system (i.e., zonal ventilation) can be added here. If the selected HVAC system does <u>not</u> already include ventilation, the zonal ventilation radio buttons become active. This would be possible, for example, with radiators or under-floor heating. You need to select either: Natural or Mechanical supply & extract, according to whether there is a mechanical ventilation system present in the zone.

Convention: <u>Passive stack ventilation</u>

The convention is that passive stack should be treated as natural ventilation.

NB: In order to ensure adequate ventilation for maintaining the concentration of CO_2 below 0.5% in spaces served by unflued heating appliances[ix], the zonal ventilation option for these spaces should be set to 'mechanical'.

NB: The supply and extract flow rate for all ventilation systems is set to take the minimum fresh air requirements value from the NCM Activity Database.

NB: See note in Section 7.6.2: Defining HVAC Systems, regarding specific fan power for fan coil systems.

NB: **If you change the HVAC system defined in your project from one that provides mechanical ventilation to one that does not (or vice versa), you <u>must</u> re-visit the Ventilation sub-tab of the Zones tab in the Building Services form <u>for all the zones served by this HVAC System</u> in order for all ventilation-related parameters to be updated by the**

[ix] For details, please refer to BS 5925:1991: Code of Practice for Ventilation Principles and Designing for Natural Ventilation.

tool. You may also wish to re-define whether the ventilation is natural or mechanical in these zones following the change in the HVAC type.

If mechanical supply & extract is selected, the following field becomes enabled:

1. Do you know the supply & extract specific fan power? - Here you can either use the default (conservative) value or enter your own SFP for the zonal mechanical ventilation system, in W/(l/s). The SFP of an air distribution system is defined as the sum of the design total circuit-watts, including all losses through switchgear and controls, such as inverters, of the fans in the system that supply air and extract it back outdoor (i.e., the sum of the total circuit-watts of supply and extract fans), divided by the design air flow rate through the system.

NB: If the SFP was calculated or measured for a mechanical ventilation system that already included heat recovery, then that is the value you enter into MBEAT. If the SFP was calculated or measured for a mechanical ventilation system before a heat recovery system was added on, then you need to add 0.15 to the SFP for a thermal wheel system, and 0.3 for any of the other heat recovery options in MBEAT, to account for the additional resistance.

Demand-Controlled Ventilation

2. If applicable, you need to select from the drop-down menu the type of demand-controlled ventilation applicable in the zone. This parameter becomes active if the zone is <u>not</u> served by an HVAC system that provides mechanical ventilation, i.e., the ventilation is defined as zone level. If the zonal ventilation type is defined as 'Natural', then the options available in the drop-down menu are: 'No demand-controlled ventilation' and 'Enhanced ventilation'. If the zonal ventilation type is defined as 'Mechanical', then the options available in the drop-down menu are: 'No demand-controlled ventilation', 'Demand control dependent on number of occupants', and 'Demand control dependent on gas sensors'.

   NB: Enhanced natural ventilation refers to natural ventilation with BMS control (i.e., modifying the ventilation flow rate provided by natural means in the space based on some form of control).

3. Flow regulation type – This parameter becomes active if the demand-controlled ventilation type in the previous parameter is selected to be either 'Demand control dependent on number of occupants' or 'Demand control dependent on gas sensors'. It specifies whether the air flow regulation type for the demand-controlled ventilation in the zone is via: 'Damper control' or 'Speed control'.

High Pressure Treatment

4. Does the activity area require high pressure drop air treatment? – This option caters for activities that inherently demand the use of high pressure drop air treatment, including HEPA filtration. This may occur in hospitals (areas such as operating theatres and intensive care suites), airports (to keep aviation fumes out), some museums and libraries (with sensitive exhibits), commercial kitchens (odour filters, grease traps, filters to protect the odour filters, etc.), some industrial processes, and in buildings designed to withstand a biological attack. Here, you can either let MBEAT take this parameter from the NCM Activity Database (recommended), or you can select to tick or untick the relevant box manually.

Figure 64 shows a zone's ventilation characteristics being defined.

Figure 64: Defining the zone ventilation in the Ventilation sub-tab

Ventilation (cont) sub-tab:

This sub-tab is used to specify the type of heat recovery, if applicable, in the ventilation system specific for each zone. It is also used to define the SFP of the terminal unit if applicable depending on the HVAC system serving the zone. The following data can be entered:

Heat recovery

1. Heat recovery – Here you need to select from: No heat recovery, Plate heat exchanger (Recuperator), Heat pipes, Thermal wheel, and Run around coil (see Table 14 for a brief descriptions of the options). This parameter is active if the zonal ventilation type is selected to be mechanical.

2. Heat recovery seasonal efficiency - This parameter is active if a heat recovery system is selected, i.e., the previous parameter is not set to 'No heat recovery'. If you know the heat recovery efficiency, it can be introduced manually into the interface. Otherwise, a default value will be used by MBEAT.

3. Tick box to denote whether the heat recovery system efficiency is variable - This parameter is active if a heat recovery system is selected above.

4. Do you know the terminal unit specific fan power? - Here you can either use the default value or enter your own SFP for the terminal unit, in W/(l/s). This parameter becomes active if the HVAC serving the zone is selected to be 'Fan coil systems' or 'Indoor packaged cabinet (VAV)' in the *Building Services* form > *HVAC Systems* tab > *General* sub-tab.

NB: If the HVAC system selected is 'Fan coil systems' or 'Indoor packaged cabinet (VAV)', the SFP input in the *Building Services* form > *HVAC Systems* tab > *System Adjustments* sub-tab, should be for the central plant, and then the SFP for the terminal units can be input in this sub-tab for all the zones served by this HVAC system.

5. Tick box to denote whether a night cooling (NC) strategy operates in the zone. If this box is ticked, then the following parameters become active:

a. Max. hours of NC per month – This is the maximum number of hours per month during which night cooling is operating in the zone.

b. Max. flow rate during NCM hours – This is the maximum air flow rate in the zone, in l/s.m^2 of floor area, during the operation of night cooling.

c. Do you know the specific fan power for the night cooling unit? - Here you can either use the default value in MBEAT or enter your own SFP for the night cooling unit, in W/(l/s). For further details on the SFP and how it is calculated, see the Non-Domestic HVAC Compliance Guide.

Figure 65 shows a zone's ventilation characteristics being defined.

Figure 65: Defining heat recovery in the Ventilation (cont.) sub-tab

Exhaust sub-tab:

This sub-tab is used to specify the characteristics of a mechanical exhaust system in the zone, if applicable. The following information is required:

Local Mechanical Exhaust

1. Is there mechanical exhaust in the zone? – An example of when this would be used is in a toilet. This tick box is enabled for all types of HVAC systems serving the zone.

   If the above tick box is ticked (i.e., there is mechanical exhaust in the zone), then the following fields become active:

   a. Local mechanical exhaust - This is the flow rate of air leaving the zone, in l/s.m^2 of floor area. Guidance on typical figures for this parameter could be found in CIBSE Guide F Part A (Table 7.2, Basic fan capacity benchmarks). **NB:** MBEAT requires the exhaust flow rate in l/(s.m^2) of floor area while the values in the CIBSE Guide are given in l/(s.m^3). Use the zone height to convert the CIBSE values into the units required by MBEAT.

b. Do you know the exhaust specific fan power? - Here you can either use the default value in MBEAT or enter your own SFP for the zonal mechanical exhaust system, in W/(l/s). **NB:** The default value may not necessarily comply with the current Building Regulations.

c. Scope of exhaust system – Here you can use the radio buttons to specify whether the exhaust fan is remote from the zone (i.e., the exhaust system serves multiple spaces) or within the zone (i.e., a local window/wall/roof unit such as in a toilet).

Figure 66 shows a zone's exhaust characteristics being defined.

Figure 66: Defining the zone mechanical exhaust in the Exhaust sub-tab

Lighting sub-tab:

In the *Lighting* sub-tab, each zone needs to be selected in turn and the following data entered:

1. What information is available on lighting? – Here, you need to choose from the following three options:

   a. Full lighting design carried out - where you need to enter the following (data usually available from the lighting design engineer for a new building):

      i. the total wattage (in Watts) and

      ii. the design illuminance in Lux for that zone.

      If the Lux level is left blank, the illuminance level from the NCM Activity Database will be used in the calculation, and a message appears in MBEAT advising what the database illuminance value is for this activity. If the wattage is left blank, a (pessimistic) default value is used by MBEAT.

   b. Lighting chosen but calculation not carried out - where you need to specify:

i. the average initial (100 hour) lamp plus ballast efficacy for the lighting in the zone in lamp-lumens per circuit-Watt and

ii. the light output ratio (LOR) of the luminaire.

c. Lighting parameters not available (where you need to choose the lamp type from a drop-down list) – usually for existing buildings. The luminous efficacy used by MBEAT when each of the lamp types is selected is shown in Table 19

d. If you cannot find your lamp type on the list, you can select the one with the closest luminous efficacy.

NB: The user can input both the full lighting design details <u>and</u> the lamp types solely for the purpose of generating recommendations for the Recommendations report. <u>The user should, however, ensure that the radio button is positioned at the option for full lighting design input, before running the calculation, so that the input wattage and illuminance level would be used in the lighting energy calculation, rather than the lamp type.</u>

NB: If you know that the lamps are fluorescent but have no further details, you should select the option 'Fluorescent (No details)'.

Lamp Type	Luminaire lumens per circuit Watt	
	Side-lit and not daylit activities	Top-lit activities
LED	27.5	33.0
Tungsten and Halogen	7.5	9.0
Fluorescent - compact	22.5	27.0
T12 Fluorescent - halophosphate - low frequency ballast	25.0	30.0
T8 Fluorescent - halophosphate - low frequency ballast	27.5	33.0
T8 Fluorescent - halophosphate - high frequency ballast	32.5	39.0
T8 Fluorescent - triphosphor - high frequency ballast	36.3	43.5
Metal Halide	25.0	39.0
High Pressure Mercury	22.5	27.0
High Pressure Sodium	35.0	42.0
T5 Fluorescent - triphosphor-coated - high frequency ballast	37.5	45.0
Fluorescent (no details)	22.5	27.0

Table 19: Luminous efficacies used by MBEAT in correspondence to the lamp types selected

NB: The total wattage value that is entered into MBEAT is for the lighting system, i.e., it should include the luminaires and ballasts (control gear).

NB: The design illuminance, in Lux, is that for which the full lighting design has been carried out. The maintained illuminance at the end of the lamp life and before cleaning of the luminaires should not be less than the design illuminance. This value will be used, along with the total wattage value, in order to determine the consequent power density values associated with the lighting system used in W/m^2 per 100 lux. This value will, in turn, be used to calculate the electrical consumption of an equivalent system which delivers the illuminance levels specified in the NCM Activity Database. The calculated lighting energy consumption will be higher or lower than you expect depending on whether the design illuminance entered is higher or lower than the database illuminance for the activity. Changing the activity in a zone will change the corresponding illuminance retrieved from the NCM Activity Database, which would be reflected in both the actual and notional buildings.

2. Are air-extracting luminaires fitted? – Select: Yes or No/don't know. An air extracting luminaire (air handling luminaire) incorporates a mechanical ventilation extract so that

heat emitted by the lamp is removed from the luminaire without entering the space below.

Figure 67 shows the lighting characteristics of a zone being defined.

Figure 67: Defining the zone lighting characteristics in the Lighting (General) sub-tab

Lighting Controls sub-tab:

In this sub-tab, each zone needs to be selected, and the controls relating to its lighting need to be defined:

1. Light controls - Here you need to indicate whether there are: No local controls (i.e., the lighting is centrally controlled according to the occupancy schedules from the NCM Activity Database for the activity selected for this particular zone), Local manual switching, and/or Photoelectric controls present by ticking none, both, or one of the two tick boxes. Local manual switching is where the occupants can control their own luminaries individually, and each light switch must be less than six metres from the luminaries it controls (it could be a hand held controller such as infra-red).

   If the "Photoelectric option" is ticked, the following fields become active:

   a. Photoelectric options - Here you need to choose between: Switching and Dimming.

   b. Indicate whether there is a different sensor to control the lighting in the back half of the zone (tick box), i.e., the half furthest from the window.

   c. Select the type of photoelectric sensors from the available options: Stand-alone sensors or (digitally) addressable systems.

   d. Parasitic power for photoelectric controls – Enter the parasitic power consumption of the photoelectric system in W/m^2 if you know it. Otherwise, the following defaults will be used by MBEAT: 0.3 W/m^2 if the type of sensors in the previous field is selected as 'Stand-alone sensors' and 0.57 W/m^2 if 'Addressable

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systems' is selected (digitally addressable systems are for special applications and are not particularly energy efficient).

NB: Values for the parasitic power need to be reasonable. Otherwise, the benefits due to the use of photoelectric controls may be negated by the extra electrical consumption required by the controls equipment.

2. Automatic daylight zoning for lighting controls? – This parameter is active if one or both of the above tick boxes on lighting controls are ticked. If you select 'Yes' (recommended), then MBEAT will automatically sub-divide the zone into daylighting zones, if needed, following the zoning rules for zones with windows and rooflights, and you do not need to sub-divide it yourself. If you select 'No', then you need to specify the percentage area of the zone where the lighting is controlled so as to respond to daylight (whether by a photosensor or manual control). If that percentage is 100%, this means that the whole area of the zone has lighting controls that respond to daylight, and MBEAT will perform no further sub-divisions for this zone, i.e., you have already done the sub-division manually yourself. If the percentage value that you enter is less than 100%, for e.g., 70%, then MBEAT will sub-divide the zone into two daylight zones whose areas are 70% and 30% of the total area of the zone, respectively. MBEAT will then consider that the 70% daylight area will have lighting controls responding to daylight while the lighting in the 30% daylight area will not be affected by daylight.

    NB: In the unlikely event that your zone has a non-typical layout of windows and/or rooflights, and you are worried that MBEAT's automatic sub-division might not correctly reflect the access to daylight in the zone, you can carry out the daylighting sub-division yourself, as with previous MBEAT versions.

3. Occupancy Sensing – Here, you need to select what kind of occupancy sensing the zone has, if applicable, from the available options shown in Table 20. If occupancy sensing is available in the zone, the following field becomes active:

    a. Parasitic power for occupancy sensing – Enter the parasitic power consumption of the occupancy sensing in W/m^2 if you know it. Otherwise, the default value of: $0.3 \ W/m^2$ will be used.

        NB: Values for the parasitic power need to be reasonable. Otherwise, the benefits due to the use of occupancy sensing may be negated by the extra electrical consumption required by the controls equipment.

        NB: If the zone is a corridor or other circulation area, dry sports, changing room, swimming pool, sales area, cold store, display area, or performance area (stage), then the types of occupancy sensing that can be applied are "AUTO-ON-DIMMED" and "AUTO-ON-OFF" only. If any other type is selected for these activities, MBEAT will disregard it during the calculation, i.e., no benefit will be considered for the zone lighting from occupancy sensing.

Type of Occupancy Sensing Control in MBEAT	Brief Description
MAN-ON-OFF+EXT	Lights manually switched on and off, with the addition of an automatic extinction signal.
AUTO-ON-DIMMED	Lights automatically switched on whenever people enter a room and dimmed to a low level when no movement has been detected for a set time (usually 5-15 minutes).
AUTO-ON-OFF	Lights automatically switched on whenever people enter a room and switched off when no movement has been detected for a set time (usually 5-15 minutes).
MAN-ON-DIMMED	Lights manually switched on and automatically dimmed to a low level when no movement has been detected for a set time (usually 5-15 minutes).
MAN-ON-AUTO-OFF	Lights manually switched on and automatically switched off

	when no movement has been detected for a set time (usually 5-15 minutes).
NONE	No occupancy sensing

Table 20: Types of occupancy sensing controls available in MBEAT

Figure 68 shows the lighting controls in a zone being defined.

Figure 68: Defining the lighting controls characteristics of a zone

Display Lighting sub-tab:

This sub-tab is active for a particular zone <u>only</u> if by nature of the activity selected for the zone, display lighting is applicable as per the NCM Activity Database, e.g., retail. In the *Display Lighting* sub-tab, each zone needs to be selected in turn and the following data entered:

1. Does display lighting use efficient lamps? – Select: Yes or No/don't know. If "Yes" is selected, then the average lamp and ballast efficacy in lamp-lumens per circuit wattage needs to be entered for the display lighting (only applies if there is display lighting in the space by nature of its selected activity).

    NB: For the purposes of the lighting calculations in MBEAT, efficient display lighting is one with a lamp and ballast efficacy better than 15 lamp-lumens per circuit-Watt. Examples of efficiency display lighting lamps include: metal halide, compact fluorescent, and white SON (high pressure sodium).

2. Time Switching for display lighting? - Select: Yes or No/don't know.

Figure 69 shows the display lighting characteristics and controls for a zone being defined.

Figure 69: Defining the zone display lighting in the Display Lighting sub-tab

TSC sub-tab:

The sub-tab (see Figure 70) is used to specify the transpired solar collector (TSC) system serving the zone, if applicable. The following information can be input:

1. You need to select from the drop-down list (of the transpired solar collector systems you have already defined in the *Building Services* form > *Transpired Solar Collector* tab) the name of the TSC system which serves the zone, if applicable.

2. Percentage of the total air pre-heated by the TSC system that is supplied to this zone. The sum of the values input for the zones in the building should not exceed 100%.
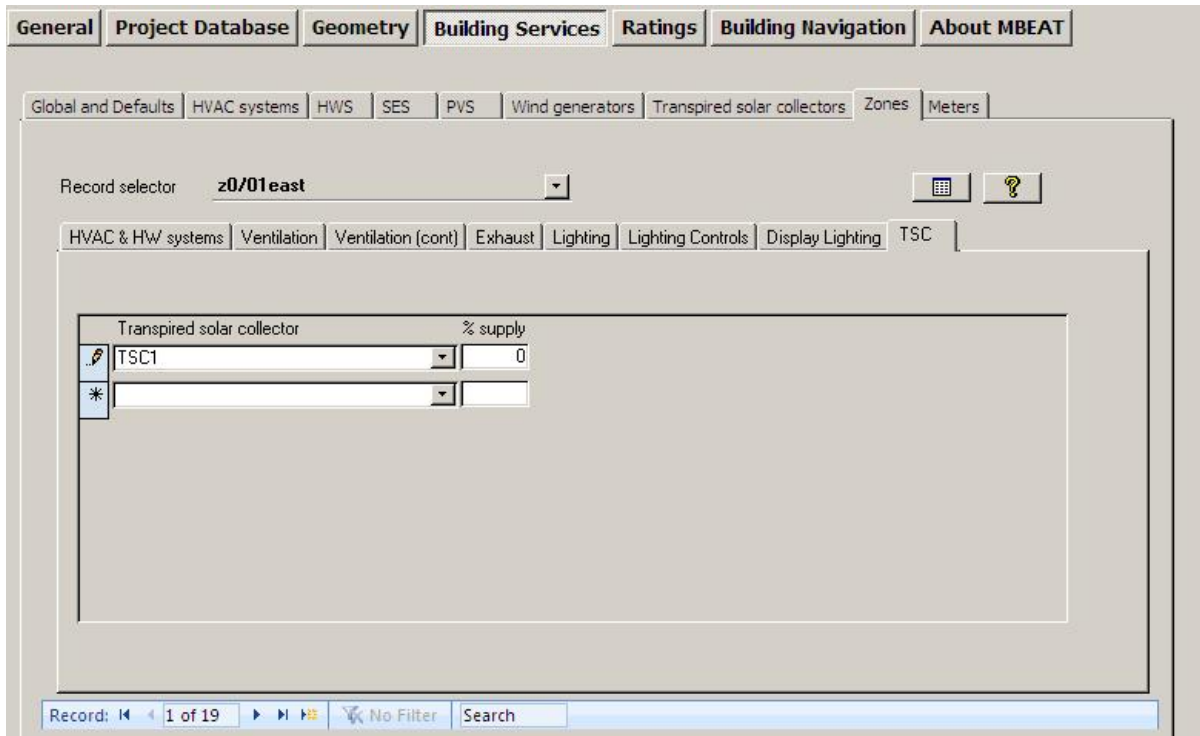
Figure 70: Defining contribution to a zone from a transpired solar collector in the TSC sub-tab

7.6.10. Inputting the metered data – Meters tab

There is only one sub-tab in the *Meters* tab:

- **General** sub-tab

General sub-tab:

The parameters required for each set of metered data in MBEAT are (see Figure 61):

1. Name – Give it a unique name.

2. Fuel type – Select from: LPG, Biogas, Fuel Oil, Diesel, Kerosene, Biomass, and Grid Supplied Electricity to define the fuel type reflected by the metered data.

3. Data quality – Select from the drop-down menu a description of the quality/reliability of the metered data value input in the next parameter.

4. Data value – Input the metered data value for the fuel type selected above. Depending on the fuel type selected, the units of the data value to be input for this parameter will appear to the right of the input field (see Table 21).

5. Unregulated portion – If known, input the percentage of the data value input above that is unregulated, i.e., this represents the unregulated portion of energy use in the building.

Fuel Type	Unit
LPG	kg
Biogas	kg
Fuel Oil	litre
Diesel	litre
Kerosene	litre
Biomass	kg
Grid Supplied Electricity	kWh

Table 21: Fuel types and the corresponding units for inputting metered data in MBEAT

Figure 71: Inputting metered data: Meters tab

7.7. Building Navigation form

This form allows the user to navigate through the project in order to view summaries of the different types of building objects that have been defined, as well as some detailed information about individual objects. This form contains the following tabs:

1. **Selections** tab
2. **Object Properties** tab

7.7.1. Selections tab

In this tab (Figure 72), depending on which radio button is selected in the 'Objects' section, you can choose to view either: HVAC systems only, HVAC systems and zones only, HVAC systems, zones, and envelopes only, or HVAC systems, zones, envelopes, windows, and doors. Depending on which radio button is selected in the 'Assignment Status' section, you can choose to view either: Assigned objects only, Unassigned objects only, or both. Also, by ticking the box

in the 'Objects' section, you can choose to also view other building objects, such as constructions, HWS, SES, etc. The objects are then listed in the left hand side 'Object Tree' window in terms of their names and types. The 'Key to Objects' section contains the key to the symbols used to denote the types of objects.

There is a 'Refresh' button which you can click on in order to manually initiate the refreshing of the contents of the *Building Navigation* form, if the relevant tick box in the *General* form > *File Options* tab > *System Configuration* sub-tab is unticked. It the box is ticked, the contents of the *Building Navigation* form will be refreshed automatically with any changes in the objects properties that might have been performed since the *Building Navigation* form was last accessed (see Section 7.3.1: File Options tab).
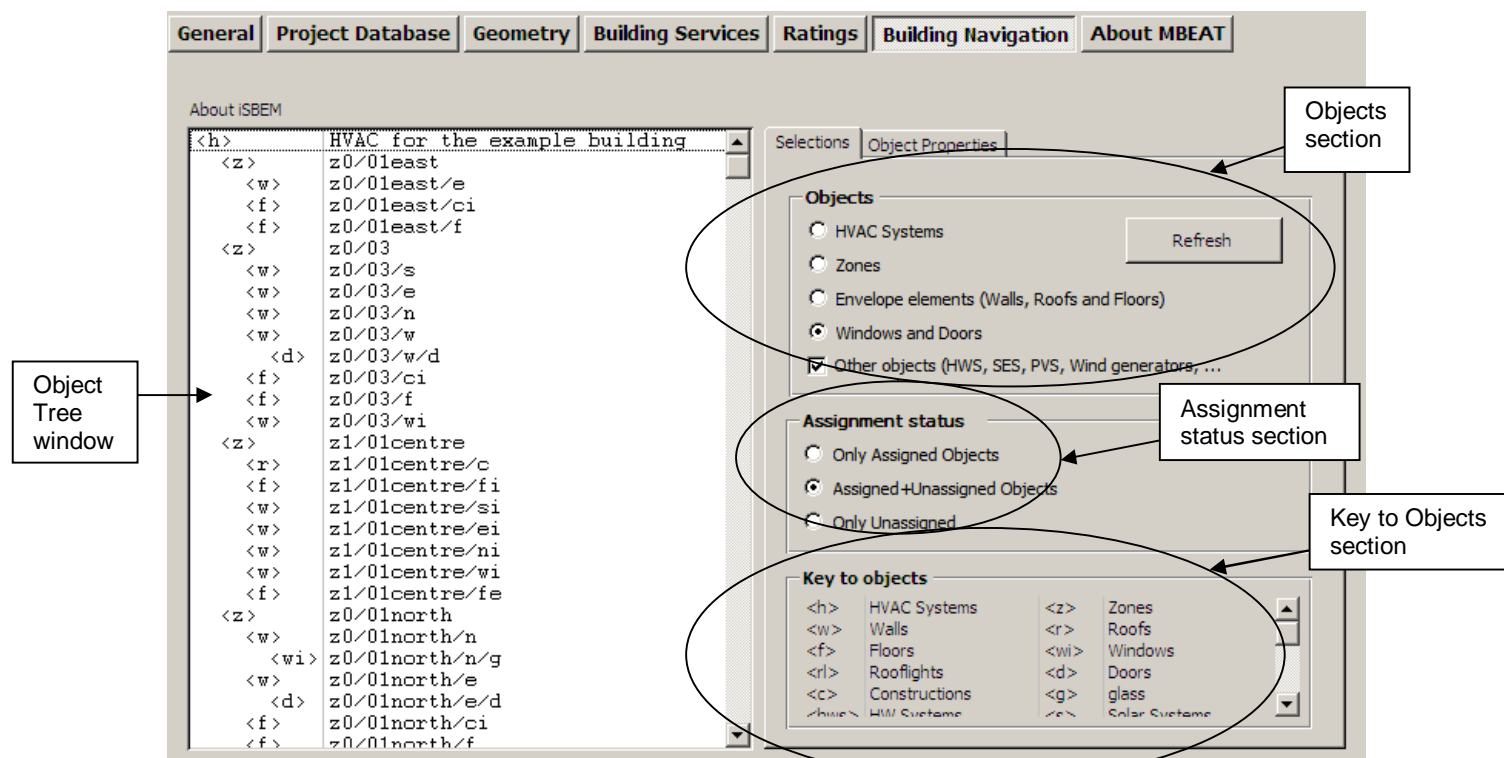
Figure 72: Selections tab in the Building Navigation form

7.7.2. Object Properties tab

In this tab (Figure 73), if any of the objects listed in the 'Object tree' window is highlighted, more details about that object's properties appear in the 'Objects properties' window on the right. For example, if the highlighted object is an envelope, the details displayed will be its area, construction, and the condition of the adjoining space, etc.
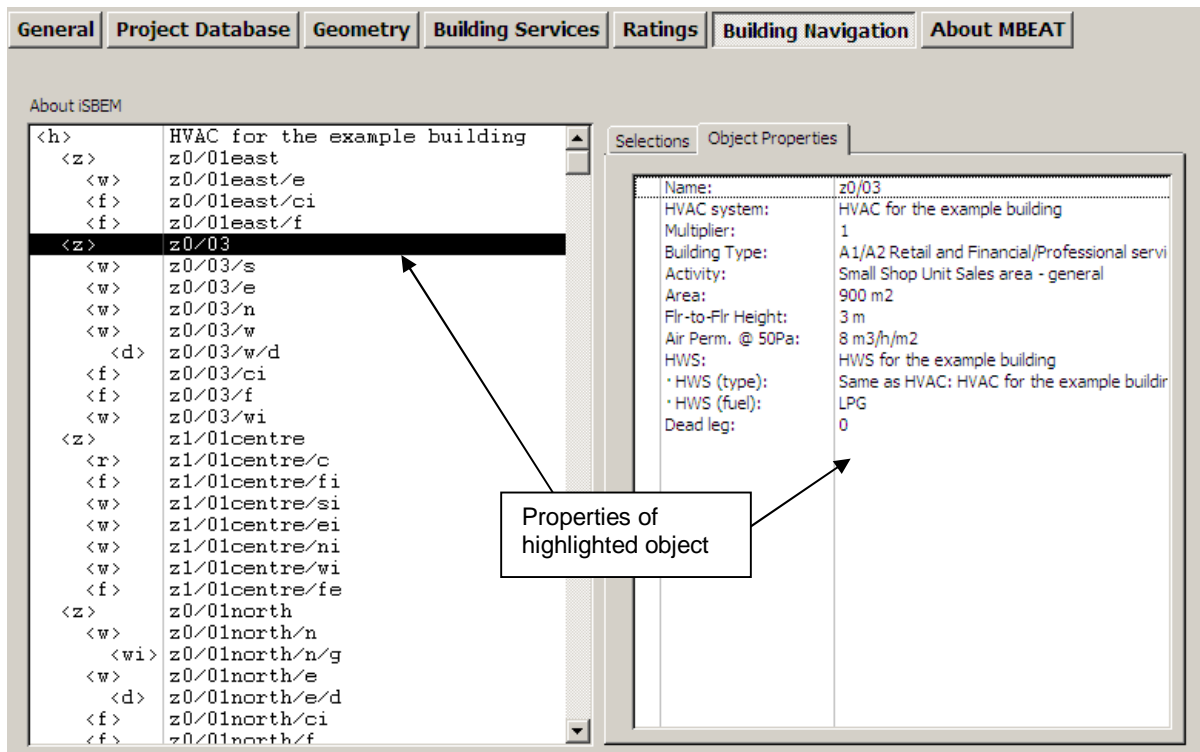
Figure 73: Objects Properties tab in the Building Navigation form

7.8. About MBEAT form

This form displays information about the MBEAT software, licensing conditions, and acknowledgement. There is no data entry in this form.

7.9. Double-checking the data

It is advisable to <u>always</u> double-check the data entered for any project, in order to ensure that the building is modelled correctly, before running the energy performance calculation and compliance checking. There are several tools within MBEAT to facilitate this:

- **The Objects reports** - These reports can be accessed from all of the forms in the interface by pressing the *Object Reports* button: [icon] This can be found at the top right-hand side of all the tabs in the *Project Database*, *Geometry*, and *Building Services* forms, the bottom of the *Energy Audit tab* in the *Ratings* form, and in the *File Options* tab in the *General* form. There are two reports available in MBEAT to help the users check their data entry.

  1. **The Unassigned Objects report** which lists all the objects which have been created/defined but not assigned to any other object.

  2. **The Data Summary report** which provides a hierarchical summary of all the building objects that have been defined and assigned along with key details on some of the objects.

- **The Assigned sub-tabs** - Wherever objects in MBEAT require that they be assigned to another object, there is usually a sub-tab which lists which objects have been assigned.

- **The Summary sub-tabs** – Similar to the *Assigned* sub-tabs and used for objects defined in the *Geometry* form.

- **The Building Navigation form** – Provides a hierarchical summary of all the objects that have been defined in the project, assigned and unassigned, along with key details on some of the objects.

7.9.1. The Unassigned Objects Report

The *Unassigned Objects* Report is a simple list of all the objects which have been created but not assigned. They are grouped into two categories: *Unassigned Building Objects* and *Other Unassigned Objects*.

The *Unassigned Building Objects* (in **red** text) include all the zones, envelope elements, windows, doors, HVAC systems, HWS, and SES that have been created in MBEAT but not assigned. These are critical unassignments, i.e., you should not run the calculation until they are addressed.

The *Other Unassigned Objects* (in **blue** text) include any construction or glazing types which have been created but not assigned to any of the envelope elements, windows, or doors. These are non-critical unassignments, i.e., you can still run the calculation.

Figure 74 shows that there are 5 zones which have not been assigned to an HVAC system. The user would then need to go into the *Geometry* form > *Zones* tab or the *Building Services* form > *Zones* tab in order to assign each zone to an HVAC system. The figure also shows that there are no non-critical unassignments.
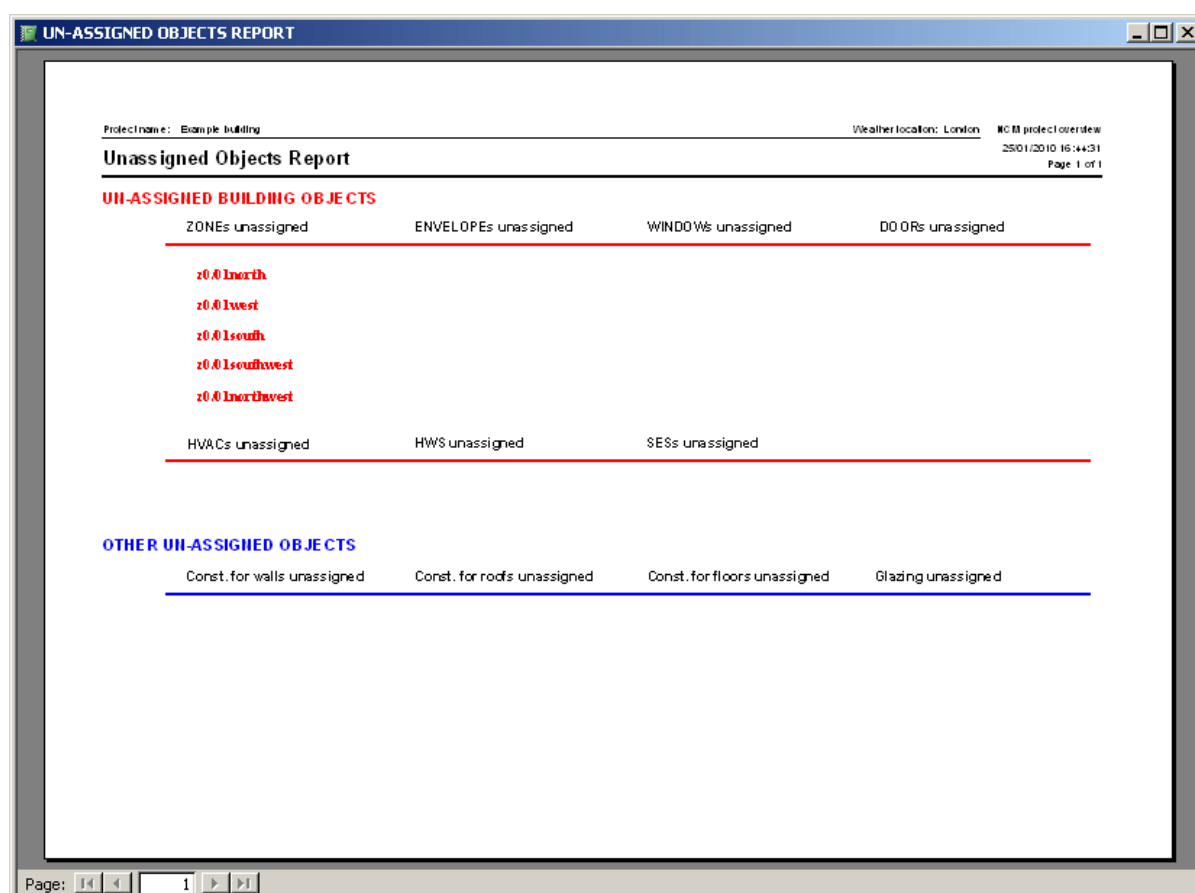
Figure 74: The Unassigned Objects Report

7.9.2. The Data Summary Report

The *Data Summary* Report has a double layer structure:

- The first layer is in **black** text and is a tree structure of all the building objects that have been defined and assigned, reflecting the hierarchical relationship of the building objects (HVAC -> Zone -> Envelope -> Window / Door).
- The second layer is in **blue** text and provides key information about each of the listed objects.

The assignment tree structure (black):

The first column lists the HVAC system status of the zone, the highest element in the hierarchy. The next column lists all of the zones that are assigned to that HVAC system. All the zones that have no HVAC system are listed first (see Figure 75) followed by those that do (Figure 76). The next column lists all of the zone's envelope elements, followed by the envelope elements' windows, and any doors.

Summary information (blue):

To the right of each zone, envelope element, and window or door name is a selection of its key parameters/details. For example, to the right of any zone, you will find its activity type and its area. To the right of an envelope element, you will find which type of envelope it is (wall, roof, ceiling/floor), what sort of space it adjoins, its construction type, and its area. To the right of a window, you will find its glazing type and its area, and for a door, its construction and its area.

Figure 75: Data Summary Report: Zones without HVAC

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Figure 76: Data Summary Report: Zones with HVAC

7.9.3. The Assigned sub-tabs

The *Assigned* sub-tabs display the parent objects which the object in question has been assigned to. There are six *Assigned* tabs in the interface:

- **The Walls Assigned sub-tab** - in the *Project Database* form > *Construction for Walls* tab - displays all of the envelopes to which the wall construction selected in the record selector has been assigned.
- **The Floors Assigned sub-tab** - in the *Project Database* form > *Construction for Floors* tab - displays all of the envelopes to which the floor construction selected in the record selector has been assigned.
- **The Roofs Assigned sub-tab** - in the *Project Database* form > *Construction for Roofs* tab - displays all of the envelopes to which the roof construction selected in the record selector has been assigned.
- **The Glazing Assigned sub-tab** - in the *Project Database* form > *Glazing* tab - displays all of the windows or rooflights to which the glazing selected in the record selector has been assigned.
- **The Doors Assigned sub-tab** - in the *Project Database* form > *Construction for Doors* tab - displays all of the doors to which the door construction selected in the record selector has been assigned.
- **The HWS Assigned sub-tab** - in the *Building Services* form > *HWS* - displays all of the zones to which the HWS selected in the record selector has been assigned.

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All the above *Assigned* tabs cannot be edited. They are for viewing only.

7.9.4. The Summary sub-tabs

The *Summary* sub-tabs show which sub-objects have been assigned to the object in question. There are three *Summary* sub-tabs in the interface:

- **The Envelopes Summary sub-tab** - in the *Geometry* form > *Zones* tab shows which envelopes have been assigned to each respective zone (see Section 7.5.3: Defining zones).
- **The Windows & Doors Summary sub-tab** - in the *Geometry* form > *Envelopes* tab shows which windows and doors have been assigned to which envelope (see Section 7.5.4: Defining envelopes – Envelope tab).
- **The Zone Summary sub-tab** - in the *Building Services* form > *HVAC Systems* tab shows which zones have been assigned to which HVAC system (see Section 7.6.2: Defining HVAC Systems).

8. CALCULATING AND VIEWING THE ENERGY PERFORMANCE OF THE BUILDING - THE RATINGS FORM AND OUTPUT REPORTS

The energy consumption of the building is calculated and the operational and asset performances are determined via the *Ratings* form. The key results are then displayed in this form while further details on the energy used and CO_2 emitted from the building are given in the MBEAT output reports, which include the Energy Audit Report. This chapter describes how to initiate the calculation of the results and access the various outputs.

8.1. The Ratings form

The *Ratings* form allows the user to:

1. Run the entered building model through MBEAT and the Energy Audit Module (EAgenMA) to calculate the energy consumption of the building, CO_2 emissions, and current operational and asset performances by pressing the "Run Energy Audit" button in the *Energy Audit tab* > *Building Rating* sub-tab if 'Assessment of current performance' has been selected as the "Audit type" in the *General* form > *General Information* tab > *Project Details* sub-tab.

2. Following the above and after the user has entered any asset improvements to the building model, the *Ratings* form allows the user to run the improved building model through MBEAT and the Energy Audit Module (EAgenMA) in order to calculate the improved energy consumption of the building, CO_2 emissions, improved operational and asset performances, and potential operational and asset savings by again pressing the "Run Energy Audit" button in the *Energy Audit tab* > *Building Rating* sub-tab but with 'Assessment of improved performance' selected as the "Audit type" in the *General* form > *General Information* tab > *Project Details* sub-tab.

NB: You will be able to monitor on the screen the progress of the calculation process as it is carried out for the different building objects.

3. View the key results within the interface.

4. Access the output reports.

The *Ratings* form is composed of one tab:

*   **Energy Audit tab**: displays a break-down of the annual energy consumption by end-use for the building in kWh/m^2 of building area, as well as the operational and asset performances.

NB: The Data Reflection Report in html format is generated, and the related access button becomes visible in the *Ratings* form, <u>only</u> if the relevant box is ticked in the *General* form > *File Options* tab > *System Configuration* sub-tab.

NB: If any changes are made to a project, the "Run Energy Audit" button needs to be clicked on <u>again</u> upon returning to this sub-tab in order to update the results as the results figures cannot be refreshed unless the calculation is re-run.

NB: You <u>must</u> close all output files before re-running the calculation (so the software can over-write them). Otherwise, an error message will be produced.

Unassignment alert

If you have omitted to assign any objects in the interface, you will be notified at the bottom of the *Energy Audit tab*. You will be able to view the *Unassigned Objects* Report by clicking on the 'Objects Report' button. You will see one of the following two messages at the bottom of the screen:

"Click to check object assignments, there are no CRITICAL un-assignments in this project".

"Please check (#) CRITICAL UNASSIGNMENTS before proceeding with final rating" (where # is the number of critical un-assignments detected in the project).

NB: CRITICAL refers to "building object" un-assignments rather than construction or glazing un-assignments.

8.1.1. Energy Audit tab

The *Energy Audit tab* has the following sub-tabs:

- **Building Rating** sub-tab
- **Recommendations** sub-tab
- **Audit Trail** sub-tab
- **Calculation Logs** sub-tab
- **Calculation Errors** sub-tab
- **Supporting Documents** sub-tab

Building Rating sub-tab:

Clicking on the "Run Energy Audit" button runs the building data through the MBEAT calculation engine and the Energy Audit Generator (EAgenMA).

The *Building Rating* sub-tab then displays the following calculated results:

1. The energy used per unit floor area (kWh/m^2) annually by the actual building for heating, cooling, auxiliary energy, lighting, and hot water.
2. The total energy used per unit floor area (kWh/m^2) annually by the actual building in terms of electricity and fuel use.
3. The current operational and asset annual performance (kWh/m^2).
4. The improved operational and asset annual performance (kWh/m^2).
5. The potential operational and asset annual savings (kWh/m^2).

Also accessible from this sub-tab is the *Energy Audit Report*, the *MBEAT Main Output* report, and the *Data Reflection* Report for the actual building. See Sections: 8.2.1: MBEAT Main Output Document, 8.2.2: Data Reflection Report – Actual Building, and 8.2.4: Energy Audit Report.

NB: The Data Reflection Report in html format is generated, and the related access button becomes visible in the *Ratings* form, <u>only</u> if the relevant box is ticked in the *General* form > *File Options* tab > *System Configuration* sub-tab.

<u>NB</u>: If any changes are made to a project (i.e., input parameters), the "Run Energy Audit" button needs to be clicked on <u>again</u> upon returning to this tab in order to update the results as the results figures cannot be refreshed unless the calculation is re-run.

NB: You <u>must</u> close all output files before re-running the calculation (so the software can over-write them). Otherwise, an error message will be produced.

Figure 77 shows the *Building Rating* sub-tab in the *Energy Audit tab* of the *Ratings* form if 'Assessment of current performance' has been selected as the "Audit type" in the *General* form > *General Information* tab > *Project Details* sub-tab and Figure 78 shows the *Building Rating* sub-tab in the *Energy Audit tab* of the *Ratings* form if 'Assessment of improved performance' has been selected as the "Audit type" in the *General* form > *General Information* tab > *Project Details* sub-tab. The message at the bottom of the screen indicates that there are no critical un-assignments detected in the project. If there were, the user would need to click on the "Objects Report" button, identify the un-assignment, make the correction in the appropriate part of MBEAT, return to this page, and then click the "Run Energy Audit" button.

Figure 77: Using the interface to run the calculation for the building in the Energy Audit tab of the Ratings form with Assessment of current performance as audit type

Figure 78: Using the interface to run the calculation for the building in the Energy Audit tab of the Ratings form with Audit as audit type

Recommendations sub-tab:

Once the Energy Audit calculation has run successfully, the EAgenMA module produces the *Energy Audit Report*, which also includes recommendations for improving the energy efficiency of the building. These recommendations can be either selected for inclusion in the report from a default list of NCM recommendations available in MBEAT or created from new by the Energy Auditor. This sub-tab (Figure 79) contains the following parameters:

1. There are 4 radio buttons in a box entitled "Show recommendations":

    a. All NCM – Click this button to view only the default NCM recommendations generated by EAgenMA.

    b. All USER – click this button to view only the recommendations added by the user. If there are no user-defined recommendations, then MBEAT will prompt you to add one (see below).

    c. All – Click this button to view both the NCM recommendations and the ones added by the user.

    d. Only from Report – Click this button to view only the recommendations that have been included in the *Energy Audit* report.

In addition to creating new recommendations in this sub-tab, the energy auditor can also edit the NCM recommendations generated by EAgenMA by adding comments, using the following parameters:

2. Click to edit this recommendation – By ticking this tick-box, you indicate that you wish to edit this particular NCM recommendation (whose text can be viewed in the grey box entitled "Recommendation") generated by EAgenMA. If the box is ticked, the following fields become active:

    a. Auditor Comments - You can enter any comments related to the recommendation, for e.g., the reason why you have chosen to edit this NCM recommendation.

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The following fields, however, remain greyed-out or un-editable as the user is not allowed to modify these parameters of NCM recommendations:

   a. Category – This describes the category under which the recommendation is classified, such as heating, cooling, etc.

   b. Code – This describes a unique code for each NCM recommendation and will appear with the list of recommendations in the *Energy Audit Report*. The code of any recommendation created by the energy auditor will be USER.

   c. Recommendation – This describes the text of the NCM recommendation.

3. Click to take out – By ticking this tick-box, you indicate that you wish to <u>remove</u> this particular NCM recommendation from the list in the *Energy Audit Report*.

If the "All USER" radio button is selected in the "Show recommendations" box or the "Add new record" button ▶✳ at the bottom of the screen is clicked, then MBEAT will prompt you to create a new recommendation.

4. Once you have confirmed that you do wish to add a recommendation to the default ones already in MBEAT, then the following fields become active (Figure 80):

   a. Category - You can select from the options available in the drop-down menu in order to specify the category under which the recommendation will be classified.

   b. Code – This parameter remains set to 'USER' for any user-defined recommendation.

   c. Recommendation – You can enter text to describe the newly-added recommendation. This text will appear in the *Energy Audit Report*.

   d. Auditor Comments - You can enter any comments related to the recommendation, for e.g., the reason why you have chosen to edit this NCM recommendation.

5. Delete Recommendation – This button allows you to delete a user-defined recommendation.
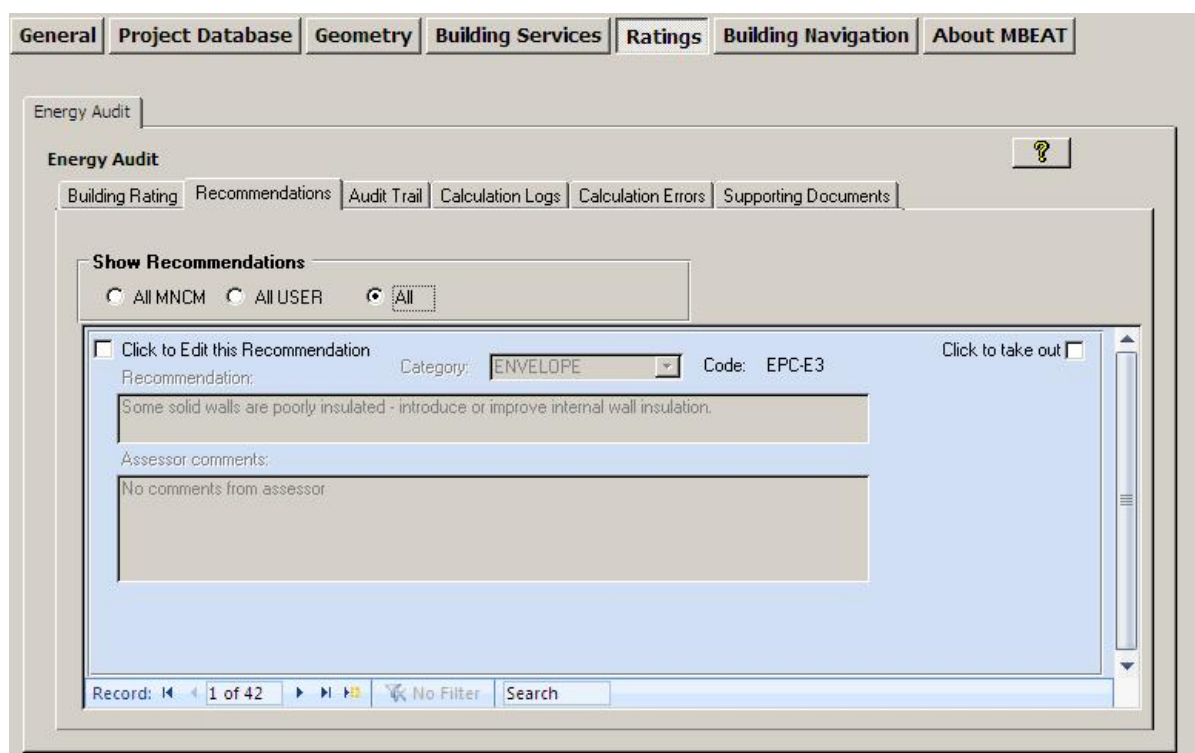
Figure 79: The Recommendations sub-tab in the Energy Audit tab of the Ratings form showing an NCM recommendation

NB: After editing, deleting, or adding any recommendations, you need to re-run the calculation in order to re-generate the Energy Audit Report with all your editing applied.

NB: The Energy Auditor is expected to use his or her knowledge to remove any recommendations from the default list that are inappropriate for the building and to add further ones.

Figure 80: The Recommendations sub-tab in the Energy Audit tab of the Ratings form showing the active fields for creating a user-defined recommendation

Audit Trail sub-tab:

The *Audit Trail* sub-tab (Figure 81) contains the following sub-forms:

- **Construction** sub-form – contains the audit trail information relating to the construction input parameters, i.e., construction specification of walls, floors, roofs, windows, rooflights, and doors.

- **Geometry** sub-form - contains the audit trail information relating to the geometry input parameters, i.e., definitions of air permeability and shading systems on glazing.

- **HVAC & HWS** sub-form - contains the audit trail information relating to the HVAC and HWS input parameters, i.e., heating and cooling system type; heating and cooling efficiencies, duct and AHU leakage, specific fan power, HWS generator efficiency, metering and controls provision, and high pressure drop air filtration.

- **Lighting** sub-form - contains the audit trail information relating to the lighting input parameters, i.e., lamp type, lighting controls, and parasitic power.

This sub-tab is where the energy auditor provides supporting evidence for over-riding any of the default values in MBEAT. This information is necessary for the audit trail regarding all the parameters that are used to carry out the energy calculations, should any of the default values or settings be changed by the energy auditor. Each of the above four sub-sub-tabs contains the following:

1. Accept defaults – this is the list of defaults set in MBEAT for each of: Construction, Geometry, HVAC & HWS, and Lighting, which the energy auditor can over-ride.

2. Auditor walk-though inspection – supporting evidence based on a walk-through inspection by the energy auditor.

3. Inspection by other: Sales particulars - supporting evidence based on sales particulars.

4. Inspection by other: Technical inspection - supporting evidence based on a technical inspection by someone other than the energy auditor.

5. On-site measurements of input parameters for assessment - supporting evidence based on on-site measurements of the input parameters.

6. Other sources - supporting evidence based on other sources.

7. Comments – additional information that the energy auditor would like to include for the audit trail.

Figure 81: The Audit Trail sub-tab in the Energy Audit tab of the Ratings form

Calculation Logs sub-tab:

Log files for the MBEAT calculation (SBEMma.log) and the Energy Audit generator, EAgenMA, (EAgenMA.log) can be viewed in this sub-tab (Figure 82).
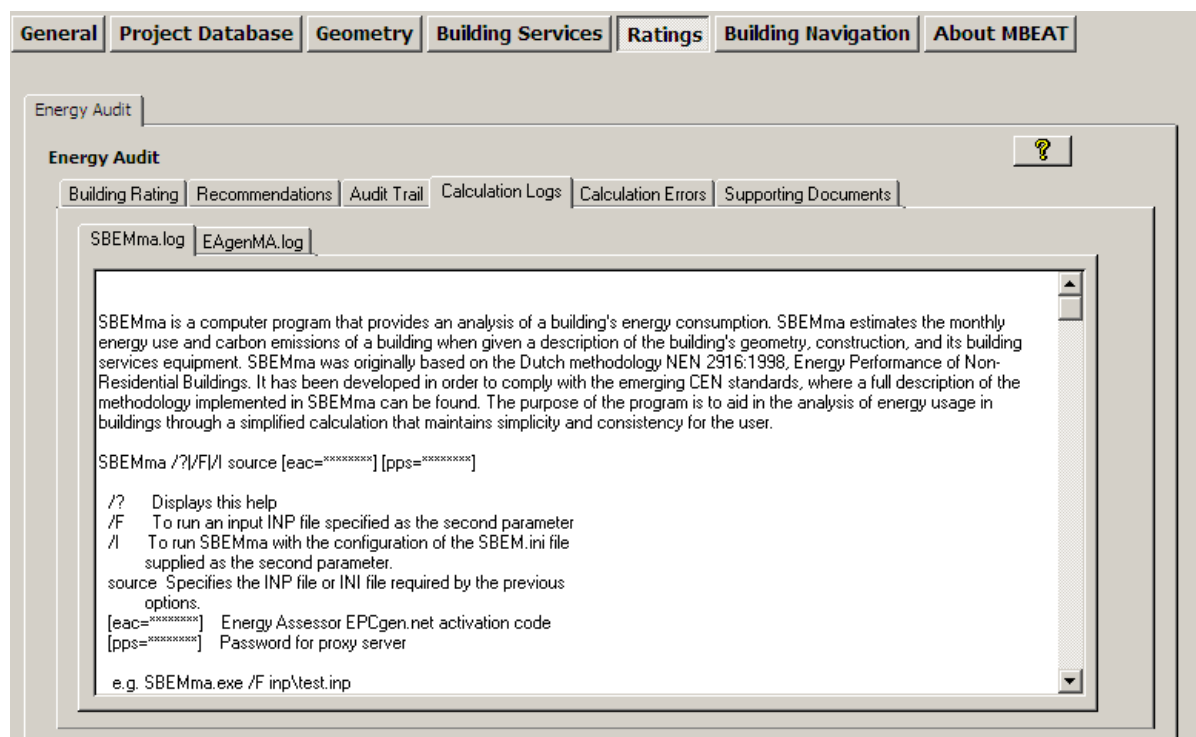
Figure 82: The Calculation Logs sub-tab in the Energy Audit tab of the Ratings form

Calculation Errors sub-tab:

Error files for the MBEAT calculation (SBEMma.err) and the Energy Audit generator, EAgenMA, (EAgenMA.err) can be viewed in this sub-tab (Figure 83). If the calculation crashes, you can refer to these files for any error messages produced during the calculation.
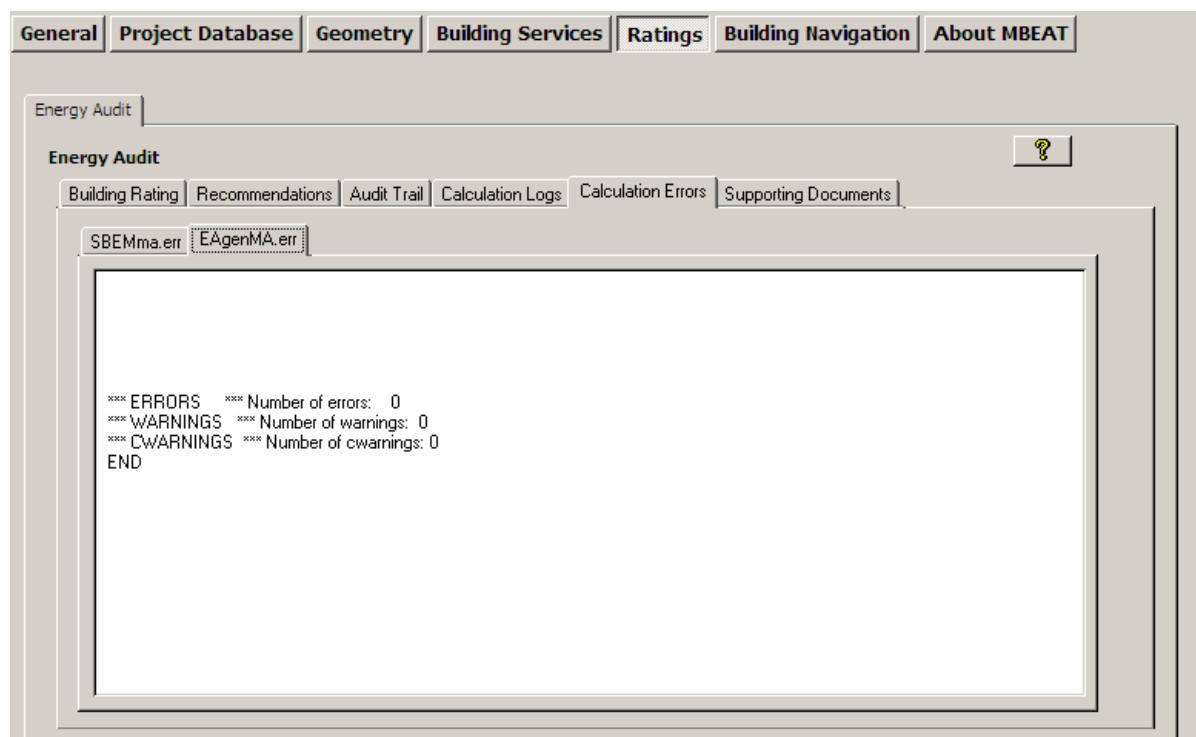
Figure 83: The Calculation Errors sub-tab in the Energy Audit tab of the Ratings form

Supporting Documents sub-tab:

This sub-tab (Figure 84) contains buttons that allow access to the following supporting documents produced by MBEAT: the *Main MBEAT Output* report (section 8.2.1: MBEAT Main Output Document) and the *Data Reflection* Report (section 8.2.2: Data Reflection Report – Actual Building).

NB: The Data Reflection Report in html format is generated, and the related access button becomes visible in the *Ratings* form, <u>only</u> if the relevant box is ticked in the *General* form > *File Options* tab > *System Configuration* sub-tab.

NB: You <u>must</u> close all output files before re-running the calculation (so the software can over-write them). Otherwise, an error message will be produced.
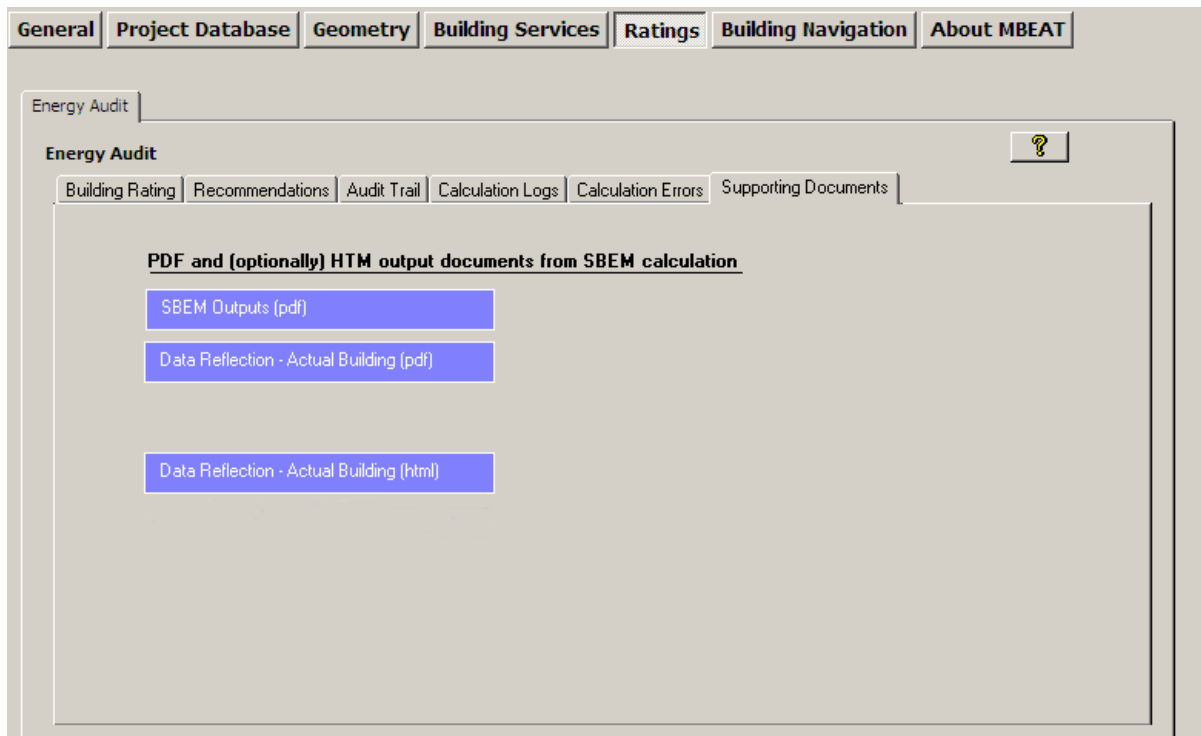
Figure 84: The Supporting Documents sub-tab in the Energy Audit tab of the Ratings form

8.2. MBEAT Output reports

As described in the previous section, the key output reports are accessible from within MBEAT, using the appropriate buttons or hyperlinks in the *Ratings* form > *Energy Audit* tab > *Building Rating* sub-tab. These reports are all stored in the same location as the project files, along with the *Technical Output* Report for the actual building, which can only be accessed from the "Projects" folder. The default location for the project files is within the specific project folder (created when the project was first created, see Section 4.4: Creating new and opening existing projects) within the MBEAT_v4.1.h folder, e.g., C:\NCM\\MBEAT_v4.1.h\ Projects\Example building-complete.

Output reports when running MBEAT for Energy Audits:

If 'Assessment of current performance' or 'Assessment of improved performance' were selected as the "Audit type" in the *General* form > *General Information* tab > *Project Details* sub-tab, and the calculation ran successfully, then MBEAT produces the following **four** output reports;

1. MBEAT Main Output Document

2. Energy Audit Report

3. Data Reflection Report – for the Actual Building

4. Technical Output Report – for the Actual Building

8.2.1. MBEAT Main Output Document

This report can be accessed from the *Ratings* form > *Energy Audit* tab > *Building Rating* sub-tab by clicking on the "MBEAT output" button, and it is stored in the same location as the project files

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as described in Section 8.2.5: Accessing the reports from the project folder. The file is in "pdf" format.

This report gives a summary of the energy consumptions and CO_2 emissions of the building. It provides:

- The name and type of the building.
- A bar chart showing the annual CO_2 emissions from the building, in kg/m^2, due to fuel and electricity consumptions. It also shows the amount of annual CO_2 emissions displaced by renewables, if applicable, and the building area, in m^2.
- A bar chart showing the annual energy consumption of the building for the different end uses, in kWh/m^2.
- A bar chart showing the variation of the monthly energy consumption by the different end uses along the year, in kWh/m^2.
- A pie chart displaying the percentage of the total annual energy consumption that is due to each of the end uses, with the energy consumed by equipment <u>excluded</u> from the total.
- A pie chart displaying the percentage of the total annual energy consumption that is due to each of the end uses, with the energy consumed by equipment <u>included</u> in the total.

See APPENDIX A: A.3 for the *MBEAT Main Output* Document for the Example building.

NB: You <u>must</u> close all output files before re-running the calculation (so the software can over-write them). Otherwise, an error message will be produced.

8.2.2. Data Reflection Report – Actual Building

This report contains all the data that MBEAT uses to calculate the energy performance of the building, along with some general details about the building (as input by the user), and can be attached to the building's "Log Book". The information is presented in the following order:

- General details
- Building fabric details
- All systems other than HVAC
- HVAC system 1

> Zone 1 in HVAC system 1
>> Envelope 1 of Zone 1
>>> Window 1 in Envelope 1 of Zone 1
>>> Door 1 in Envelope 1 of Zone 1
> *Etc..for all other zones in HVAC system 1*

Etc.. for all other HVAC systems

- Compliance Check Summary details

The report contains hyperlinks (in blue) to aid in navigation around the report (which can quite large depending on the project). See Figure 85 for a screen shot of a section of the *Data Reflection* report and for examples of the hyperlinks.

The data in this report for the actual building is also produced in a more compact layout in pdf format (Figure 86). This report is more printer-friendly than the html one, and it can be printed either on A4 or A3 paper, for e.g., to be carried around while surveying the building.
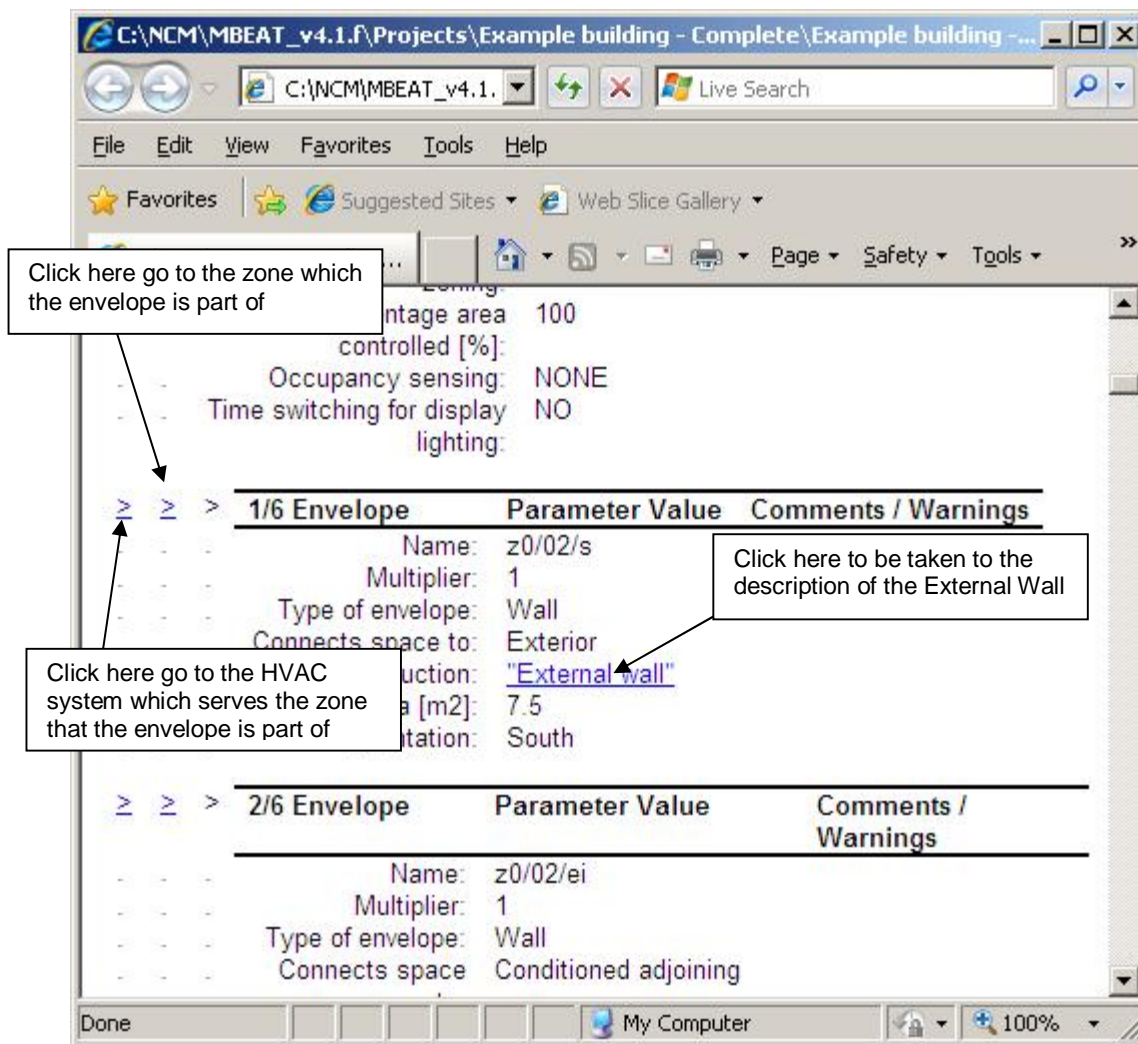
Figure 85: Data Reflection report in html format

NB: The *Data Reflection* Report in html format is generated, and the related access button becomes visible in the *Ratings* form, <u>only</u> if the relevant box is ticked in the *General* form > *File Options* tab > *System Configuration* sub-tab.
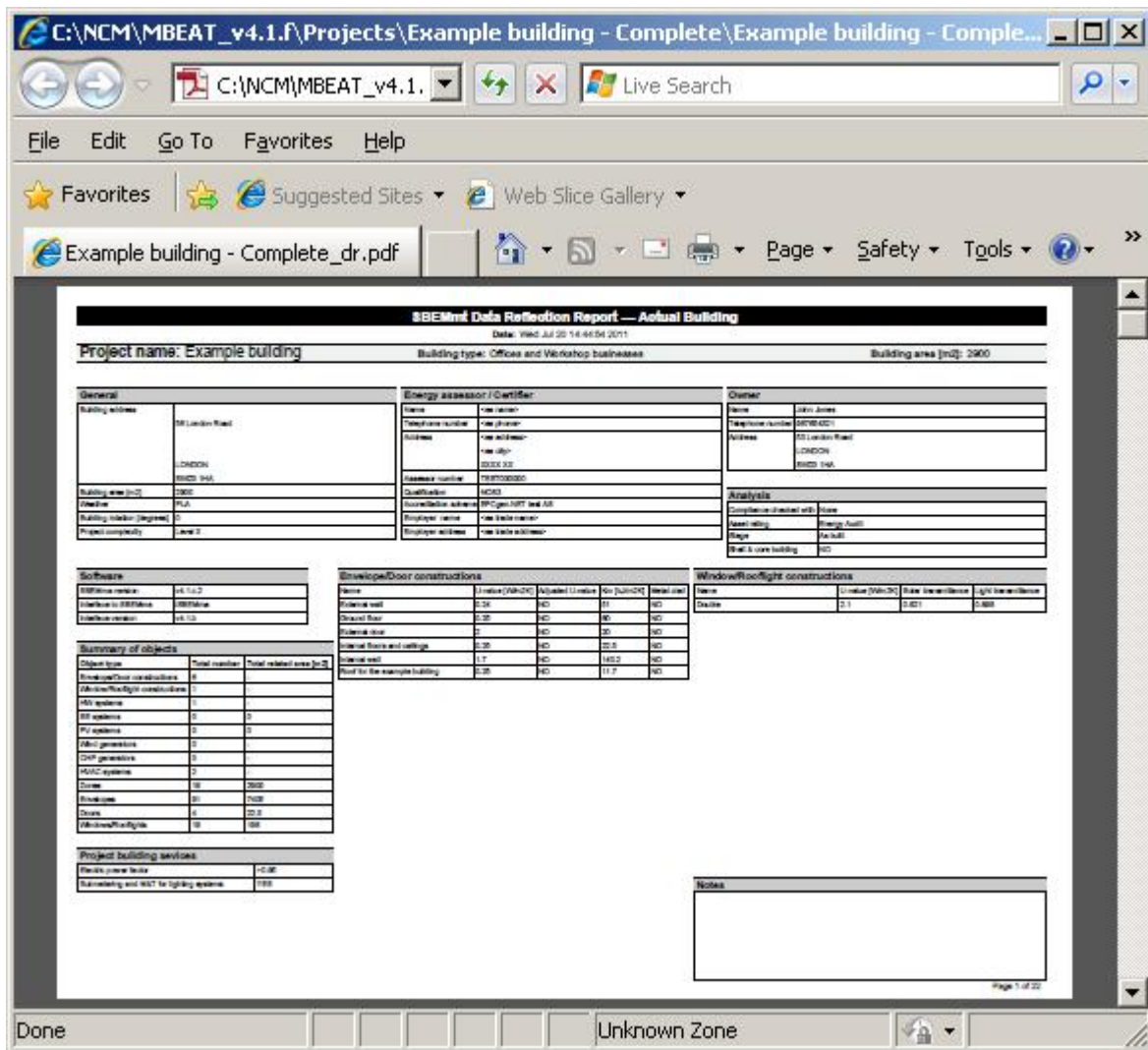
Figure 86: Data Reflection report in pdf format for the actual building

8.2.3. Technical Output Report – Actual Building

This is a comma-separated-values '.csv' file (which can be opened using Microsoft Excel) and is intended for those who wish to do a more in-depth analysis of the results and create their own graphs and tables. It is accessible from the project folder, as described in Section 8.2.5: Accessing the reports from the project folder. It contains the calculated values for (Figure 87):

- Monthly and annual energy use by fuel type (in MJ/m^2 and kWh/m^2).
- Monthly and annual energy use by end use (in MJ/m^2 and kWh/m^2).
- Annual CO_2 emissions by fuel type (in $kgCO_2/m^2$).
- Monthly and annual energy production (in MJ/m^2 and kWh/m^2) and CO_2 emissions (in $kgCO_2/m^2$) displaced by renewables, if applicable.

Figure 87: Technical output report

8.2.4. Energy Audit Report

This report can be accessed from the *Ratings* form > *Energy Audit tab* > *Building Rating* sub-tab by clicking on the "Energy Audit Report" button and is stored in the same location as the project files as described in Section 8.2.5: Accessing the reports from the project folder. The file is in "pdf" format.

This report gives a summary of the energy performance of the building and contains the following:

- <u>Administrative information:</u> contains the title of the report, address of the building, the report number, the energy auditor's name and number, and validity dates of the report.

- <u>Building Energy Consumption:</u> contains the Current operational performance of the building, Improved operational performance of the building, Potential operational saving, Transposed (current) asset performance of the building, Improved asset performance of the building, and Potential asset saving.

- <u>Management Scores:</u> contains information about the current and improved scores for the quality of services management.

- <u>Recommendations:</u> contains a list of recommendations, edited by the energy auditor, for the improvement of the energy performance of the building.

See APPENDIX A:, A.4 for a sample *Energy Audit Report* for the Example building.

NB: You <u>must</u> close all output files before re-running the calculation (so the software can over-write them). Otherwise, an error message will be produced.

NB: The Energy Auditor is expected to use his or her knowledge to remove any recommendations from the default list that are inappropriate for the building and to add further ones.

8.2.5. Accessing the reports from the project folder

All of the above reports are accessible from the specific project folder (created when the project was first created, see Section 4.4: Creating new and opening existing projects). The default location for this folder is within the main **Projects** folder within the **MBEAT_v4.1.h** folder, e.g., "C:\NCM\\MBEAT_v4.1.h\ Projects\Example building-complete". The reports have the following file names and extensions:

Output reports when running MBEAT for Energy Audits:
1. MBEAT Main Output Document – "project name"**_mbeat. pdf**
2. Energy Audit Report – "project name"**_ea[aud].pdf**
3. Data Reflection Report - Actual Building – "project name"**_dr.htm**
4. Data Reflection Report - Actual Building – "project name"**_dr.pdf**
5. Technical Output Report - Actual Building – "project name"**_sim.csv**

The project folder for the "Example building – Complete" file is shown in Figure 88 with the output reports highlighted when running MBEAT for Energy Audits.

Also highlighted is **the NCT file which is the file that is read by MBEAT and where all the input data has been stored.** If you need to share a project with your colleagues, this is the only file you need to send them. They will be able to open it through MBEAT and generate all the other files.

Other files highlighted in Figure 88 are 2 error files (with the extension **.err**) which you should check for any warnings or error messages generated by MBEAT or EAgenMA during the calculation. These are text files which can be opened by any text editor on your computer, for e.g., MS Notepad. The contents of these files can also be viewed in the *Calculation Errors* sub-tab in the *Ratings* form (see section 8.1.1).

You will also notice that there is one further *Data Reflection* Report with the extension '.csv'. This file contains the same data as in the *Data Reflection* '.htm' files described above but in a comma-separated-values format (which can be opened using Microsoft Excel).

NB: You <u>must</u> close all output files before re-running the calculation (so the software can over-write them). Otherwise, an error message will be produced.
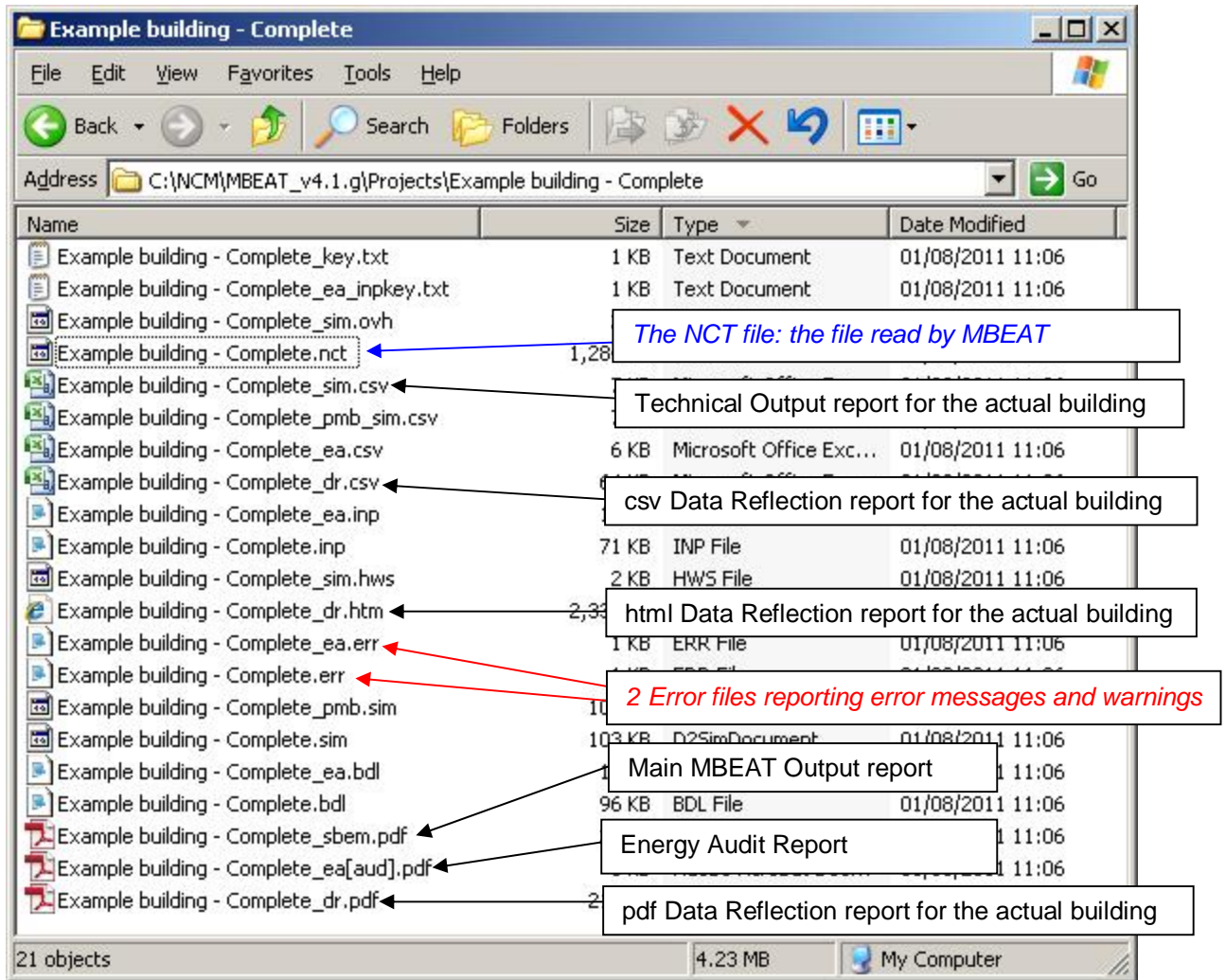
Figure 88: Contents of the Projects folder showing the MBEAT output reports when running MBEAT for Energy Performance Certificates

APPENDIX A: Example building details and MBEAT output documentation

A.1. Building description

The building is located in Plaisance. It is rectangular in shape with dimensions of 50 m x 30 m. It provides space for offices, a supermarket, and a coffee shop.
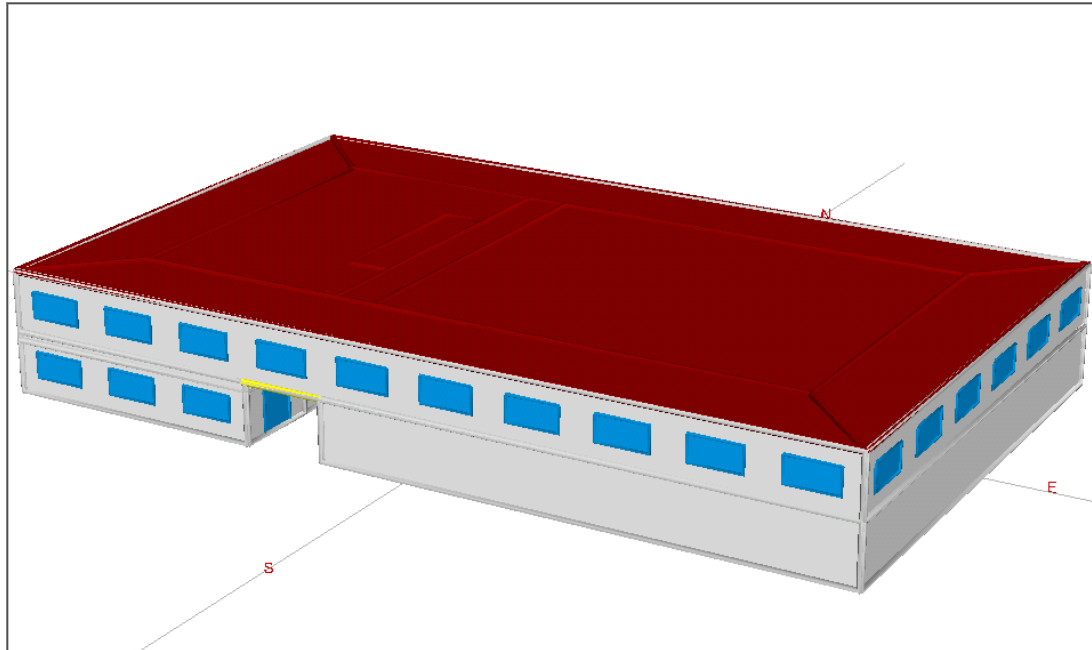
Figure 89: 3D view of the Example building

It has two floors. The supermarket and the coffee shop are located on the ground floor, with an outdoor passage between them, and the offices are located on the first floor. The first floor is accessible by stairs and lifts.

Height inside the building:

Ground floor: 3 m floor to floor

First floor: 3 m floor to soffit

All windows are set-back by 30 cm. This gives a transmission factor of approximately 0.8. The window sill height is 1 m. The doors are 2.5 m high.

The supermarket has an auxiliary room (see drawings), and there are another two auxiliary rooms in the coffee shop. There are toilets serving the offices on the first floor.

Constructions

q **Roof:**   U-value = 0.15 W/m^{2}K, K_m = 11.7 kJ/m^2

q **Ground floor:**   U-value = 0.18 W/m^{2}K, K_m = 60 kJ/m^2

q **Internal floor/ceiling:**   U-value = 0.25 W/m^{2}K, K_m = 22.5 kJ/m^2

q **Internal Walls:**   U-value = 1.7 W/m^{2}K, K_m = 140.2 kJ/m^2

q **External Wall:**   U-value = 0.16 W/m^{2}K, K_m = 51 kJ/m^2

q **Glazing**:   U-value = 1.5 W/m^{2}K, T-Solar = 0.821 and L-Solar = 0.898

q **Doors:**   U-value = 2 W/m^{2}K, K_m = 20 kJ/m^{2}K.

The **air permeability** of the building at 50pa is 8 m^3/h.m^2.

Systems

HVAC: System is a single duct VAV system powered by an electric ground-source heat pump with a seasonal heating efficiency of 3.9 and seasonal cooling energy efficiency ratio of 3.7. It has heat recovery (Thermal wheel) with a seasonal efficiency of 0.75. The ductwork leakage meets the CEN standard Class D, and the AHU has been tested and meets the CEN standard Class L1. The specific fan power is 1.2 W/(l/s).

The HVAC system serves all the zones in the building <u>except</u> for the circulation spaces and the toilets.

Lighting: Full lighting design has been carried out for lighting in the zones. There is manual switching and photoelectric dimming with a back sensor in the coffee shop and the office. The sensors are stand-alone with a parasitic power of 0.2 W/m^2. There is manual switching in all other areas.

Hot water: Dedicated hot water boiler fuelled by LPG with a seasonal efficiency of 0.85. There is a solar hot water system consisting of 10 m^2 of evacuated tube solar panels, orientated towards the north with a tilt angle of 30°. The circulation is forced powered by PVs.

Ventilation: Toilets have mechanical exhaust with 5 l/s.m^2.

Zoning of the building

The building has been divided into **19** zones:

z0/01east: The coffee shop on the ground floor – core and unglazed east perimeter area.

z0/01north, z0/01northwest, z0/01west, z0/01south west, and z0/01south: The coffee shop on the ground floor – glazed perimeter areas.

z0/02: The circulation area / staircase / lift area on the ground floor.

z0/03: The supermarket on the ground floor.

z1/01centre: The open plan office area on the first floor – core zone.

z1/01north, z1/01northeast, z1/01east, z1/01southeast, z1/01south, z1/01southwest, z1/01west, and z1/01northwest: The open plan office area on the first floor – glazed perimeter areas.

z1/02: The circulation area / staircase / lift area on the first floor.

z1/03: The toilets on the first floor.

As you can see in Figure 90: Ground floor plan, the supermarket and the coffee shop contain smaller (auxiliary) areas which could be considered as separate zones. For e.g., it would be possible to separate the supermarket (z0/03) into two zones: the main area and the smaller room at the west end of the space. Similarly, the coffee shop core and east perimeter zone (z0/01/east) could be split into two zones. For simplicity, however, it has been assumed that the activities of the auxiliary rooms within the supermarket and coffee shop do not vary from the activity within the main areas. Hence, these auxiliary spaces have been absorbed within the main zones. More details on zoning can be found in Section 3.3: Zoning guide – How to zone your building.

Table 22 below shows the area information you need for entering the geometry of the zones into MBEAT. See Section 3.5 for a description of the nomenclature used in this example. (e.g.: z0/01north/n = external north wall of zone z0/01/north).

GROUND FLOOR					
Zones	Area (m^2)	Envelope	Area (m^2)	Perimeter length (m)	Windows/Doors	Area (m^2)
z0/01north[x]	54	z0/01north/n	27	9	z0/01north/n/g	8.1
		z0/01north/e	18	6	z0/01north/e/d	3.75
		z0/01north/f	54	-		
		z0/01north/ci	54	-		
z0/01east	162	z0/01east/e	54	18		
		z0/01east/f	162	-		
		z0/01east/ci	162	-		
z0/01south	54	z0/01south/s	27	9	z0/01south/s/g	8.1
		z0/01south/e	18	6	z0/01south/e/d	3.75
		z0/01south/f	54	-		
		z0/01south/ci	54	-		
z0/01southwest	36	z0/01southwest/s	18	6	z0/01southwest/s/g	5.4
		z0/01southwest/w	18	6	z0/01southwest/w/g	5.4
		z0/01southwest/f	36	-		
		z0/01southwest/ci	36	-		
z0/01west	108	z0/01west/w	54	18	z0/01west/w/g	16.2
		z0/01west/f	108	-		
		z0/01west/ci	108	-		
z0/01northwest	36	z0/01northwest/n	18	6	z0/01northwest/n/g	5.4
		z0/01northwest/w	18	6	z0/01northwest/w/g	5.4
		z0/01northwest/f	36	-		
		z0/01northwest/ci	36	-		
z0/02	50	z0/02/n	7.5	2.5		
		z0/02/ei	60	20		
		z0/02/s	7.5	2.5		
		z0/02/w	60	20	z0/02/w/d	2 x 3.75 =7.5
		z0/02/f	50	-		
		z0/02/ci	50	-		
z0/03	900	z0/03/n	90	30		
		z0/03/e	90	30		
		z0/03/s	90	30		
		z0/03/w	30	10	z0/03/w/d	2 x 3.75

[x] For a description of nomenclature used in the example, see Section 3.5.

					=7.5
	z0/03/wi	60	20		
	z0/03/f	900	-		
	z0/03/ci	900	-		

FIRST FLOOR					
Zones	Area (m²)	Envelope	Area (m²)	Perimeter length (m)	Windows/Doors	Area (m²)

Zones	Area (m²)	Envelope	Area (m²)	Perimeter length (m)	Windows/Doors	Area (m²)
z1/01north	225.5	z1/01north/n	114	38	z1/01north/n/g	34.2
		z1/01north/ni	7.5	2.5		
		z1/01north/ei	3	1		
		z1/01north/wi	3	1		
		z1/01north/fe	27.5	-		
		z1/01north/fi	198	-		
		z1/01north/c	225.5	-		
z1/01northeast	36	z1/01northeast/n	18	6	z1/01northeast/n/g	5.4
		z1/01northeast/e	18	6	z1/01northeast/e/g	5.4
		z1/01northeast/fi	36	-		
		z1/01northeast/c	36	-		
z1/01east	108	z1/01east/e	54	18	z1/01east/e/g	16.2
		z1/01east/fi	108	-		
		z1/01east/c	108	-		
z1/01southeast	36	z1/01southeast/e	18	6	z1/01southeast/e/g	5.4
		z1/01southeast/s	18	6	z1/01southeast/s/g	5.4
		z1/01southeast/fi	36	-		
		z1/01southeast/c	36	-		
z1/01south	225.5	z1/01south/s	114	38	z1/01south/s/g	34.2
		z1/01south/si	7.5	2.5		
		z1/01south/ei	3	1		
		z1/01south/wi	3	1		
		z1/01south/fe	27.5	-		
		z1/01south/fi	198	-		
		z1/01south/c	225.5	-		
z1/01southwest	36	z1/01southwest/s	18	6	z1/01southwest/s/g	5.4
		z1/01southwest/w	18	6	z1/01southwest/w/g	5.4
		z1/01southwest/fi	36	-		
		z1/01southwest/c	36	-		
z1/01west	108	z1/01west/w	54	18	z1/01west/w/g	16.2
		z1/01west/fi	108	-		
		z1/01west/c	108	-		
z1/01northwest	36	z1/01northwest/n	18	6	z1/01northwest/n/g	5.4
		z1/01northwest/w	18	6	z1/01northwest/w/g	5.4
		z1/01northwest/fi	36	-		
		z1/01northwest/c	36	-		
z1/01centre	614	z1/01centre/ei	54	18		
		z1/01centre/wi	54	18		
		z1/01centre/fe	20	-		
		z1/01centre/fi	594	-		
		z1/01centre/c	614	-		
		z1/01centre/ni	7.5	2.5		
		z1/01centre/si	7.5	2.5		
z1/02	50	z1/02/ni	7.5	2.5		

		z1/02/ei	60	20
		z1/02/si	7.5	2.5
		z1/02/wi	30	10
		z1/02/wi.1	30	10
		z1/02/fi	50	-
		z1/02/c	50	-
z1/03	25	z1/03/ni	7.5	2.5
		z1/03/ei	30	10
		z1/03/si	7.5	2.5
		z1/03/wi	30	10
		z1/03/fe	25	-
		z1/03/c	25	-

Zone Name	Lighting Wattage
z0/01east	742
z0/01north	251
z0/01northwest	160
z0/01south	247
z0/01southwest	162
z0/01west	511
z0/02	232
z0/03	4401
z1/01centre	2790
z1/01east	519
z1/01north	1077
z1/01northeast	168
z1/01northwest	174
z1/01south	1093
z1/01southeast	168
z1/01southwest	162
z1/01west	488
z1/02	236
z1/03	117

Other information	
Window to wall (%)	30
Door area (m^2)	3.75

Table 22: Zoning summary and dimensions of the Example building

A.2. Drawings

The next figures show architectural drawings and building zoning for each floor of the Example building.
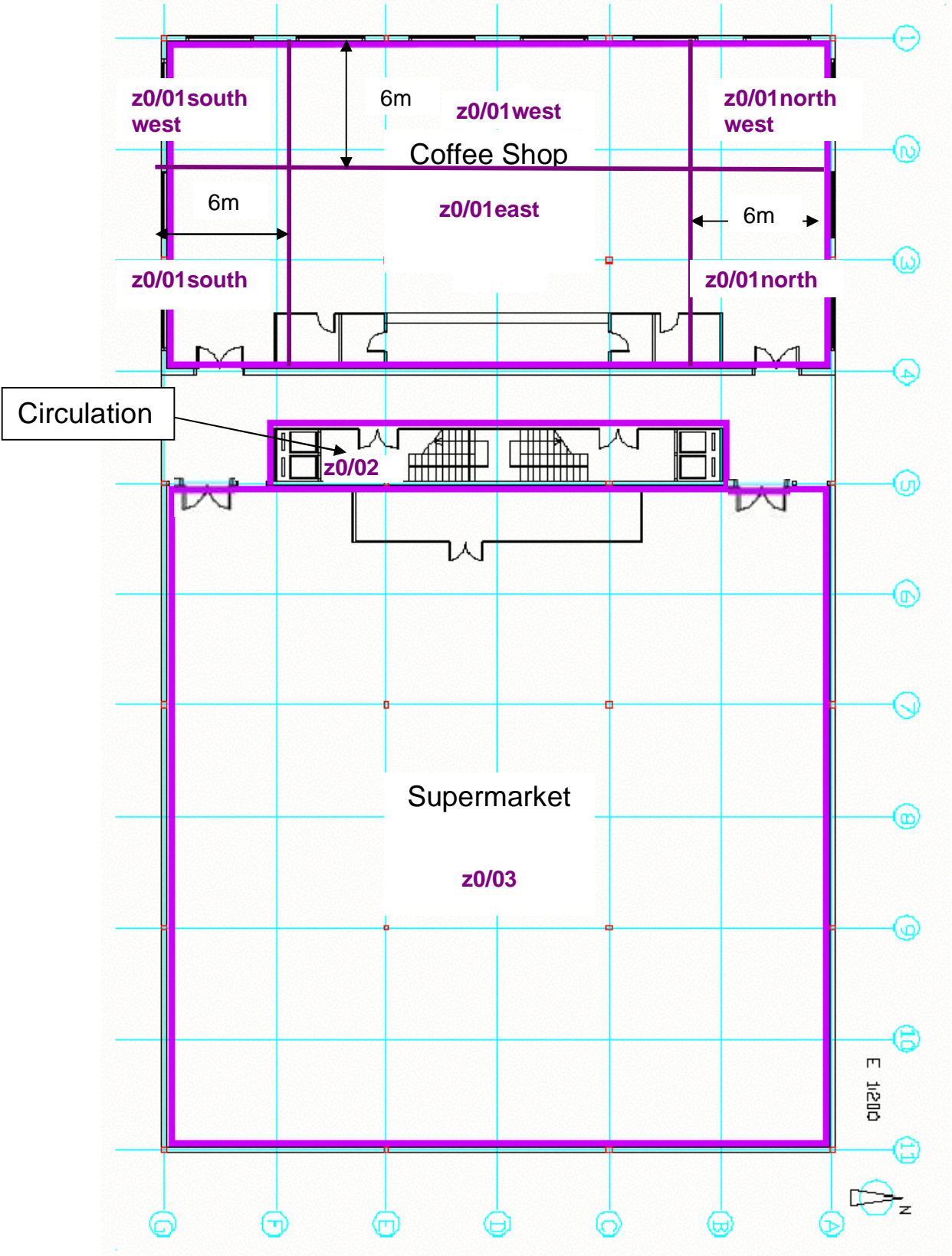
Figure 90: Ground floor plan

Figure 91: First floor plan

z1/01south west

z1/01west

6m

z1/01north west

Toilets

Circulation

z1/03

z1/02

6m

6m

Open Plan Office

z1/01south

z1/01north

z1/01centre

z1/01south east

z1/01east

6m

z1/01north east

1:200

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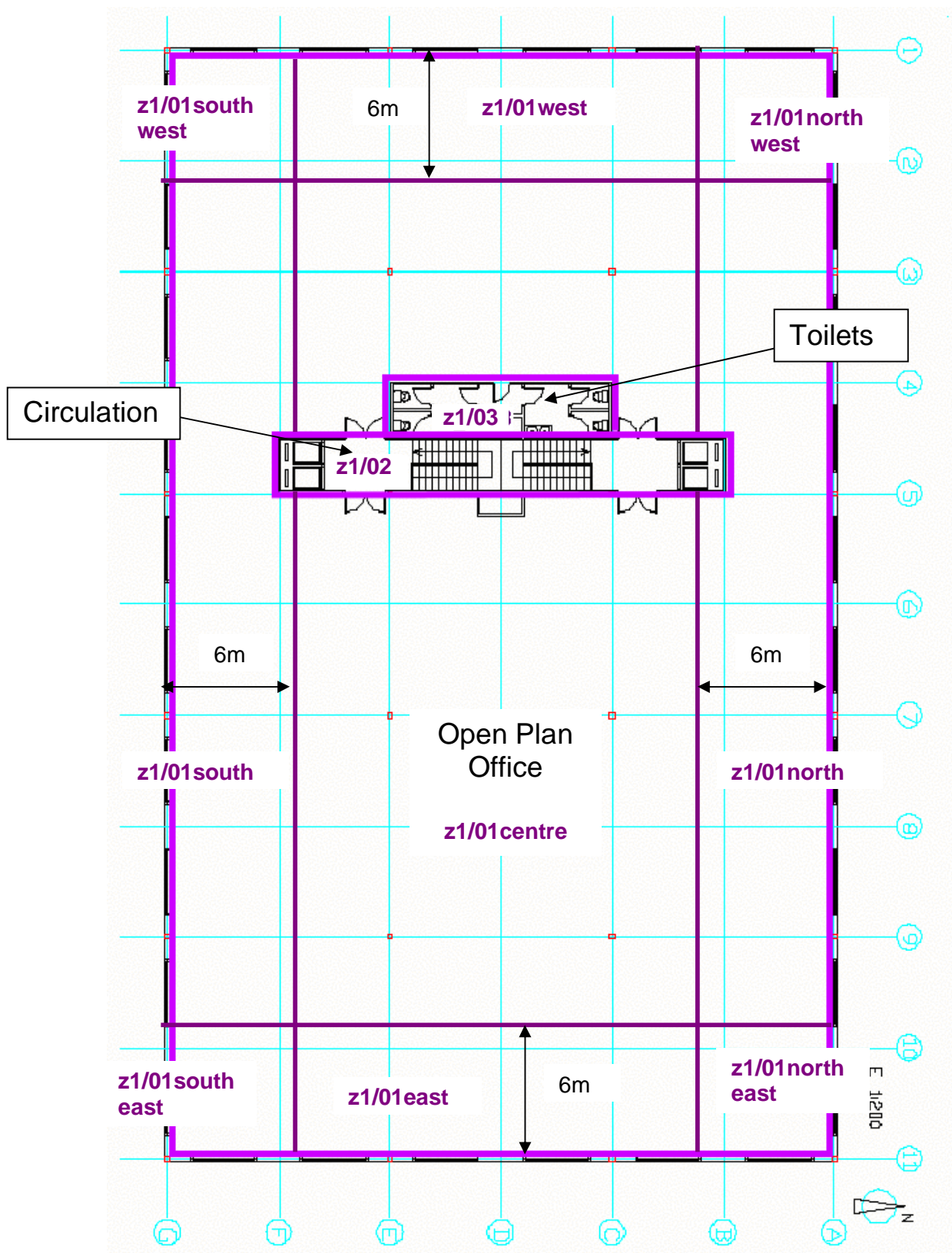
A.3. MBEAT Main Output Document for Example Building

MBEAT Main Calculation Output Document
Wed Jul 20 14:42:19 2011   v4.1.c.2

Building name

Example building

Building type: Offices and Workshop businesses

MBEAT* is an energy calculation tool for the purpose of energy auditing of non-domestic buildings in Mauritius. Although the data produced by the tool may be of use in the design process, **MBEAT is not intended as a building design tool.**

*MBEAT is based on SBEM, an energy calculation tool developed by BRE for DCLG (UK) for the purpose of assessing the energy performance of buildings.

Building Energy Performance and CO2 emissions
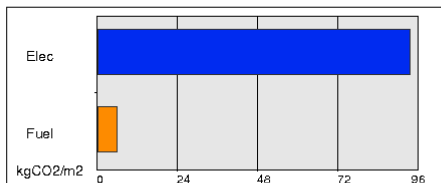
0 kgCO2/m2 displaced by the use of renewable sources.

Building area is 2900 m2

Annual Energy Consumption

(Pie chart including Equipment end-use)
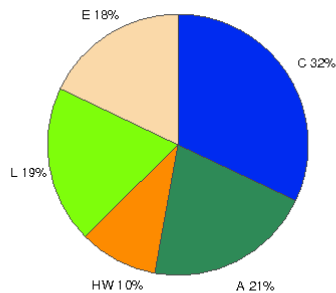
(Pie chart excluding Equipment end-use)
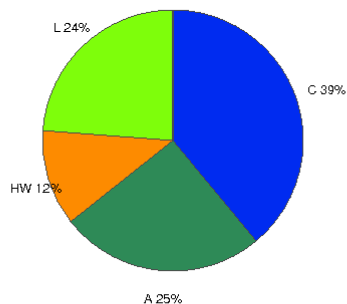
(*) Although energy consumption by equipment is shown in the graphs, the CO2 emissions associated with this end-use have not been taken into account when producing the rating.

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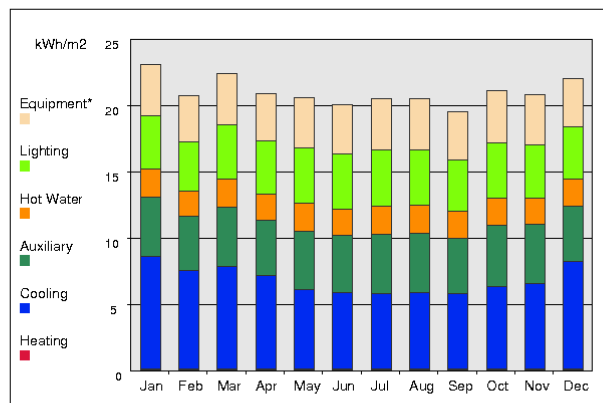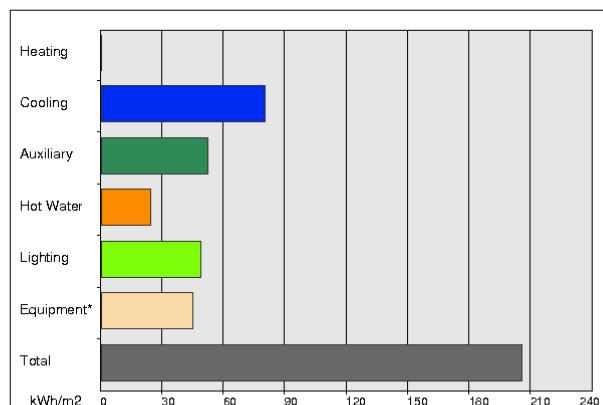
A.4. Energy Audit Report for Example Building

Energy Audit Report
Non-domestic Building

Republic of
Mauritius

56 London Road	**Report number:** 9000-3003-0090-0000-0025
	Issue date: 20 Jul 2011
	Valid until: 19 Jul 2012
LONDON	
SW23 1HA	**Auditor name:** <ea name>
Information not provided by the user	**Auditor number:** TEST000000
Information not provided by the user	

Building Energy Consumption [kWh/m²]

Current Operational Performance:	272.46
Improved Operational Performance:	214.65
Potential Operational Saving:	**57.81**

Transposed Asset Performance:	99.02
Improved Asset Performance:	72.85
Potential Asset Saving:	**26.17**

Management Score

Current:	20
Improved:	30

Building type:	Offices and Workshop businesses
Useful floor area [m²]:	2900
Building environment:	Air Conditioning

Assessment software:	iSBEMma v4.1.b using calculation engine SBEMma v4.1.c.2

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Recommendations for energy efficiency improvements

EPC-C1	The default chiller efficiency is chosen. It is recommended that the chiller system be investigated to gain an understanding of its efficiency and possible improvements.
EPC-C2	Chiller efficiency is low. Consider upgrading chiller plant.
EPC-C3	Ductwork leakage is high. Inspect and seal ductwork.
EPC-W1	Install more efficient water heater.
EPC-W3	Improve insulation on HWS storage.
EPC-W4	Add time control to HWS secondary circulation.
EPC-W2	Consider replacing HWS with point of use system.
EPC-E1	Some floors are poorly insulated - introduce and/or improve insulation. Add insulation to the exposed surfaces of floors adjacent to underground, unheated spaces or exterior.
EPC-E2	Roof is poorly insulated. Install or improve insulation of roof.
EPC-E3	Some solid walls are poorly insulated - introduce or improve internal wall insulation.
EPC-E4	Some walls have uninsulated cavities - introduce cavity wall insulation.
EPC-E5	Some windows have high U-values - consider installing secondary glazing.
EPC-E6	Some loft spaces are poorly insulated - install/improve insulation.
EPC-E7	Carry out a pressure test, identify and treat identified air leakage. Enter result in EPC calculation.
EPC-E8	Some glazing is poorly insulated. Replace/improve glazing and/or frames.
EPC-F1	Consider switching from oil or LPG to natural gas.
EPC-F2	Consider converting the existing boiler from coal to natural gas.
EPC-F3	Consider switching from coal to biomass.
EPC-F4	Consider switching from oil or LPG to biomass.
EPC-F5	Consider switching from gas to biomass.
EPC-F6	Consider switching from coal to oil.
EPC-H2	Add time control to heating system.
EPC-H5	Add local time control to heating system.
EPC-H6	Add local temperature control to the heating system.
EPC-H7	Add optimum start/stop to the heating system.
EPC-H8	Add weather compensation controls to heating system.
EPC-H1	Consider replacing heating boiler plant with high efficiency type.
EPC-H3	Consider replacing heating boiler plant with a condensing type.
EPC-H4	The default heat generator efficiency is chosen. It is recommended that the heat generator system be investigated to gain an understanding of its efficiency and possible improvements.
EPC-L1	Replace 38mm diameter (T12) fluorescent tubes on failure with 26mm (T8) tubes.
EPC-L2	Replace tungsten GLS lamps with CFLs: Payback period dependent on hours of use.

EPC-L3	Replace high-pressure mercury discharge lamps with plug-in SON replacements.
EPC-L4	Replace tungsten GLS spotlights with low-voltage tungsten halogen: Payback period dependent on hours of use.
EPC-L5	Consider replacing T8 lamps with retrofit T5 conversion kit.
EPC-L6	Replace high-pressure mercury discharge lamps with complete new lamp/gear SON (DL).
EPC-L7	Introduce HF (high frequency) ballasts for fluorescent tubes: Reduced number of fittings required.
EPC-V1	In some spaces, the solar gain limit is exceeded, which might cause overheating. Consider solar control measures such as the application of reflective coating or shading devices to windows.
EPC-R1	Consider installing a ground source heat pump.
EPC-R2	Consider installing building mounted wind turbine(s).
EPC-R3	Consider installing solar water heating.
EPC-R4	Consider installing PV.
EPC-R5	Consider installing an air source heat pump.

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APPENDIX B: MBEAT file conversion

If you want to open and edit files created with previous versions of MBEAT (or UK iSBEM) using this current version (v4.1.h), you will need to convert them to MBEAT v4.1.h using the conversion tool "nct_convertMA_v4.1.h.mdb", as described below. The file conversion tool is downloaded and installed to your computer at the same time as you download and install the new version of MBEAT. There are 6 stages to converting the files from previous versions to v4.1.h:

1. **Open the file conversion tool** - Double-click on the 'nct_convertMA_4.1.h.mdb' file in the MBEAT_v4.1.h folder, as shown in Figure 92.
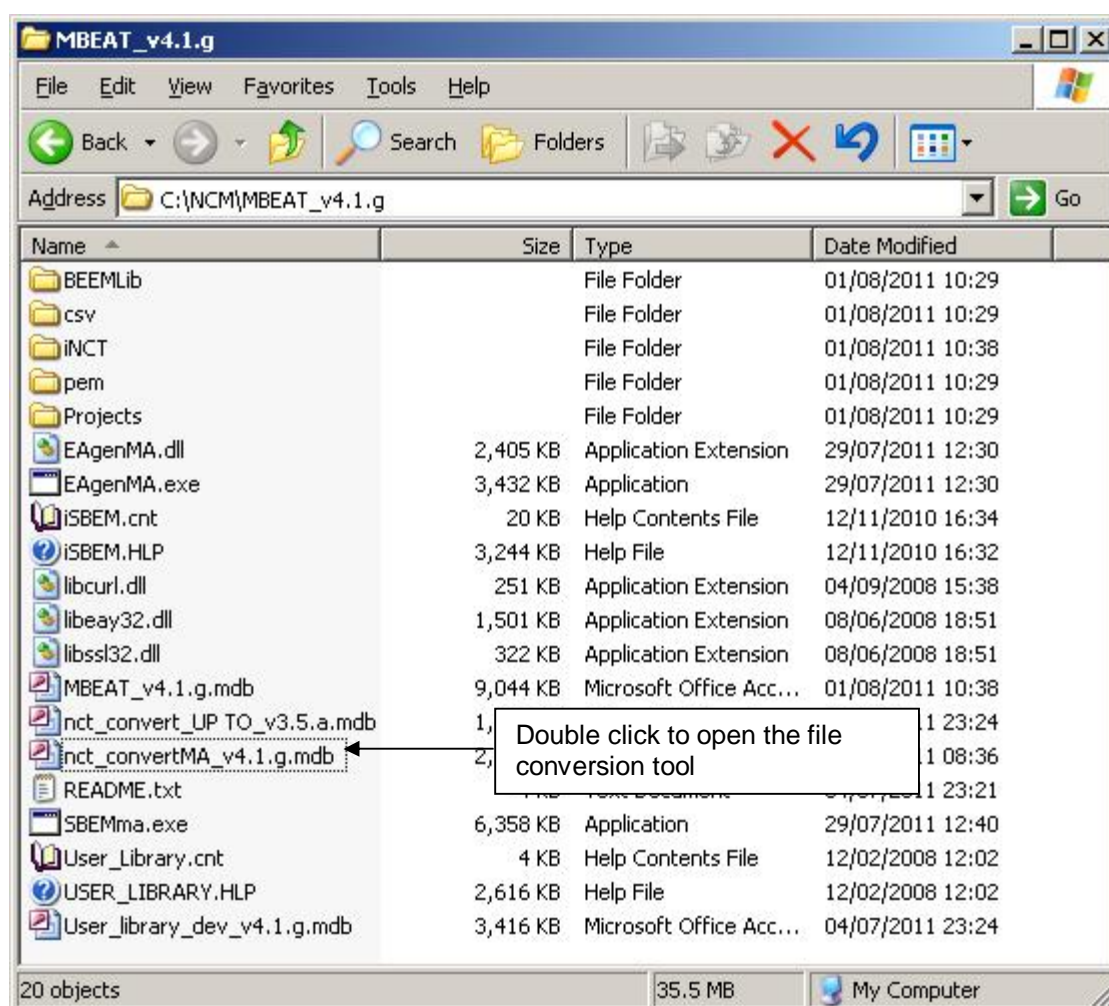
Figure 92: Folder showing the file conversion tool

2. **Select the file you want to convert** - To do this, click on the button shown in Figure 93. This opens a dialogue box, shown in Figure 94, from which you need to browse to find the file you want to convert. Once you have found the file, click on 'Open'.

Figure 93: Selecting a file to convert - stage 1
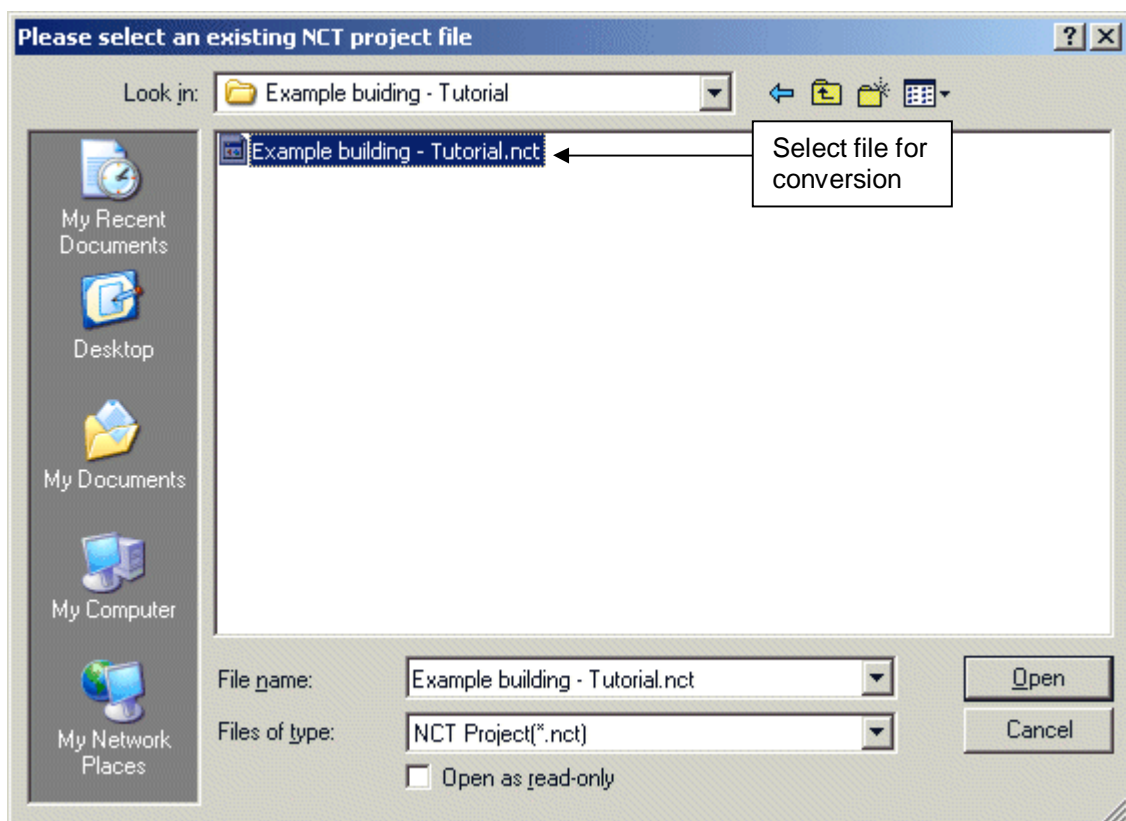
Figure 94: Selecting a file to convert - stage 2

3. **Choose a name for the converted file - There are two options:**

    i. Click on the button shown in Figure 95. This opens a dialogue box (the same as in stage 2). Re-select the file you are converting and click on 'Save'. The new file will automatically be given the name: "original file name_**v4.1.h.nct**". The original file will not be over-written by the conversion tool, and you should keep it for future reference.

    ii. If you want to give the converted file a new name of your own, type a new name and its full path into the field (shown in Figure 95).
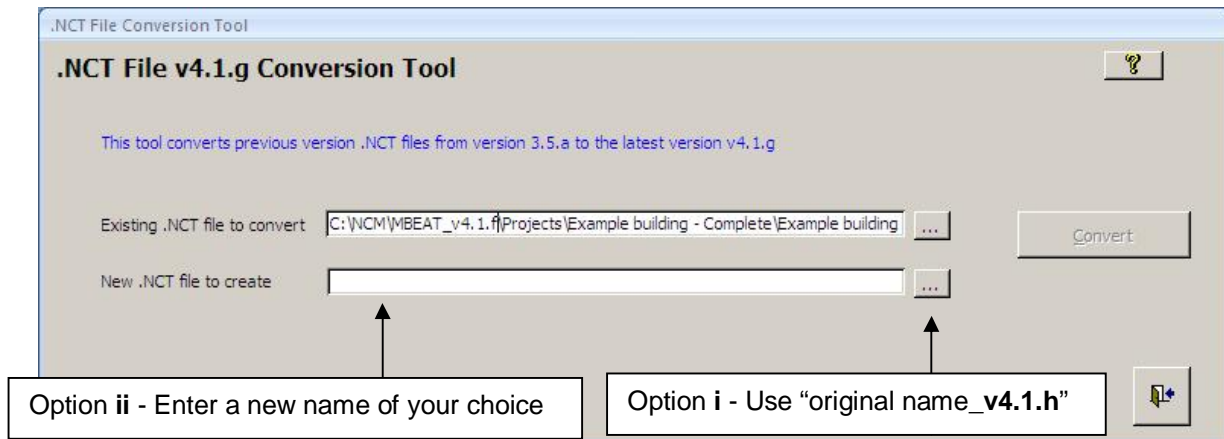
Figure 95: Naming the new file

4. **Convert the file** – When both of the fields are filled, the 'Convert' button becomes active (see Figure 96). Clicking on this button converts the files and produces the message shown in Figure 97. Click on 'OK'. The new file will be saved to the same folder as the original file by default, unless you specify otherwise.

5. **Close the tool** – Click on the 'Exit' button (see Figure 96).
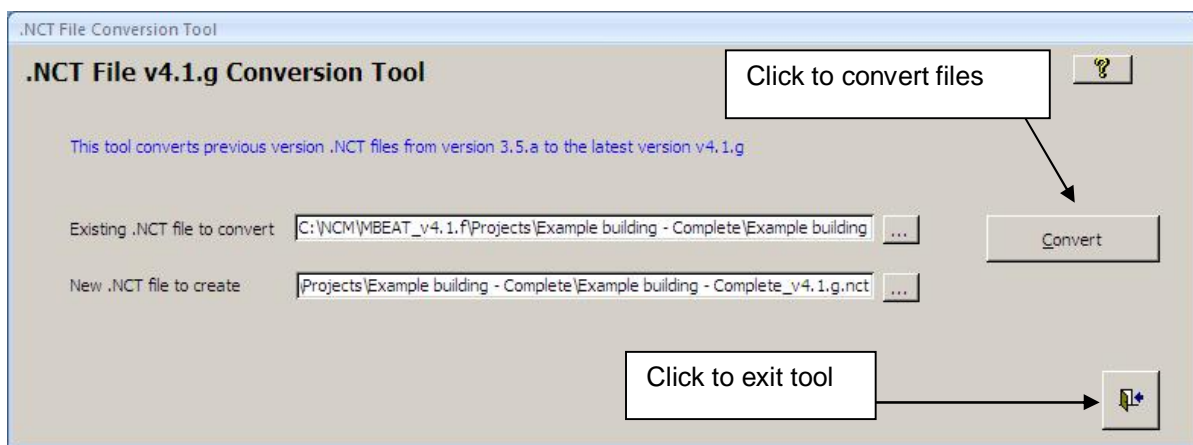
Figure 96: The Convert and Quit buttons
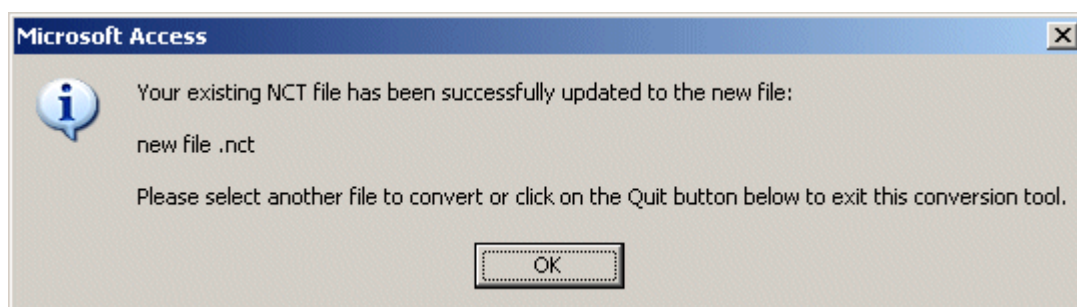
Figure 97: Message which appears after conversion

6. **Open MBEAT and open the newly created nct file** - <u>Due to the nature of the changes usually introduced in any new version, some fields in some projects may not get refreshed automatically. In order to ensure all the fields in your project are refreshed and updated, after converting files generated by a previous version, you need to do the following (using the record navigation arrows at the bottom):</u>

   - Click through all the envelope elements in the *Geometry* form > *Envelope* tab in order to refresh the adjacencies (i.e., the "connects space to" field).
   - Click through all the HVAC systems in the *Building Services* form > *HVAC systems* tab > *General* sub-tab.
   - Click through all the sub-tabs in the *Building Services* form > *Zones* tab.
   - Click through all the recommendations sub-tabs in the *Ratings* form > *Energy Audit* tab.

APPENDIX C: User-defined construction database

The User Library (User_library_4.1.c.mdb) is a feature in which you can build up a database of your commonly used constructions so that you do not need to re-enter them each time you start a new project. You can also import constructions into your Library from a project you have been working on in MBEAT or from another User Library.

This appendix will take you through the basics of:

1. How to add a construction type to your library – and add this to MBEAT
2. How to add a glazing type to your library – and add this to MBEAT
3. How to add a frame type to your library – and add this to MBEAT
4. How to edit the list of opaque constructions categories and the list of sources
5. How to import constructions previously entered into an MBEAT project or in another User Library into your own User Library

For definitions of a particular parameter, place the curser in that field and press F1. This will open a window with the Help item for that field, in the same way that the Help can be accessed within MBEAT. These definitions are not included in this appendix.

The User library can be found as shown in Figure 98:
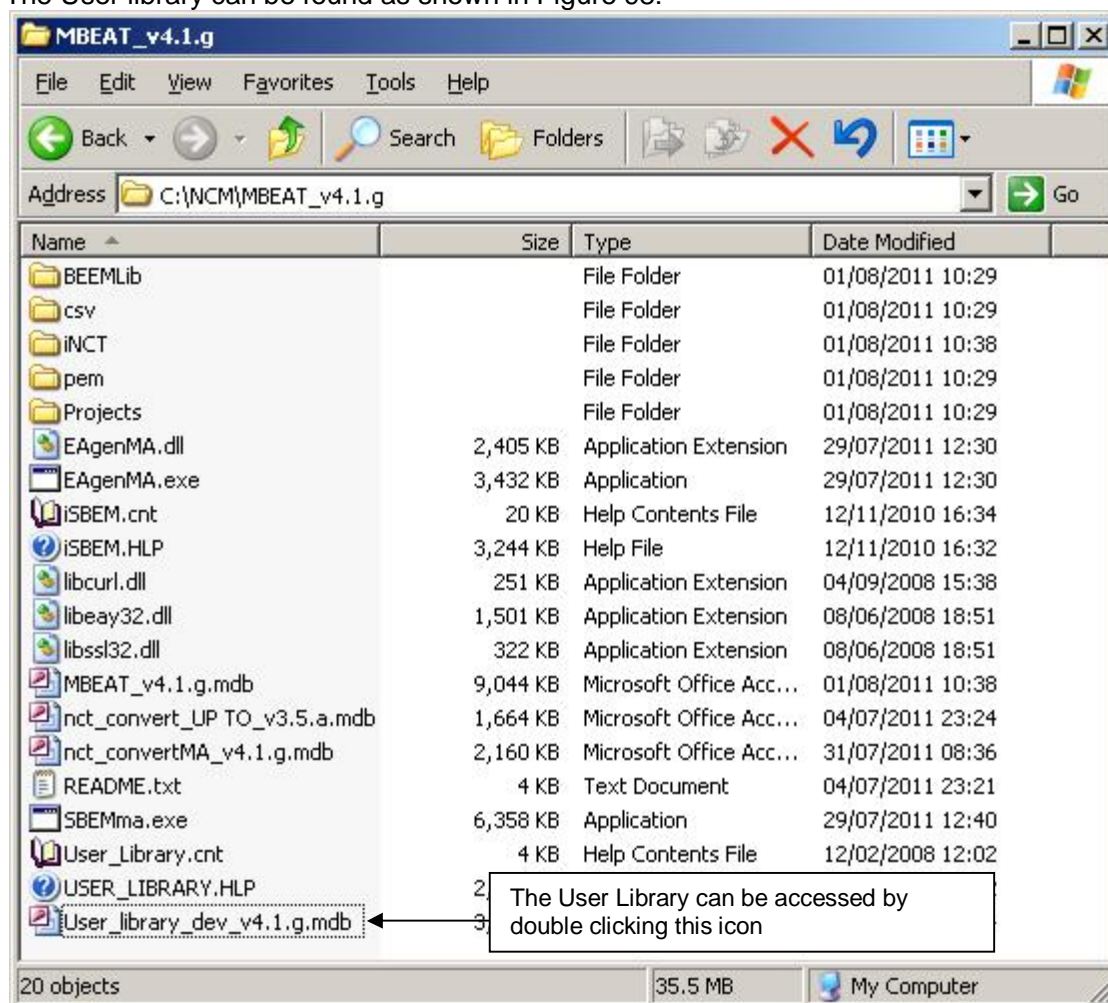
Figure 98: Location of the User-defined construction library

1. How to add a construction type to your library – and add this to MBEAT

To add a construction to the User Library, click into the *Constructions* form and follow the instructions starting by clicking on the "create new construction" button and finishing by updating the library in MBEAT.

2 – enter a unique name. **NB**: in MBEAT, this name will be proceeded with a $

1 – click on the "create new construction" button

To view all the constructions in your library click here

To delete a construction click here

3 – select the envelope type (wall/roof/ floor/door)

4 – select the category under which you want this to appear in MBEAT *(to add a category, see Section 5 of this appendix)*

5 – select a source *(to add a source to this list see Section 4 of this appendix)*

8- Click on this button to update MBEAT with your new construction.

7 – enter a description (optional)

Figure 99: Description of Constructions tab in User-defined construction library

6 – enter $\mathcal{K}_m$ value, U-value and tick if construction contains metal cladding. For further details on these parameters, press F1 in the library or refer to Section 7.4 of the MBEAT User Guide.

A construction created in this way will be accessible in MBEAT from the *Project Database* form. It will be located in the "Constructions for X" tab, where X is the type of envelope as selected in the envelope type field (stage 3) and under the category as selected in the category field (stage 4). The construction will be called $*Construction Name,* where *Construction Name* is the name entered in the name field.

2. How to add a glazing type to your library – and add this to MBEAT

Adding a new glazing type to the glazing Library and updating MBEAT with this information is done in the same way as for constructions but in the *Glazing* form. For glazing, in addition to requiring a unique name, U-value, and source of the information, you are required to enter parameters which describe the solar and light transmission properties of the glazing. For details of any of the parameters, press F1 or see Section 7.4 of the MBEAT User Guide.

2 – enter a unique name. **NB**: in MBEAT, this name will be proceeded with a $

1 – click on the "create new glazing" button

To view all the glazing types in your library click here

3 – select the envelope type (window/ rooflight)

To delete a glazing type click here

4 – select number of panes

9 – Click on this button to update MBEAT with your new glazing types.

5 – select coating type

6 – select a source *(to add a source to this list see Section 4 of this appendix)*

8 – enter a description (optional)

Figure 100: Description of Glazings tab in User-defined construction library

7 – enter T-Solar, L-Solar and U-value. For further details of these parameters, press F1 in the library or refer to Section 7.4 of the MBEAT User Guide.

A glazing type created in this way will be accessible in MBEAT in the *Project Database* form > *Glazing* tab. It will be accessible when the "import one from the library" radio button is selected, from the glazing library. The glazing type will be called $*Glazing Name,* where *Glazing Name* is the name entered in the name field.

3. How to add a frame type to your library – and add this to MBEAT

As with the glazing, you can add a frame to your frames library in the same way that you add a construction to the constructions library but in the *Frames* form. The only parameters required to define a frame is the type (PVC, hardwood, softwood, steel, etc.) and the U-value. You are able to enter a description as with the constructions and glazing libraries.

2 – enter a unique name. **NB**: in MBEAT, this name will be proceeded with a $

1 – click on the "create frame" button

To view all the frames in your library click here

To delete a frame click here

3 – select the type (Softwood/ Hardwood/ Steel/ Aluminium/ PVC/ Other)

7 – Click on this button to update MBEAT with your new frames

4 – select a source *(to add a source to this list see Section 4 of this appendix)*

6 – enter a description (optional)

Figure 101: Description of Frames tab in User-defined construction library

5 – enter the U-value. For further details of this parameter, press F1 in the library or refer to Section 7.4 of the MBEAT User Guide.

A frame type created in this way will be accessible in MBEAT in the *Project Database* form > *Glazing* tab. It will be accessible when the "import one from the library" radio button is selected, from the frame library. The frame type will be called $*Frame Name,* where *Frame Name* is the name entered in the name field.

4. How to edit the list of opaque constructions categories and the list of Sources

- *Editing the list of categories for opaque constructions*

  As described in Section 1, when creating a new construction type for your library, you need to select a category under which your construction will appear in MBEAT. If none of the pre-defined categories are appropriate, you can add a new one to the library in the *Category* form. To do this, enter the *Category* form, click on the "create new category" button, add a unique name in the name field, select an envelope type, and if you want, add a description. This category will now appear in the "Category" field in the *Constructions* form.
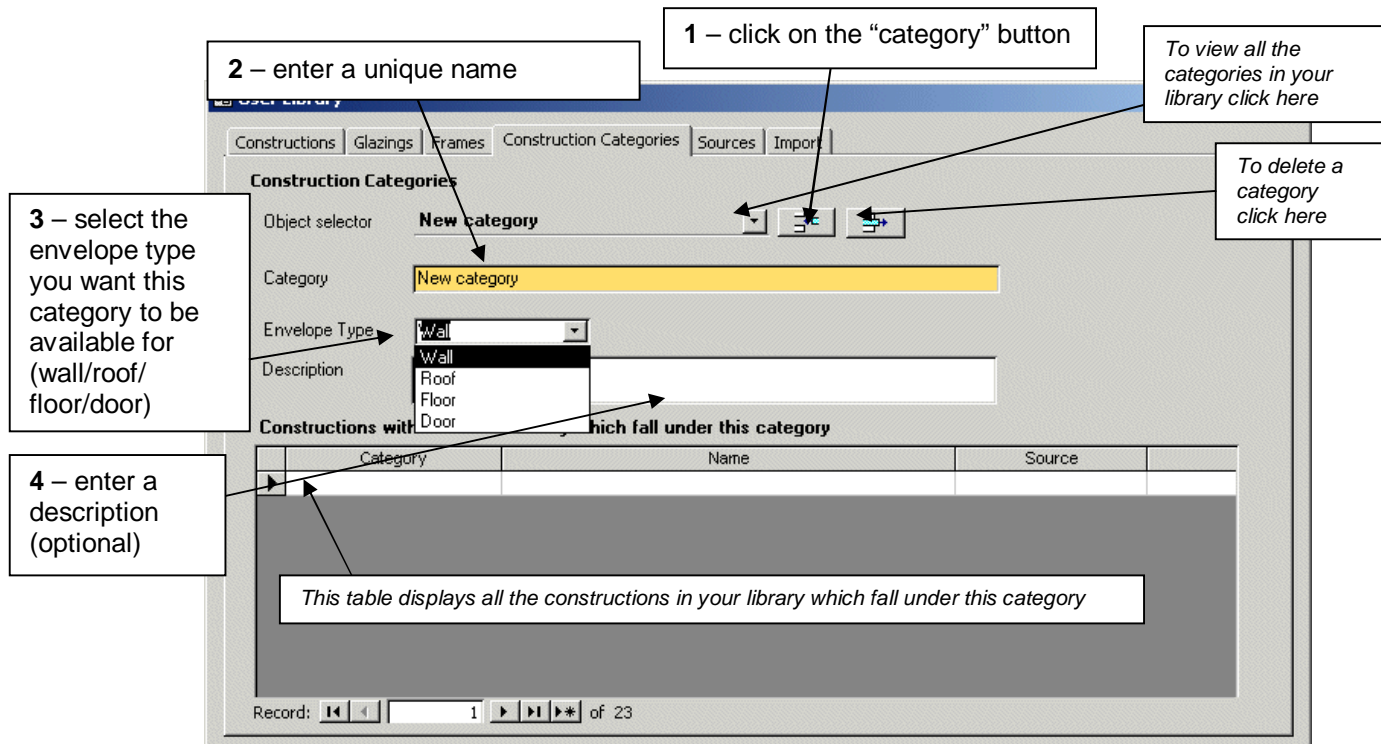
Figure 102: Description of Construction Categories tab in User-defined construction library

- ***Editing the list of sources which you can select when defining opaque constructions, glazing types, or frame types***

The list is viewable and editable in the *Sources* form. To add a new source, click on the "enter new source" button and write the name of the source in the source field. This source will now be available for selection in the *Construction*, *Glazing*, and *Frames* form.

2 – enter a unique name

1 – click on the "source" button

To view all the sources in your library click here

To delete a source click here

User Library

Constructions | Glazings | Frames | Construction Categories | Sources | Import

Source Categories

Object selector   **New source**

Source   New source

Constructions, glazing types and frames within this user library which use this source

Source	Name	Category

This table displays all the constructions, glazing types, and frames which use this source in your library.

Record: 1 of 18

Figure 103: Description of Sources tab in User-defined construction library

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5. How to import constructions previously entered into an MBEAT project or in another User Library into your own User Library

You may wish to import constructions from an existing User Database into your own, for example, from a colleague's User Database. This can be done in the *Import* form. Similarly, In MBEAT, there is already a library of constructions which you can choose from in the *Project Database* form. If you wanted to edit any of these, you could import these into your User Library. This is done by selecting the mdb (User Database) file or nct (MBEAT file) and clicking on the appropriate import button as shown in Figure 104.
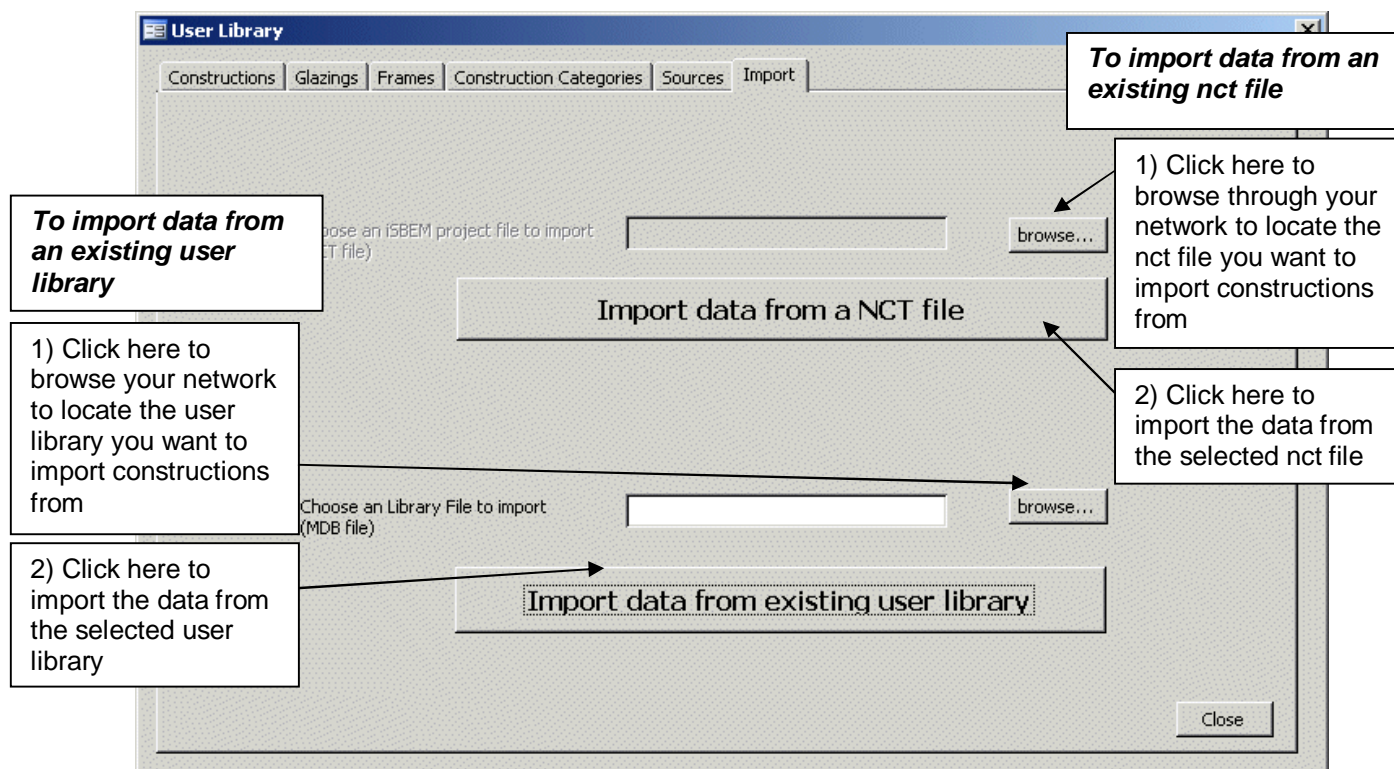
Figure 104: Description of Import tab in User-defined construction library

Once this procedure is successfully completed, these records will be available for editing within the User Library tool, and should also be automatically available for use within MBEAT without any further updates needing to be carried out.

NB: All user-updated constructions, glazings, and frames from the User Library (including those that have been imported) will have the prefix "§ " added to them (unless it already exists, in which case an additional § will NOT be added).

NB: Should a construction/glazing/frame of the same name as an existing construction/glazing/frame be imported into the User Library, a number will be appended to the end of it, according to the number of records in the User Library with a similar name, i.e., a record with name *Name* will have its name changed to *Name.1*, *Name.2*, *Name.3,* etc. depending on whether there are already 1, 2, 3, etc. records in the database already with a similar name (excluding the suffix).

NB: Frames cannot be imported from NCT files due to the nature of their table layouts. Only constructions and glazings can be imported by this procedure.

APPENDIX D: List of parameters required by MBEAT

Form: General

> ***Tab: General Information***
>
> > <u>Sub-tab: Project details</u>
> > - Purpose of analysis
> > - Audit type
> > - Weather (location)
> >
> > <u>Sub-tab: Building details</u>
> > - Building type
> > - Name of project
> > - Building address
> > - City
> > - Postcode
> > - Location description
> > - UPRN
> > - Inspection date
> > - Is building of special conservation status?
> >
> > <u>Sub-tab: Energy Auditor's details</u>
> > > <u>Sub-form: Energy Auditor's details</u>
> > > - Name
> > > - Telephone number
> > > - Address
> > > - City
> > > - Postcode
> >
> > <u>Sub-tab: Owner's details</u>
> > - Name
> > - Telephone number
> > - Address
> > - City
> > - Postcode

Form: Project Database

> ***Tab: Construction for walls***
>
> > <u>Sub-tab: General</u>
> > - Name of construction
> > - Does it involve metal cladding?
> > - Globally used in walls that connect zone to
> > - Definition of construction of walls using one of the following 3 options:
> >   1) Library
> >   - Category
> >   - Library
> >
> >   *or*
> >
> >   2) Enter parameters manually
> >   - U-value [W/m^{2}K]
> >   - $\mathcal{K}_m$ [kJ/m^{2}K]
> > - Absorption coefficient
>
> ***Tab: Construction for roofs***
>
> > <u>Sub-tab: General</u>
> > - Name of construction
> > - Does it involve metal cladding?
> > - Globally used in roofs that connect zone to
> > - Definition of construction of roofs using one of the following 3 options:
> >   1) Library
> >   - Category

- o Library
- 2) Enter parameters manually
  - o U-value [W/m^{2}K]
  - o K_m [kJ/m^{2}K]
- Absorption coefficient

Tab: Construction for floors
Sub-tab: General
- Name of construction
- Globally used in floors that connect zone to
- Definition of construction of floors using one of the following 3 options:
  1) Library
     - o Category
     - o Library

  or

  2) Enter parameters manually
     - o U-value [W/m^{2}K]
     - o K_m [kJ/m^{2}K]
     - o Has the U-value been corrected to account for heat loss through floors in contact with the ground?

Tab: Construction for doors
Sub-tab: General
- Name of construction
- Definition of construction of doors using one of the following 3 options:
  1) Library
     - o Category
     - o Library

  or

  2) Enter parameters manually
     - o U-value [W/m^{2}K]
     - o K_m [kJ/m^{2}K]

Tab: Glazing
Sub-tab: General
- Name of construction
- Definition of construction of glazing using one of the following 3 options:
  1) Library
     - o Glazing Library
     - o Frame Library

  or

  2) Enter parameters manually
     - o U-value - for glazing in vertical inclination [W/m^{2}K]
     - o T-solar – for normal incidence
     - o L-solar – for normal incidence

Form: Geometry

Tab: Project
Sub-tab: General & Geometry
- Global air permeability at 50pa [m^3/h.m^2]
- Building (clockwise) rotation [degrees]
- Global zone floor-to-floor height [m]
- Maximum number of storeys
- Building area [m^2]

Tab: Zones
Sub-tab: General
- Zone name
- HVAC system which serves the zone
- Building type

- Activity type in the zone
- Zone area [m^2]
- Zone floor-to-floor height [m], or select global value
- Air permeability at 50pa [m^3/h.m^2] in the zone, or select global value
- Zone multiplier
- Share to building
- User's notes

Tab: Envelopes
Sub-tab: General
- Envelope name
- Envelope multiplier
- Zone which envelope belongs to
- Type of envelope
  - Pitch angle [degrees] *(field enabled if envelope type is roof or floor/ceiling)*
  - Perimeter length [m] *(field enabled if envelope type is wall)*
- Envelope connects space to, or select global value
- Envelope construction
- Envelope area [m^2]
- Envelope orientation
- Is there a transpired solar collector (TSC) on this wall? *(field enabled if envelope type is wall)*
  - TSC name
  - TSC area [m^2]
- Transmission factor due to overhangs

Tab: Doors
Sub-tab: General
- Door name
- Door multiplier
- Envelope which door is in
- Door type
- Door construction
- Door area [m^2]

Tab: Windows & Rooflights
Sub-tab: General
- Window/Rooflight name
- Window/Rooflight multiplier
- Envelope which window/rooflight is in
- Glazing type
- Window/Rooflight projected area [m^2]
- Ratio of developed area to projected area of window/rooflight
- Ratio of roof area covered by rooflight array to area of rooflight glazing
- Is it a display window?
- Frame factor
- Aspect ratio
- Shading position on window/rooflight
  - Shading colour
  - Shading translucency
- Transmission factor due to fins and overhangs

Form: Building Services
Tab: Global and Defaults
Sub-tab: HVAC System Defaults
- Fuel type for default Heating only – Other systems
- Fuel type for heating in default Heating and mechanical cooling systems

- Fuel type for cooling in default Heating and mechanical cooling systems

Sub-tab: Services Management
- Electric power factor
- Current Management Score
- Improved Management Score

Tab: HVAC Systems
Sub-tab: General
- HVAC system name
- HVAC system type
  - Heat recovery in ventilation system *(field enabled if there is mechanical ventilation at HVAC level)*
    - § Heat recovery seasonal efficiency
    - § Variable heat recovery efficiency?
  - Is this heating and cooling system used to provide cooling only?

Sub-tab: Heating System
- Heat source
- Fuel type for heat generator
- Does this heating system also use CHP?
- Effective heat generating seasonal efficiency for heat generator
- Heat generator radiant efficiency

Sub-tab: Cooling System *(enabled only if HVAC system provides cooling)*
- Generator type
- Generator kW
- Fuel type for cooling generator
- Seasonal energy efficiency ratio for cooling generator
- Nominal energy efficiency ratio for cooling generator

Sub-tab: System adjustment *(enabled only if there is mechanical ventilation at HVAC level)*
- Has the ductwork been leakage tested?
  - CEN classification it meets
- Does the AHU meet CEN leakage standards?
  - CEN classification it meets
- Specific fan power [W/(l/s)]
- Variable speed pumping?
  - Type

Sub-tab: Bi-valent Systems
- Heat source
- Fuel type for heat generator
- Effective heat generating seasonal efficiency for heat generator
- Proportion of heating load provided by heat generator

Tab: HWS
Sub-tab: General
- HWS name
- HWS generator type
  - Fuel type for HWS generator *(field enabled if hot water is not generated by HVAC system)*
  - Effective heat generating seasonal efficiency for HWS generator *(field enabled if hot water is not generated by HVAC system)*

Sub-tab: Storage & Secondary Circulation
- Is the system a storage system?
  - Storage volume [litres]
  - Insulation type on storage vessel
    - § Insulation thickness [mm]
  - *or*
  - Storage losses [MJ/month]
  - Does the system have secondary circulation?
    - § Circulation losses [W/m]
    - § Pump power [kW]

- § Loop length [m]
- § Is there time control on the secondary circulation?
- Sub-tab: Bi-valent Systems
  - Heat generator type
  - Fuel type for heat generator
  - Effective heat generating seasonal efficiency for heat generator
  - Proportion of water heating load provided by heat generator

Tab: SE Systems
- Sub-tab: Collector Parameters
  - SES name
  - HWS which SES is in
  - SES area [m^2]
  - SES multiplier
  - SES orientation
  - SES inclination [degrees]
  - Do you know the collector performance parameters according to EN 12975-2?
    - o Zero-loss collector efficiency factor
    - o Collector heat loss coefficient [W/m^{2}K]
    - o Temperature dependence of heat loss coefficient [W/m^{2}K]
    - o Incidence angle modifier of collector
- Sub-tab: Solar Storage & Collector Loop
  - Solar storage volume [litres]
  - Solar pre-heating type
    - o Insulation type on storage vessel
      - § Insulation thickness [mm]
  - Do you know the heat transfer rate of the heat exchanger(s) in the collector loop?
    - o Heat transfer rate [W/K]
  - Do you know the overall heat loss coefficient of all pipes in the collector loop?
    - o Heat loss coefficient [W/K]
- Sub-tab: Auxiliary Energy & Distribution Losses
  - Are the distribution pipes between the solar energy system and the back-up system insulated? *(field enabled only if the solar pre-heating type is a separate solar cylinder)*
  - Circulation system
    - o Do you know the nominal power of the pumps?
      - § Nominal power of the pumps [W]

Tab: PV Systems
- Sub-tab: General
  - PVS name
  - PVS type
  - PVS area [m^2]
  - PVS multiplier
  - PVS orientation
  - PVS inclination [degrees]
  - Overshading
  - Ventilation strategy

Tab: Wind Generators
- Sub-tab: General
  - Wind generator name
  - Terrain type
  - Horizontal axis?
    - o Diameter of blades [m]
  - Other axis?
    - o Area swept by blades [m^2]
  - Hub height [m]

- Wind generator power [kW]

Tab: CHP Generator
    <u>Sub-tab: General</u>
- Fuel type
- Heat efficiency
- Electrical efficiency
- CHPQA Quality Index
- % of building space heat supplied by CHP
- % of building hot water supplied by CHP
- Is it a tri-generation system?
  - % of building space cooling supplied by CHP
  - Chiller efficiency

Tab: Transpired Solar Collectors
    <u>Sub-tab: General</u>
- TSC name
- TSC type
- TSC operation
- TSC control type
- TSC absorptivity
- TSC shading factor
- Is TSC provided with independent fan?
  - TSC supply specific fan power [W/(l/s)]
- TSC design air flow rate [m^3/s]

Tab: Zones
    <u>Sub-tab: HVAC, HWS, and Lighting systems</u>
- HVAC system which services the zone
- Are there de-stratification fans in the zone?
- HWS which serves the zone
- Dead leg length for HWS in the zone [m]

    <u>Sub-tab: Ventilation</u>
- Zonal ventilation system – natural or mechanical *(field enabled if there is <u>no</u> mechanical ventilation at HVAC level)*
  - Specific fan power for supply & extract [W/(l/s)] *(field enabled if there is mechanical ventilation at zone level)*
  - Demand-controlled ventilation?
    - § Flow regulation type
- Does activity require high pressure drop air treatment?

    <u>Sub-tab: Ventilation (cont.)</u>
- Heat recovery in the zone ventilation (*field enabled if there is mechanical ventilation at zone level)*
  - Heat recovery seasonal efficiency
  - Variable heat recovery efficiency?
- Specific fan power for system terminal units [W/(l/s)]

    <u>Sub-tab: Exhaust</u>
- Is there mechanical exhaust in the zone?
  - Flow rate of mechanical exhaust [l/s.m^2]
  - Specific fan power for exhaust [W/(l/s)]
  - Extract system serves single or multiple rooms?

    <u>Sub-tab: Lighting</u>
- Provide information on lighting using one of the following 3 options:
  1) Full lighting design
     - Total wattage [W]
     - Design illuminance [lux]
  or
  2) Lighting chosen but calculation not carried out
     - Lumens per circuit wattage
     - Light output ratio
  or
  3) Lighting parameters not available

- o Lamp type
- Are air-extracting luminaries fitted?

Sub-tab: Lighting Controls
- Type of lighting controls in the zone
  - o Local manual switching?
  - o Photoelectric?
    - § Dimming or switching?
    - § Type of sensors?
    - § Different sensor for back of zone?
    - § Parasitic power for photoelectric control
  - o Do you want MBEAT to perform automatic daylight zoning for lighting controls?
    - § Percentage area of zone where lighting is controlled by daylight.
- Type of occupancy sensing in the zone
  - o Parasitic power for occupancy sensing

Sub-tab: Display Lighting
- Does display lighting use efficient lamps? *(field enabled for activities with display lighting)*
  - o Lumens per circuit wattage for display lighting
- Is there time-switching for display lighting? *(field enabled for activities with display lighting)*

Sub-tab: TSC
- Name of TSC system providing pre-heated air to this zone
- Percentage of the total air pre-heated by the TSC system that is provided to this zone

Tab: Meters

Sub-tab: General
- Meter name
- Fuel type
- Data quality
- Data value [*unit determined by fuel type selected*]
- Unregulated portion [%]

APPENDIX E: Matrix of activity areas and building types

Activity Type / Building Type	Retail and Financial/Professional services	Restaurant and Cafes/Drinking Establishments and Hot Food takeaways	Offices and Workshop businesses	General Industrial and Special Industrial Groups	Storage or Distribution	Hotels	Residential Institutions - Hospitals and Care Homes	Residential Institutions - Residential schools	Residential Institutions - Universities and colleges	Secure Residential Institutions	Non-residential Institutions - Community/Day Centre	Non-residential Institutions - Crown and County Courts	Non-residential Institutions - Education	Non-residential Institutions - Libraries Museums and Galleries	Non-residential Institutions - Primary Health Care Building	General Assembly and Leisure plus Night Clubs and Theatres	Others - Car Parks 24 hrs	Others - Emergency services	Others - Miscellaneous 24hr activities	Others - Passenger terminals	Others - Stand alone utility block	Others - Telephone exchanges	Residential spaces
24 hrs Consulting/treatment areas							X																
24x7 Generic Office Area					X																		
24x7 Warehouse storage					X																		
Assembly areas / halls						X	X																
Auditoria																X							
Bathroom						X	X	X	X	X									X				
Bedroom								X	X										X				
Bedroom unit						X	X																
Car Park	X		X														X						
Cell (police/prison)										X		X							X				
Changing facilities with showers			X		X	X	X	X	X	X	X		X		X	X		X			X		
Circulation area (corridors and stairways)			X	X	X	X		X	X	X	X	X	X		X	X		X				X	
Circulation area (corridors and stairways) - non public	X	X												X		X				X			
Circulation area (corridors and stairways) - non-public/restricted					X																		
Classroom							X		X	X													
Common circulation areas																							X
Computer lab								X	X				X										
Cupboard	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X		X		X	
Data Centre																			X				
Dept Store Sales area - chilled	X																						
Dept Store Sales area - electrical	X																						
Dept Store Sales area - general	X																						
Diagnostic Imaging							X																
Display and Public areas														X									
Display area																X							
Display window	X																						
Domestic Bathroom																							X
Domestic Bedroom																							X
Domestic Circulation																							X

Domestic Dining room																							X
Domestic Kitchen																							X
Domestic Lounge																							X
Domestic Toilet																							X
Dry sports hall						X		X	X	X	X		X			X		X					
Eating/drinking area	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X		X		X			
Fitness Studio																X							
Fitness suite/gym			X			X			X	X						X		X					
Food preparation area	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X		X		X			
Generic Checkin areas																				X			
Generic Office Area	X	X	X	X	X	X							X		X	X	X	X		X		X	
Generic Ward							X																
Hall/lecture theatre/assembly area								X	X	X	X	X	X	X		X							
Heavy Plant Room																			X				
Hydrotherapy pool hall							X																
Ice rink																X							
Industrial process area				X			X																
Laboratory				X			X	X	X				X	X									
Laundry	X					X	X	X	X	X						X							
Light plant room	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X		X	
Lounges																				X			
Office and consulting areas							X	X	X	X	X		X		X								
Operating theatre							X																
Performance area (stage)		X														X							
Physiotherapy Studio							X																
Post Mortem Facility							X																
Public circulation areas							X									X							
Reception		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X		X		X	
Residents common rooms								X	X														
Residents kitchen									X														
Retail Warehouse Sales area - chilled	X																						
Retail Warehouse Sales area - electrical	X																						
Retail Warehouse Sales area - general	X																						
Sales area - general																X							
Server Room																			X				
Small Shop Unit Sales area - chilled	X																						
Small Shop Unit Sales area - electrical	X																						
Small Shop Unit Sales area - general	X																						
Swimming pool						X		X	X				X			X							
Teaching Areas								X					X										
Toilet	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X		X	
Waiting Rooms																				X			
Warehouse sales area - chilled	X																						
Warehouse sales area - electrical	X																						
Warehouse sales area - general	X																						
Warehouse storage				X	X																		
Workshop - small scale			X					X	X	X	X		X	X		X							

APPENDIX F: Agreed definitions

Air Permeability

Air permeability is expressed as volume flow per hour (m^3/h) of air supplied to the space per square metre (m^2) of envelope area for an internal to external pressure difference of 50 Pa, i.e., 25 m^3/hm^2 at 50Pa.

Atrium

In this context, a non-continuously occupied interior space within a building, often several storeys high, bounded on at least one side by occupied spaces set to the conditions determined from the activity database. There may or may not be building elements (such as glazing) surrounding the atrium (although there may need to be something for smoke control in case of fire). The atrium itself is not maintained to the conditions set by the activity database for adjoining spaces. The technical purpose of the atrium can be one or more of the following:

- Providing a buffer between the thermal conditions in the adjoining spaces and the exterior, to reduce the direct impact of the exterior on those zones. In this case, it should not be maintained to conditions as though it is occupied. (If it is conditioned and the features below do not apply, in this context, it is not considered to be an atrium.)
- Providing a means for daylight to reach the middle of deep plan spaces that would otherwise not receive it
- Encouraging stack effect or other passive ventilation to draw extract air from the adjoining spaces.

Automatic Blind Control

In this context, internal or inter-pane (but not exterior) blinds that are motorised so that the position can be modified to control solar heat gain and/or glare, controlled by automatic sensors. The control regime must also open the blinds as the heat gain and/or daylight levels decrease, so that the use of these natural resources can be optimised for each zone. Note that exterior shading devices can be modelled using MBEAT in the definition of each window; however MBEAT currently does not model the re-radiation effects of blinds where solar gain has entered the space before it is modulated by the shading device.

Demand-Controlled Ventilation

Is defined as supply and/or extract ventilation that is modulated to match the needs of the actual occupation level of each zone, rather than operating at a constant level defined by the activity database. Thus the energy required to adjust the condition of the supply air and that required to move the air can be reduced. The rate of ventilation would typically be controlled by presence detectors, CO_2 sensors, or another device that senses the varying requirement.

Lightwell

A lightwell is a space surrounded by the walls of a building but that has no roof or glazing above it. It is, therefore, similar to a courtyard in appearance. The walls that surround the lightwell are exposed to external air.

Night Ventilation Strategy

Can be defined as the presence of suitable systems, controls, and operating strategy such that overnight ventilation (passive and/or mechanical) is used to cool down the exposed building mass and, thereby, offset daytime cooling demands. If no such operation and subsequent offset is possible through the automatic operation of systems and controls, then night ventilation strategy is deemed to be not present as part of the building energy asset rating.

Lightpipes

A lightpipe is a tube/pipe, consisting of internal reflective surfaces, which channels daylight to an internal area.

**Ventilation with Enhanced Thermal Coupling to Structure**

This is a further development of the 'night ventilation' strategy such that significant components of the building structure, in addition to its ordinary surfaces, are exposed to night ventilation, in order to enhance the building's capability of offsetting daytime cooling demands. An example of this procedure is the ThermoDeck system where night ventilation is passed through ducts in the solid floors of the building, thereby, increasing the 'coolth' contained in the thermal capacity of the building structure available to offset subsequent summertime daytime cooling loads.

APPENDIX G: Agreed convention for determining dimensions

Horizontal dimensions

Consider
- Plan view of two buildings in a terrace
  – Separated by a party wall
  – Building 1 has two zones
- Wall types
  – "Perimeter" surrounds each building (external and party walls)
 – "Internal" refers to walls within each building (partitions)
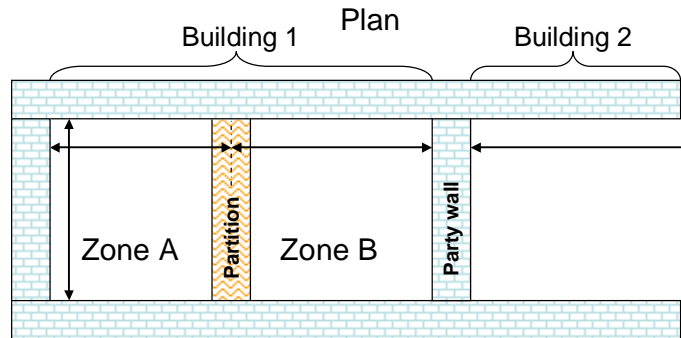
Generally follow RICS definition of Gross Internal Area

Need to measure
- Inside perimeter walls
- Mid point of internal walls
- Party walls are perimeter, so measure to surface, not mid point

Openings
- Inside structural opening (w x h)
- *Not just glass area*
- Percentage glazing is as viewed from inside
  – ie percentage of wall area to full zone height (defined below)

- 100% Glazing
  – Enter a wall of total area
  – Enter glazing with same area (or as 100%)
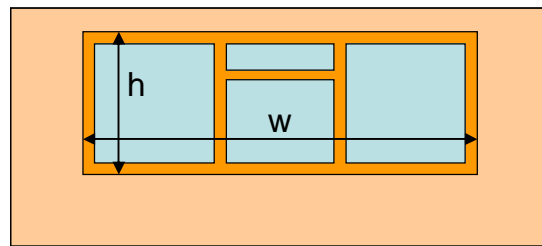
Zone height and element areas

Generally zone height is top of slab to top of slab for ground and intermediate floors, or soffit/eaves level at roof level

- For ground and intermediate floors
  – Zone height is top of floor to top of floor

- For top floors with flat roof
  – Zone height is top of floor to soffit/underside of roof slab
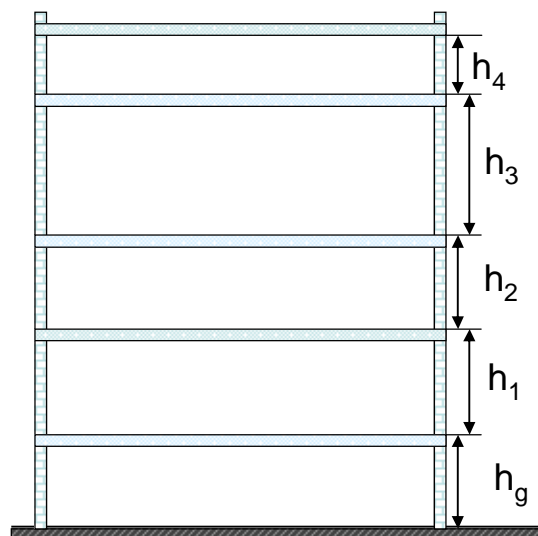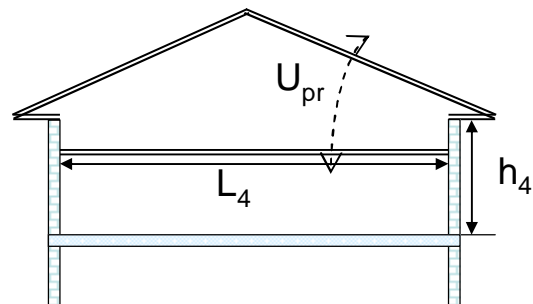
- For top floors with pitched roof but flat ceiling

    - Zone height is top of floor to underside of soffit/eaves level
    - U value is from under ceiling to outside roof including insulation wherever it is
        - that is, consistent with the area being entered
    - Area of gable wall is that below soffit/eaves level ie length L_4 x h_4
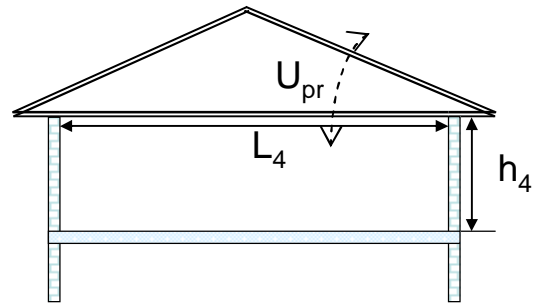
- For top floors with pitched roof and dropped ceiling with or without insulation at ceiling level

    - Zone height (h_4) is top of floor to underside of soffit/eaves level (not ceiling)
    - U value is from under ceiling to outside roof
    - Side and end wall areas are calculated to soffit/eaves level i.e. dropped ceiling is treated as though it is at soffit/eaves level
    - This convention has been adopted to avoid having to determine the relative levels of ceiling and soffit, and confusion over where the insulation is placed

- For rooms with pitched ceiling (e.g. where ceiling is fixed in line of pitched roof)

    - Zone height (h_4) is top of floor to underside of soffit/eaves level *(not average room height)*
    - Roof heat loss area is as seen from underside of ceiling, i.e. L_r x d (zone depth)
    - U value is from under ceiling to outside roof (U_r)
    - End wall area is whole gable up to roof apex (as this is all exposed to inside temperature)

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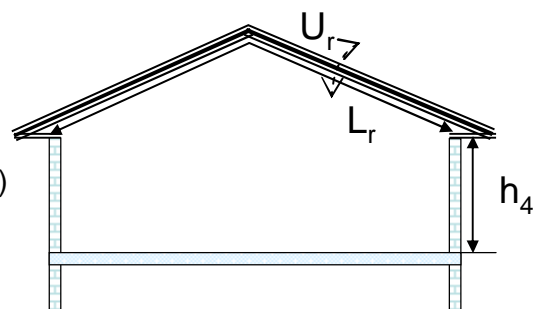
- If there is a horizontal ceiling half way up the pitched roof, split the area into

    - The part with a void (L_{r1}), using the U-value including the void (U_{r1})
    - The part where there is no void (L_{r2}, L_{r3}), using the U-value without a void (Ur2)
   - Zone height is still to underside of soffit/eaves level
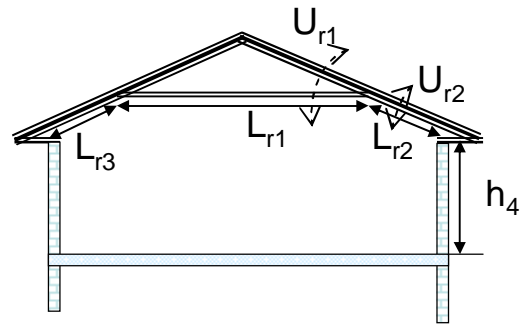
So the general rule is to **input the area exposed to the inside temperature, and the U-value between this surface and outside**, except for the dropped ceiling case.

- Intermediate floors with suspended ceilings and raised floors

    - Zone height is top of floor slab to top of next floor slab e.g. h_1
    - So, ignore the suspended ceilings and raised floors for the purposes of
        - zone height
        - surrounding wall areas
    - But include their impact on Kappa values of the slabs above and below so that thermal mass effects are calculated correctly

- With suspended timber ground floor and ventilated void below

    - Zone height is top of suspended floor surface to top of first floor surface (h_{sf})
    - Where the floor U value is calculated it should take account of the ventilated void (U_{sf})
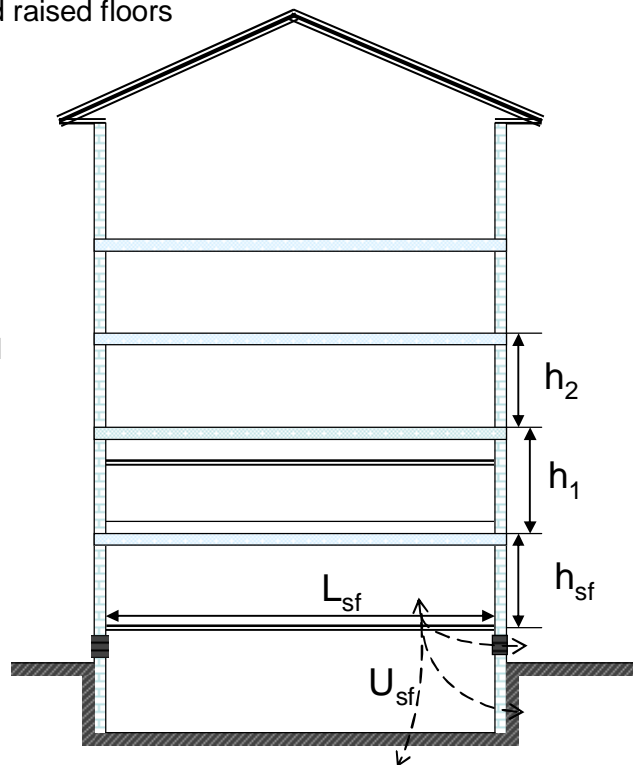
When there are walls of different heights to consider:

- For sloping floors and ceilings (eg auditoria)

  - If the activity above and under the floor is the same, or the void is inaccessible, choose normal zone height, otherwise
  - zone height = weighted average wall height h_{a1}, h_{a2}, h_{a3}, etc (from where floor adjoins each wall to top of floor above)
  - Zone area A_a is projected area/plan area as per RICS GIA standard
  - Make sure in addition that all external (and internal) wall and slab areas are input so that all heat loss/gain and thermal mass is calculated
  - ***Note that zoning for daylit areas must be carried out manually in these circumstances (do not use automatic daylight zoning)***

- For cubical rooms under the sloping floor
  - Zone height = top of slab to top of slab (h_s)
- Area weighted average wall height is defined as total wall area divided by horizontal perimeter length (eg $2L_a + 2$ x depth (d) in the diagram)
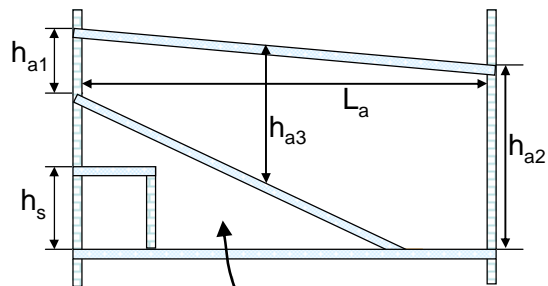
Don't forget this void is another zone if it has a different activity! Its zone height = area weighted average vertical wall height.
If it has the same activity or is inaccessible, then merge with auditorium and enter zone area as though the floor is flat (L_a x d). However, the sloping floor area must be input so that thermal mass is calculated.)

- For rooms with mono-pitched ceiling

  - Zone height is top of floor to weighted average height of all walls - h_4
  - Area of roof (A_r) is as seen from underside i.e. L_4 x zone depth
  - U value from under ceiling to outside roof is U_r
  - Use total area of gable wall
  - ***Note that zoning for daylit areas must be carried out manually in these circumstances***

Average of all four wall heights

- If there is a horizontal ceiling under the mono-pitched roof
  - Level with or below eaves: zone height at eaves
  - Above eaves: zone height = average exposed wall height
  - Roof area would have to be divided into areas with different U-values with and without void
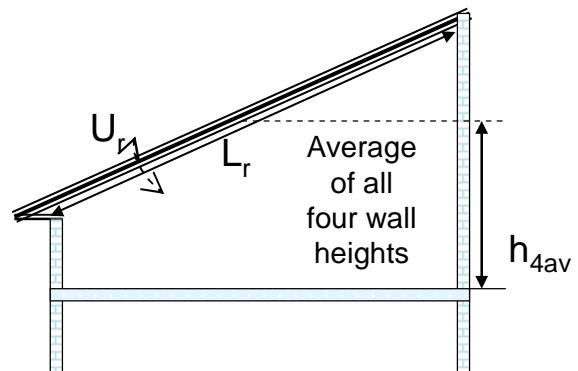
- Curved roof – for EPCs all buildings with curved roof sections shall be approximated as in the diagram:
    - Circular (not elliptical or other shapes)
    - Semi-circular so that width = 2 x height

- Walls are 70-90° from horizontal, roofs are <70°
- So zone height h_{cw} = dividing point between wall and roof, where slope = 70° at "eaves"

- If a floor (eg as shown dotted) meets roof at <70°, there is no wall, so zone height h_{cr} = average height of space

- If the dotted line represents the ceiling with an unoccupied void above, remember to input
    - the area of roof where the slope < 70° between this ceiling and the "eaves", with its U value (U_{rc}), and
    - the flat ceiling with U value (U_{clg}) including the void above the ceiling

- Treat dormer windows the same as for a room in a pitched roof (see below)
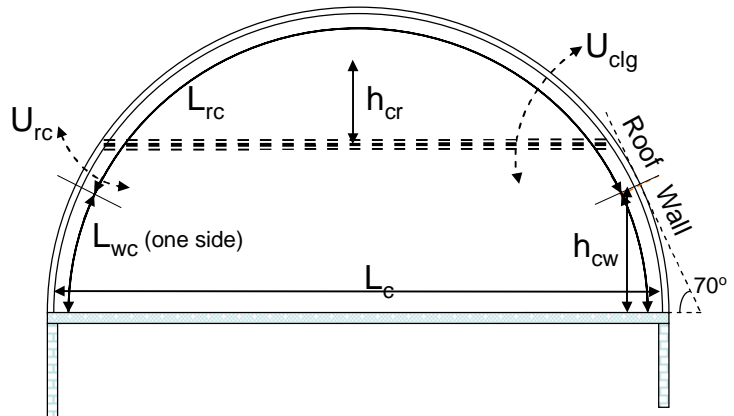
For consistency, the convention is to assume all such roofs are semi-circular. If floor width = L_c and building depth is d
- Zone height h_{cw} = 0.171 x L_c
- Wall height L_{wc} = 0.175 x L_c
- Area curved walls = L_{wc} x d x 2 (both sides)
- Curved roof width L_{rc} = 1.222 x L_c
- Area curved roof = L_{rc} x d

- For room in roof (or mansard roof):
    - Areas and U values should correspond
    - U values for walls should include any voids – U_{w1}, U_{w2}
    - Zone height (h_{w1}) = height of vertical part of wall
    - If this varies, calculate area weighted average height

- Where there are dormer windows (ie window bays that project through the roof)
    - Do not adjust zone height for the dormer windows
    - Zone manually for daylit areas (if the glazing > 20% of vertical wall area)
    - Enter the glazing details and areas as normal
    - ***Note that zoning for daylit areas must be carried out manually in these circumstances***

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