Asset Performance: Energy

25%

Summary

This category recognises building fabric and installed building services systems that lead to lower operational energy consumption and reduce carbon emissions over the lifetime of the asset. Issues in this section assess the inherent energy efficiency of the building fabric, the energy efficiency of installed services systems and installed renewable energy generation capacity. This category also encourages the installation of energy monitoring and energy management capabilities to support efficient energy management and the avoidance of waste throughout the life of the asset.

Context

Climate change is the biggest environmental challenge that the world is currently facing. It is already resulting in higher global temperatures, greater risk flooding and more extreme weather events. It is mainly due to rising levels of carbon dioxide and other greenhouse gases, such as methane, in the atmosphere create a 'greenhouse effect', that is causing the Earth to warm. Greenhouse gas emissions have increased by about 45% since before the industrial revolution and this is almost entirely due to human activity.

The observed increase in greenhouse gas emissions is mainly caused by the burning of fossil fuels for energy, agriculture, deforestation and industrial processes. Worldwide, buildings and construction together account of 39% of energy related carbon emissions, the majority of which is due to energy consumption in use. The impact on people and communities from climate change and energy generation must be recognised. Poorer communities are disproportionately impacted by the negative effects of climate change and energy generation from fossil fuels, contributing to poor health, higher mortality rates and higher risks of severe damage from extreme weather events.

The Paris Agreement, ratified in 2016, reflects a desire to accelerate the global response to the threat of climate change by limiting global temperature rise this century to at least 2^{o}C, and preferably 1.5^{o}C, above pre-industrial levels. Subsequently, in October 2018 the urgency of the need to tackle climate change was highlighted by an IPCC Special Report which indicates that it will be necessary to limit this increase to 1.5^{o}C to avoid the most severe impacts of climate change. The report concludes that to limit the increase to 1.5^{o}C CO_2 emissions must reduce by around 45% from 2010 levels by 2030, and to reach net zero emissions by 2050. The United Nations included clean energy as one of their SDGs (Goal 7) and target 'doubling the rate of improvement in energy efficiency' and 'increasing substantially the share of renewable energy in the global energy mix' by 2030. This scale of reduction will require rapid and far-reaching transitions for all energy systems, including buildings.

It is therefore vital to substantially reduce the total operational energy use in buildings and to increase use of renewable energy sources where possible, if the worse effects of climate change are to be avoided. Addressing climate change and shifting the way in which we produce and use energy can help address inequities such as fuel poverty that are currently present in our communities and provide a healthy environment for all demographic and economic groups, especially those that are part of less advantaged or underserved communities.

Asset energy calculator guidance

Introduction

This section provides further information on the workings of the asset energy calculator. It describes the scope of the asset calculator and how answers to the questions that feed into the asset calculator influence the asset energy performance score.

The asset calculator measures the energy performance that the building is capable of, given its envelope and installed services.

The building services that are considered in the asset calculator are heating, cooling, heating distribution, cooling distribution, lighting, ventilation and hot water. Energy use by other installed building services, e.g. lifts, external lighting and building management systems, is not included in the asset calculator.

The asset energy performance score does not currently take account of the orientation of the building or the local environment around the building, e.g. overshadowing, but does take account of the building geometry.

The asset energy performance score reflects how the asset would be expected to perform compared to another asset with a similar function, e.g.an office, if it were typically operated and had a typical occupancy pattern. For these reasons, the assessed energy performance of the asset is likely to be very different from that calculated for the asset energy performance. If a building service is not present in the assessed asset, the energy consumption for the relevant end use will be zero, but the energy use for the relevant end use will not be removed from the standard version of the asset. This means that the energy performance benefits of naturally ventilated buildings will be recognised.

The asset calculator is valuable for indicating areas where improvements to specific system and fabric components are likely to lead to a significant increase in the assessed energy performance. More detailed consideration of the expected energy benefits associated with specific measures should be undertaken before making improvements to the asset.

Modelling approach

The energy consumption and hence the annual $kgCO_2eq$ emissions per m^2 for the asset are calculated using a simplified energy modelling approach.

Instead of carrying out a detailed “bottom up” energy modelling calculation, the BREEAM In-Use asset energy performance score is calculated relative to that expected for a standard asset to determine the end use energy consumption.

This approach avoids the need to explicitly determine the energy service requirements (e.g. internal temperatures and lighting levels), occupancy patterns and climate as these are already included in the BREEAM In-Use benchmarks.

Because the methodology calculates the energy consumption relative to the BREEAM In-Use benchmarks which are based on measured energy consumption data, the asset energy performance scores implicitly take into account typical energy management and building operational practices and will therefore more closely relate to the assessed energy consumption than would be the case for bottom up modelling. The asset energy calculator uses a simplified energy modelling approach. This takes account of the expected energy demands and efficiencies associated with each end use and uses a heat balance approach to take account of factors that affect the demand for heating and cooling. For example, more energy efficient lighting will reduce the internal heat gains within the asset leading to a decreased demand for cooling energy in the summer but increased heating energy use in the winter.

The component and sub component elements that contribute to determining the energy consumption for each of the end uses considered in the asset energy calculator are shown in Table 17.

Table 17: The components and subcomponents used to determine end use energy consumption

End use	Component	Subcomponent
Heating	Fabric	Heat transfer through fabric
		Air leakage through fabric
	Internal heat gains	Solar gains through glazing
		Equipment gains
		People
	Heat generator (Distribution losses)	
Cooling	Internal gains	Solar gains through glazing
		Equipment gains
		People
	Free cooling (when the external temperature is lower than the required internal temperature)	
	Cooling generator (and distribution losses)	
Heating distribution/ Cooling distribution/ Ventilation	Pumps efficiencies	
	Fans efficiencies	
	Ducts leakage rate	
	Leakage from Air Handling Units (AHUs)	
Hot Water	Heat generator efficiency (and distribution losses)	
Lighting	Efficiency Installed Lamps	
	Installed lighting control systems	

Details of how the energy consumption for each end use is calculated for the asset energy performance scores are provided later in this section.

The methodology works by comparing the calculated performance of the assessed asset to that of a standard version of the same asset type. The standard version of the asset represents a typical building specification for an asset constructed in the 1980s and corresponds to the BREEAM In-Use energy benchmark values broken down by end use.

A simplified energy modelling approach is used to calculate how much better (or worse) the assessed asset is expected to perform compared to the standard asset (BREEAM In-Use benchmark). This is achieved by applying improvement factors to each end use which reflect the calculated difference in the energy performance between the assessed and standard asset for each end use. For example, for space heating the efficiency of the heat generator and the rate of heat loss through the building fabric are two factors that contribute to energy consumption.

The end use improvement factors are then applied to benchmark energy consumption to generate the expected energy consumption for the assessed asset as shown in Figure 4.

Figure 4: The relationship between the standard asset (BIU benchmark) and the assessed asset

Standard building specification

The standard version of the asset has the same main asset sub type, the same floor area and is in the same location as the asset that is being assessed, but with fixed geometry and fabric, and building services specification that is representative of a typical building.

An example of the standard specification is shown in Table 18 below.

Table 18: Standard asset specification

Type	Parameter	Value
Basic	Percentage of floor area mechanically ventilated	0.5
Fabric	Average U-value of the external walls	0.625
	Average U-value of the roof	0.5
	Average U-value of the glazing	2.32
	Ratio external wall area: floor area	0.385
	Ratio roof area: floor area	0.321
	Ratio glazing area: floor area	0.257
	Ratio internal volume: floor area	0.321
	g value of the glazing	0.5
	External solar shading to reduce excess solar gains during the cooling season	No
	Air pressure test result ($m^3/h.m^2$@50Pa)	20
Space heating	Generation type for space heating	Boiler
	Heat generation efficiency	0.7
	Heat generation fuel	Natural Gas
	Heat supply = district/centralised/local	Centralised
	Heat distributed around the building via air	Yes
Cooling	Main generation type for cooling	Chiller
	Energy efficiency ratio (EER) of the cooling generator	2.5
	Cooling supply = district/centralised/local	Centralised
	Cooling distributed around the building via air	Yes
	Fans fitted with VSDs	No
	Pumps fitted with VSDs	No
Ventilation	Specific fan power for air handling systems?	3
	Ductwork tested for leakage and appropriate remedial action taken	No

Type	Parameter	Value
Hot water	Type of water heating	Local
	Energy source used to heat water	Electricity
	Hot water generation efficiency or COP	1
Lighting	Proportion of fluorescent lamps with high frequency ballasts	0%
	Percentage of Compact Fluorescent lamps	0%
	Percentage of Tungsten Halogen lamps	0%
	Percentage Incandescent lamps	0%
	Percentage of T12 lamps	0%
	Percentage of T8 lamps	100%
	Percentage of T5 lamps	0%
	Percentage of LED lighting (with special design lighting control system)	0%
	Percentage of LED lighting (with typical lighting control system)	0%
	Percentage of metal halide lamps	0%
	Percentage of the building floor area (not accessible to clients/customers) with access to daylight which has fully functioning daylight sensors for lighting	0%
	Percentage of the building floor area (not accessible to client/customers) which has fully functioning occupancy sensors for lighting	0%

Data requirements

The questions in the asset energy category issues Ene 01 to Ene 09 are designed to collect the information needed to carry out the asset energy calculation. As of these values can be difficult to determine for many existing buildings, the calculator uses default values where values are not entered by the user. The default values are based on year of installation where this has been provided, otherwise, year of construction. The default values are country specific and relate to the minimum standards that were prevalent at the time.

The minimum level of user data inputs required to generate an asset energy performance score is the building type, the age of the building and the installed building services. However, entering more information into the calculator will result in a more accurate assessment of the asset energy performance which will almost always be better than that generated using default values. The parameter input values for each subcomponent and the source of the information is shown in Table 19 below.

Table 19: Subcomponents, parameters and sources for modelling asset energy performance

Subcomponent	Parameter	Source	Applicability
Heat transfer through fabric	Average U value of external building envelope	user entry or asset age default value	All assets
Air leakage through fabric	Air permeability of external building envelope	user entry or asset age default value	All assets
	% heat recovery	user entry or asset age default value	Assets with mechanical ventilation or a heating system with air distribution
Solar gains	g value and window area	user entry or window age default value	All assets
Equipment gains	Annual energy consumption lighting and equipment	Embedded within model	
People gains	Standard occupancy for building type	Embedded within model	
Efficiency of heat generator	Efficiency or COP	user entry or system age default value	Assets with heating systems
Efficiency of cooling generator	Efficiency or SEER	user entry or system age default value	Assets with cooling systems
VSD pumps	Are they present?	user entry or system age default value	Assets with heating or cooling systems with liquid distribution
VSD fans	Are they present?	user entry or system age default value	Assets with mechanical ventilation or heating, cooling systems with air distribution
Duct leakage rate	Have they been tested?	user entry or system age default value	Assets with mechanical ventilation or a heating system

Subcomponent	Parameter	Source	Applicability
			with air distribution
AHU leakage rate	Have they been tested?	user entry or system age default value	Assets with mechanical ventilation or a heating system with air distribution
Efficiency of hot water generation	Efficiency or COP	user entry or system age default value	Assets with hot water systems
Efficiency of hot water distribution	Hot water type	user entry or system age default value	Assets with hot water systems
Efficiency Installed Lamps	% lamp types	user entry or default value	All assets
Installed control systems	% floor area with controls	user entry or default value	All assets

Asset energy performance score

The asset energy performance score, and hence the number of credits awarded, is calculated by comparing the calculated kgCO_2eq emissions per m^2 for the assessed asset compared to that of the BREEAM In-Use benchmark value.

The performance scale is designed so that the median value for BREEAM In-Use assets will achieve 50% of the credits.

As well as generating an asset energy performance score, a report is generated which shows the calculated value for carbon emissions broken down by end use, along with indicators which identify the energy performance improvement potential associated with each end use and end use component compared to that of a best practice version of the asset .See Best practice asset specification Table 20.

Table 20: Best practice asset specification

Type	Parameter	Value
Basic	Percentage of floor area mechanically ventilated	75%
Fabric	Average U-value of the external walls	0.2
	Average U-value of the roof	0.2
	Average U-value of the glazing	0.7
	Ratio external wall area: floor area	0.385

Type	Parameter	Value
	Ratio roof area: floor area	0.321
	Ratio glazing area: floor area	0.257
	Ratio internal volume: floor area	0.321
	g value of the glazing	0.5
	External solar shading to reduce excess solar gains during the cooling season	No
	Air pressure test result ($m^3/h.m^2$@50Pa)	20
Space heating	Generation type for space heating	Boiler
	Heat generation efficiency	0.7
	Heat generation fuel	Natural Gas
	Heat supply = district/centralised/local	Centralised
	Heat distributed around the building via air	Yes
Cooling	Main generation type for cooling	Chiller
	Energy efficiency ratio (EER) of the cooling generator	2.5
	Cooling supply = district/centralised/local	Centralised
	Cooling distributed around the building via air	Yes
	Fans fitted with VSDs	No
	Pumps fitted with VSDs	No
Ventilation	Specific fan power for air handling systems	3
	Ductwork tested for leakage and appropriate remedial action taken	No
Hot water	Type of water heating	Point of use
	Energy source used to heat water	Electricity
	Hot water generation efficiency or COP	1
Lighting	Proportion of fluorescent lamps with high frequency ballasts	0%
	Percentage of Compact Fluorescent lamps	0%
	Percentage of Tungsten Halogen lamps	0%

Type	Parameter	Value
	Percentage Incandescent lamps	0%
	Percentage of T12 lamps	0%
	Percentage of T8 lamps	100%
	Percentage of T5 lamps	0%
	Percentage of LED lighting (with special design lighting control system)	0%
	Percentage of LED lighting (with typical lighting control system)	0%
	Percentage of metal halide lamps	0%
	Percentage of the building floor area (not accessible to clients/customers) with access to daylight which has fully functioning daylight sensors for lighting	0%
	Percentage of the building floor area (not accessible to client/customers) which has fully functioning occupancy sensors for lighting	0%

Calculating improvement end use energy consumption

This section describes how the end use improvement factors are calculated for each end use.

Space heating

The simplified energy modelling approach for space heating is shown below in Figure 5.

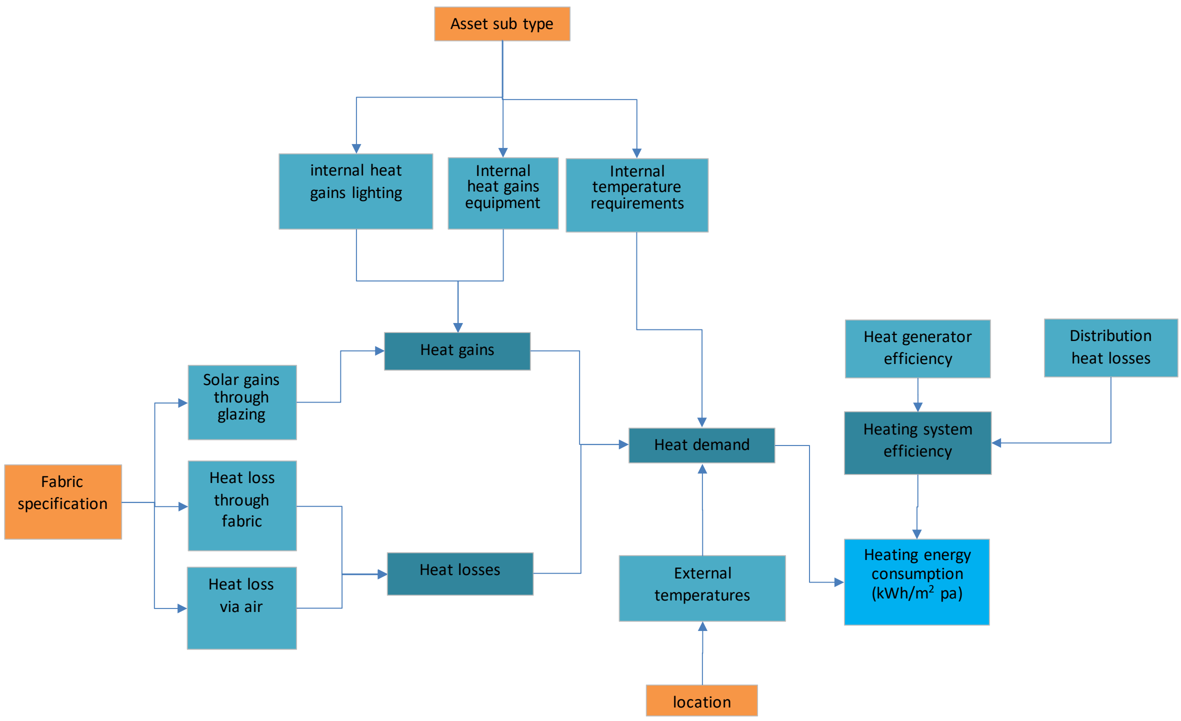

Figure 5: Schematic of the simplified energy modelling approach for space heating

Heat demand

The demand for space heating is determined by the difference between the internal and external temperature over the heating season. As this will be the same for both the standard and the assessed asset this is not explicitly calculated within the asset calculator.

Heat generator efficiency

The efficiency of the heat generator affects the amount of energy needed to meet the heat demand, where a heat generator with a higher efficiency will result in a lower energy consumption. The heat generator efficiency improvement factor is therefore determined by:

$$\textit{Heat generator improvement factor} = (1/\textit{efficiency}_{asset})/(1/\textit{efficiency}_{std})$$

Heating system efficiency

The efficiency of the space heating system includes the heat generator efficiency and any distribution losses. The asset calculator assumes that there will be no heat losses associated with local generation systems, and applies a 10% heat loss for centralised systems and a 20% heat loss for district heating systems.

$$\textit{Heating system efficiency improvement factor} = \textit{Heat generation improvement factor} \times (1+\textit{losses}_{asset})/(1+\textit{losses}_{std})$$

Heat loss through fabric

Heat loss through fabric is determined as the surface area weighted average U-value for the external fabric and is calculated as follows:

$$\textit{Surface area weighted U-value} = \textit{U-value}_{wall} \times \textit{Area}_{wall}/\textit{Area}_{total} + \textit{U-value}_{roof} \times \textit{Area}_{roof}/\textit{Area}_{total} + \textit{U-value}_{glazing} \times \textit{Area}_{glazing}/\textit{Area}_{total}$$

The improvement factor for heat loss through the fabric is determined by the ratio of the surface area weighted average of the U-values across all fabric elements (external walls, roofs and windows) for the assessed and the standard asset.

$$\text{Fabric heat loss improvement factor} = \text{Surface area weighted U-value}_{asset} / \text{Surface area weighted Uvalue}_{std}$$

Heat losses via air

This comprises air infiltration through the building envelope and the ventilation requirements of the building occupants.

Air infiltration through the building envelope is determined by the air permeability of the building fabric, and the ratio of surface area to volume for the building envelope as air changes per hour.

Infiltration heat loss = air changes per hour x internal volume x (1-%heat recovery)

Air changes per hour = (air permeability of the external envelope x surface area/volume)/20

Ventilation requirements for an asset are the number of air changes per hour required by the expected occupant density which is determined by the asset sub type. Therefore, this will be the same for both the asset and the standard version of the asset. However, where there is mechanical ventilation the % heat recovery from exhaust air needs to be taken into account as follows:

Air heat loss = infiltration changes per hour + ventilation air changes per hour x (1-% heat recovery)

$$\text{Air heat loss improvement factor} = \text{heat loss via air}_{asset} / \text{heat loss via air}_{std}$$

Internal heat gains

Internal heat gains arise from equipment, lighting, building occupants and from solar gains through glazing. As the asset energy calculator only considers the efficiency of the fabric and installed building services, the heat gains from equipment in the assessed asset are assumed to be the same as for the standard building. The asset calculation therefore only explicitly considers the differences in lighting energy efficiency and solar gains. However, the overall internal gains improvement factors take into account the relative contribution each type of internal gains makes to the total for the standard version of the asset.

The lighting efficiency for both the asset and the standard version of the asset are calculated based on the average efficiency of lamp types installed with additional % energy saving applied where lighting controls are fitted. Solar gains through glazing will depend on the glazed area, the orientation of the windows, the amount of sunlight incident on the windows and the g value of the glazing (which relates to the proportion of heat transferred). The asset energy performance calculator currently only takes account of the ratio of glazed area and the g value of the glazing.

Total heat gains = equipment gains + people gains + lighting gains + solar gains

Where

- Equipment gains = equipment energy use
- People gains = occupants per m^2 x 10 kW per person x annual occupancy hours
- Lighting gains = lighting energy use
- Solar gains ∝ window area x g value glazing x shading factor

The assumed equipment and people gains are determined by the benchmark energy consumption values and typical occupation densities for the relevant asset subtype. Therefore, they will be the same for the asset and the standard version of the asset, so only the improvements in lighting efficiency and solar gains need to be explicitly considered. These values are determined as follows:

$$\text{Lighting improvement factor} = (1/\text{lighting efficiency}_{asset})/(1/\text{lighting efficiency}_{std})$$

Solar gains improvement factor = solar gainsasset/solar gainsstd

Total heat gains improvement factors = % solar gains x solar gains improvement factor + % lighting gains x lighting efficiency improvement + % equipment gains + % people gains

Heating distribution losses

A distribution improvement factor is applied which reflect the typical or (actual where provided for district heating) losses associated local, centralised and district heating systems

Distribution improvement factor = distribution loss for standard building system type/distribution loss for actual building system type x distribution loss improvement factor

Overall heating improvement

The overall heating improvement factor is then calculated by multiplying the component heating improvement factors identified above.

Overall heating improvement factor = heat generation improvement factor x (fabric heat loss improvement factor + air heat loss improvement factor) x total heat gains improvement factor x distribution loss improvement factor

Energy and carbon emissions from space heating

Energy consumption for space heating is then calculated based on the heating improvement factor as follows:

Asset heating energy use (kWh/m^2 per year) = Heating improvement factor x benchmark heating energy use (kWh/m^2 per year)

Asset heating carbon emissions (kgCO$_2$eq/m^2) = Asset heating energy use x fuel CO$_2$ emission factor = Asset heating carbon emissions (kgCO$_2$eq/m^2)

Cooling

The simplified energy modelling approach for cooling is shown below in Figure 6.

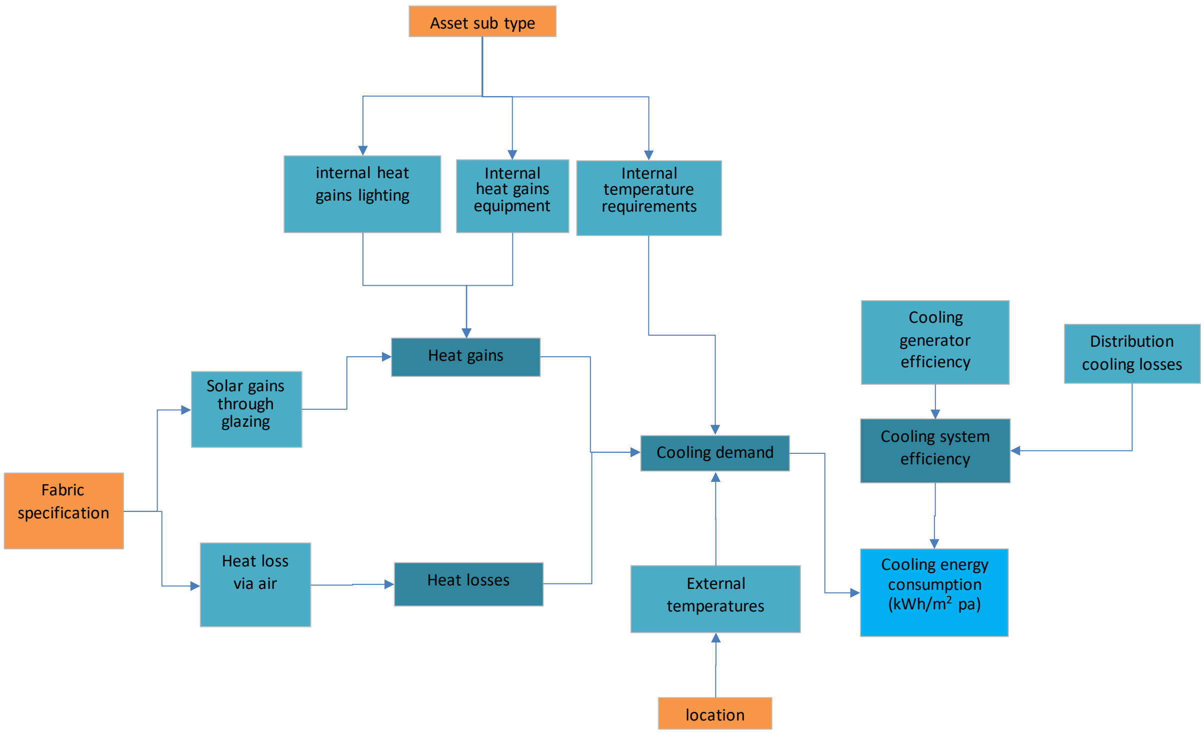

Figure 6: Schematic of the simplified energy modelling approach for space cooling

Cooling demand

The demand for cooling is determined by the difference between the internal and external temperature over the cooling season and the annual number of cooling hours. As this will be the same for both the standard and the assessed asset this is not explicitly calculated.

Cooling generator efficiency

The efficiency of the cooling generator affects the amount energy needed to meet the cooling demand, where a cooling generator with a higher efficiency will result in a lower energy consumption. The cooling generator efficiency improvement factor is therefore determined by:

$$\text{Cooling generator improvement factor} = 1/\text{efficiency}_{asset} / 1/\text{efficiency}_{std}$$

Internal heat gains

Internal heat gains are calculated as described for space heating, except for solar gains where the improvement factor also includes a shading factor:

$$\text{Solar gains} \propto \text{window area x g value glazing x shading factor}$$

Overall reduction in heat gains improvement factor = % solar gains x solar gains improvement factor + % lighting gains x lighting efficiency improvement + % equipment gains + % people gains

Cooling distribution losses

Calculated as for heating distribution losses

Overall cooling improvement

The overall cooling improvement factor is then calculated by multiplying the component cooling improvement factors identified above.

Overall cooling improvement factor = cooling generation improvement factor x overall reduction in heat loss improvement factor x cooling distribution loss improvement factor

Energy and carbon emissions from cooling

Energy consumption for cooling is then calculated based on the cooling improvement factor as follows:

Asset cooling energy use (kWh/m^2 per year) = Overall cooling improvement factor x benchmark cooling energy use (kWh/m^2 per year)

Asset cooling carbon emissions (kgCO_2eq/m^2 per year) = Asset cooling energy use x fuel CO_2 emission factor

Mechanical ventilation

The demand for ventilation in the building is implicitly included in the BREEAM In-Use energy benchmark so the improvement for mechanical ventilation is determined by the relative system efficiencies and the percentage of asset floor area that is treated compared to the standard building.

Mechanical ventilation system efficiency

The mechanical ventilation system efficiency is determined by the fan efficiency and the ductwork losses and the improvement factor is determined as follows:

Mechanical ventilation system improvement factor = Fan efficiency improvement factor x ductwork improvement factor

Where:

Fan efficiency improvement factor = *((% fans with VSDs x 0.75)+(1-% fans without VSDs)) x SFP actual/ SFP standard building*

Ductwork improvement factor = (1- asset ductwork factor)/ (1-standard building ductwork factor)

Adjustment for floor area

Mechanically ventilated floor area adjustment = % asset with mechanical ventilation/% standard building with mechanical ventilation

Overall mechanical ventilation efficiency

Overall mechanical ventilation improvement factor = mechanical ventilation system improvement factor x floor area adjustment factor

Energy and carbon emissions from mechanical ventilation

Asset mechanical ventilation energy use (kWh/m^2 per year) = Overall mechanical improvement factor x benchmark cooling energy use (kWh/m^2 per year)

*Asset mechanical ventilation carbon emissions (kgCO_2eq/m^2 per year) = Asset mechanical ventilation energy use * fuel CO_2 emission factor*

Distribution of heating and cooling by air

The improvement factor for air distribution of heating and cooling systems is calculated using the same formulae as the mechanical ventilation system improvement factor.

For heating and cooling systems with liquid distribution systems the improvement factor is determined based on the proportion of pumps with VSDs as follows:

Pump efficiency improvement factor = ((% pump with VSDs x 0.75) + (1-% pumps without VSDs))

Energy and carbon emissions from heating and cooling distribution

Asset distribution of heating and cooling energy use (kWh/m^2 per year) = fan or pump efficiency improvement factors x benchmark distribution of heating and cooling energy use (kWh/m^2 per year)

*Asset distribution of heating and cooling carbon emissions (kgCO_2eq/m^2 per year) = Asset mechanical ventilation energy use * fuel CO_2 emission factor*

Lighting

The lighting end use is determined by the average lighting level in the building, which is implicitly included in the BREEAM In-Use benchmark. The improvement factor for lighting is therefore determined by the average efficacy of the installed lamps in the assessed asset and the standard asset and the expected reduction in energy use from installed lighting controls.

Lighting efficacy

The lighting efficacy improvement factor is calculated based on a floor area weighted average value for the efficacy of the installed lamp types, which takes into account whether the lamps are fitted with diffusers or shades and, for LED and fluorescent lamps, whether they are fitted with constant illuminance controls.

$$\text{Floor area weighted lamp efficacy} = \text{Efficacy}_{lamp1} \times \text{Floor area}_{lamp1}/\text{Floor area}_{total} + \text{Efficacy}_{lamp2} \times \text{Floor area}_{lamp2}/\text{Floor area}_{total} + \ldots\ldots \text{Efficacy}_{lampn} \times \text{Floor area}_{lampn}/\text{Floor area}_{total}$$

Lighting system efficiency

The efficiency of the lighting system includes the lighting efficacy and the expected reduction in energy use from installed lighting controls. The asset calculator considers four types of lighting controls; dimmable photoelectric controls, photoelectric switching controls, auto off presence detection and auto on presence detection and a typical % saving is associated with each type of control. The average lighting control saving is calculated as a floor area weighted average value.

$$Floor\ area\ weighted\ lighting\ control\ savings = Saving_{control1} \times Floor\ area_{contorl1}/Floor\ area_{total} + Saving_{control2} \times Floor\ area_{contorl2}/Floor\ area_{total} + \ldots\ldots Saving_{controln} \times Floor\ area_{contorln}/Floor\ area_{total}$$

$$Lighting\ efficiency\ improvement\ factor = 1-((Floor\ area\ weighted\ lamp\ efficacy_{asset} \times (1+ Floor\ area\ weighted\ lighting\ control\ savings_{asset})/((Floor\ area\ weighted\ lamp\ efficacy_{std} \times (1+ Floor\ area\ weighted\ lighting\ control\ savings_{std})$$

Hot water

The demand for hot water is implicitly included in the BREEAM In-Use energy benchmark so the improvement factor for hot water only needs to consider the hot water generator efficiency and distribution losses.

Hot water generator efficiency

The efficiency of the hot water generator affects the amount of energy needed to meet the hot water demand, where a hot water generator with a higher efficiency will result in a lower energy consumption. The hot water generator efficiency improvement factor is therefore determined by:

$$Hot\ water\ generator\ improvement\ factor = (1/efficiency_{asset})/(1/efficiency_{std})$$

Hot water system efficiency

The efficiency of the hot water system includes the hot water generator efficiency and any distribution losses. The asset calculator assumes that there will be no heat losses associated with local generation systems, and applies a 10% heat loss for centralised systems and a 20% heat loss for district heating systems.

$$Hot\ water\ system\ efficiency\ improvement\ factor = Hot\ water\ generation\ improvement\ factor \times (1+losses_{asset})/(1+losses_{std})$$

Energy and carbon emissions from hot water

Energy consumption for hot water is then calculated based on the hot water improvement factor as follows:

Asset hot water energy use (kWh/m^2 per year) = overall hot water improvement factor x benchmark hot water energy use (kWh/m^2 per year)

*Asset hot water carbon emissions (kgCO_2eq/m^2 per year) = Asset hot water energy use * fuel CO_2 emission factor*

Carbon emissions from on-site renewable electricity generation.

The energy performance calculation takes account of the carbon benefits associated with renewable electricity generated on-site by assigning a zero-emission factor on-site renewable electricity generation.

Overall asset energy performance and credits

The overall asset energy performance score is then calculated by summing the calculated carbon savings for all end uses and comparing this to benchmark carbon emissions.

Improvement potential

In addition to calculating the energy performance, the asset calculator also generates outputs which indicate areas where scope for improving energy performance may exist. An example of the output generated is provided below in Figure 7.

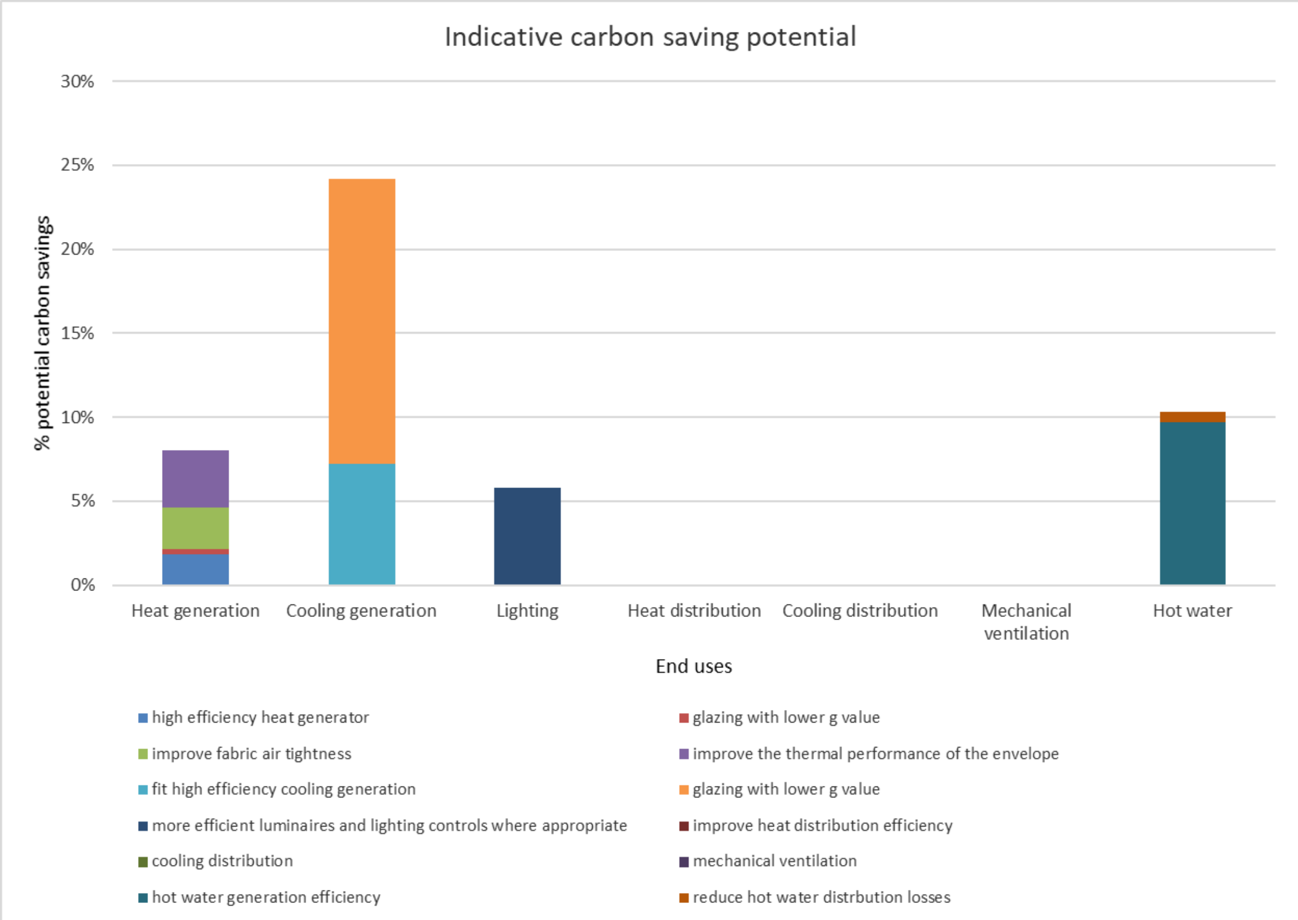

Figure 7: Example of output - Indicative carbon saving potential

Because of the simplified modelling approach adopted, the actual savings potential is likely to vary and may not be technically or economically feasible. Where the asset rating is based on default rather than actual values the carbon saving potential will be even less accurate. Therefore, this information should be used to identify areas that warrant more detailed investigation and not be used directly to inform investment decisions.

The calculation methodology for the carbon savings potential is the same as that described for the energy performance calculation but, rather than calculating how the assessed asset compares to a standard version of the asset, the assessed asset is compared to the best practice version of the asset.