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TATA STEEL

TATA

Colorcoat® Technical Paper

The role of the building envelope in Part L 2010 compliance

About Tata Steel

Tata Steel, formerly known as Corus, is one of Europe's largest steel producers. We serve many different and demanding markets worldwide, including aerospace, automotive, construction, energy and power, and packaging.
Our primary steelmaking operations in the UK and the Netherlands are supported by a global sales and distribution network.

Innovation and continuous improvement are at the heart of our performance culture. We aim to create value by offering a sustainable and value-added steel product range supported by unrivalled customer service.

By working in partnership with you, we find the best solutions to meet your needs and help your business to perform.

Our European operations are a subsidiary of Tata Steel Group, one of the world's top ten steel producers. With a combined presence in nearly 50 countries, the Tata Steel Group including the Europe operations, Tata Steel Thailand and NatSteel Asia, has approximately 80,000 employees across five continents and a crude steel production capacity of over 28 million tonnes.

Working together to deliver Part L 2010 compliance

The 2010 revision of Approved Document L requires an aggregate 25% reduction in the CO_2 emissions from buildings other than dwellings.

We have worked closely with cladding system manufacturers CA Group, Euroclad, Eurobond and Panels and Profiles, with technical input from Oxford Brookes University School of Architecture, to assess the impact of enhancing different aspects of the building envelope and provide guidance on which aspects of the building envelope and services will provide the greatest reduction in overall CO_2 emissions.

OXFORD BROOKES UNIVERSITY

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Overview

The UK government has a stated trajectory towards zero carbon buildings by 2019. In England and Wales, the conservation of fuel and power is covered by Approved Document L of the Building Regulations.

Approved Document L is subdivided into four sections, covering dwellings' and buildings other than dwellings' for new build and existing buildings. This technical paper focuses on Approved Document L2A for new buildings other than dwellings.

The 2010 revision of this document has been issued and further revisions with associated reductions in CO_2 emissions are expected in 2013, 2016 and 2019.

The thermal performance of the building envelope has a key role in retaining heat within the building, allowing sufficient natural light and useful solar gains into the building, while ensuring that the building does not overheat.

This Colorcoat® Technical Paper, quantifies the effect of changing different aspects of the building envelope on the building heat losses and the CO_2 emissions on a range of different size industrial buildings. The CO_2 emission reductions generated by improving the building lighting efficiency and control systems are compared with the reductions that can be achieved through building envelope enhancements.

These have been assessed by the Colorcoat® Centre for the Building Envelope, based at Oxford Brookes University, using the current version of SBEM (simplified building energy model) and other dynamic simulation modelling tools.

Low and zero carbon renewable energy systems can also be integrated with pre-finished steel cladding, and can contribute towards a CO_2 reduction strategy.

Main changes to Part L for 2010

History of changes to Part L

1985	U-value for wall, roof and floor 0.7. Rooflights 5.7.
1990	U-values for wall, roof and floor tightened to 0.45.
1995	Rooflight U-value tightened to 3.3.
2002	Air-tightness testing requirement first introduced. All buildings over 1000 m^2 to achieve minimum of 10 $m^3/m^2/h$.
2006	Introduction of whole building CO_2 emissions with a target based on approximately 25% improvement over a 2002 notional building. Development of National Calculation Methodology and SBEM for calculation of CO_2 emissions. All buildings over 500m^2 to achieve minimum of 10$m^3/m^2/h$.
2010	Overall 25% reduction in whole building CO_2 emissions over 2006.
2013	
2016	Zero carbon for Dwellings and some public buildings.
2019	Zero carbon for Buildings other than dwellings.

Main changes to ADL2A with effect from October 2010

1. An overall 25% reduction in CO_2 emissions across the projected UK new building stock.
2. The target emission rate for the building will be generated by a 2010 notional building specification.
3. CO_2 emissions compliance will be calculated using an updated version of SBEM or other approved modelling package.
4. A CO_2 emission rate for the building must be submitted to local building control at the design stage.
5. CO_2 compliance is achieved when the BER (building emissions rate) < TER (target emissions rate).
6. Increased focus on the performance of building details, with penalties for using generic and non-accredited details.

Specification for the 2010 notional building (envelope parameters)

The specification for the 2010 notional building envelope parameters and building service details are embedded within the SBEM calculation and compliance methodology. The building envelope specifications for the 2010 notional building and the backstop or worst allowable performance for the individual elements are summarised below.

Table 1. Specification for the 2010 notional building

	2010 notional building		Backstop value
	Rooflit	Side lit / No natural lighting	
Walls (U-value)	0.26	0.26	0.35
Roof (U-value)	0.18	0.18	0.25
Rooflights (U-value)	1.8	NA	2.2
Rooflight area	12%	NA	
Windows (U-value)	NA	1.8	2.2
Window area	NA	40% or <1.5m high	
Air permeability	5	5	10

Background to CO_2 emissions calculations

Energy Performance of Buildings Directive

The EU Energy Performance of Buildings Directive (EPBD) was introduced in the UK from January 2006 with a three year implementation period ending January 2009. Its objective was to improve energy efficiency and reduce CO_2 emissions as part of the government's strategy to achieve a sustainable environment and meet climate change targets agreed under the Kyoto Protocol.

The EPBD introduced higher standards of energy conservation for new and refurbished buildings and requires energy performance certification for all buildings when sold or leased.

The EPBD required member states to develop a methodology for the calculation of whole building energy performance/CO_2 emissions.

There are two types of energy certification required for new and existing commercial buildings;

1. Energy Performance Certificates (EPC) that are required on construction, sale or lease of all buildings from October 2008.
2. Display Energy Certificates (DEC) required for public buildings over 1000m^2 from April 2008.

National Calculation Methodology

The National Calculation Method (NCM), is defined by the department for Communities and Local Government (CLG). The procedure for demonstrating compliance with the Building Regulations for buildings other than dwellings is by calculating the annual CO_2 emissions for a proposed building and comparing it with the CO_2 emissions of a comparable 'notional building'. Both calculations make use of standard sets of data for different activity areas and call on common databases of construction and service elements.

The CO_2 emissions target and actual building emissions are calculated using approved dynamic simulation modelling software. The BRE have developed SBEM, the simplified building energy model for CLG as a simplified compliance modelling tool.

The NCM defines the operating conditions under which each building must be assessed. The conditions may be different from those under which the building operate, however this approach allows comparison against a standard building, under standardised conditions. This also allows comparison between buildings when calculating EPC ratings.

Dynamic Simulation Modelling

SBEM and other Part L approved dynamic simulation modelling packages produce a virtual model of the building. A detailed description of the building geometry, construction, building services and end use are required. Standard operating conditions for each building type are defined in the NCM and are applied to the building being assessed.

From this data, the building energy requirements and CO_2 emissions are calculated. This data is also broken down and attributed to heating, lighting, hot water and auxiliary power. The energy use and CO_2 emissions are also calculated for a 2010 notional building which generates a target emission rate (TER).

SBEM is a simplified modelling package and was originally based on the Dutch methodology NEN 2916:1998 (Energy Performance of Non-Residential Buildings). It has since been modified to comply with the recent CEN Standards. It makes use of standard data contained in associated databases.

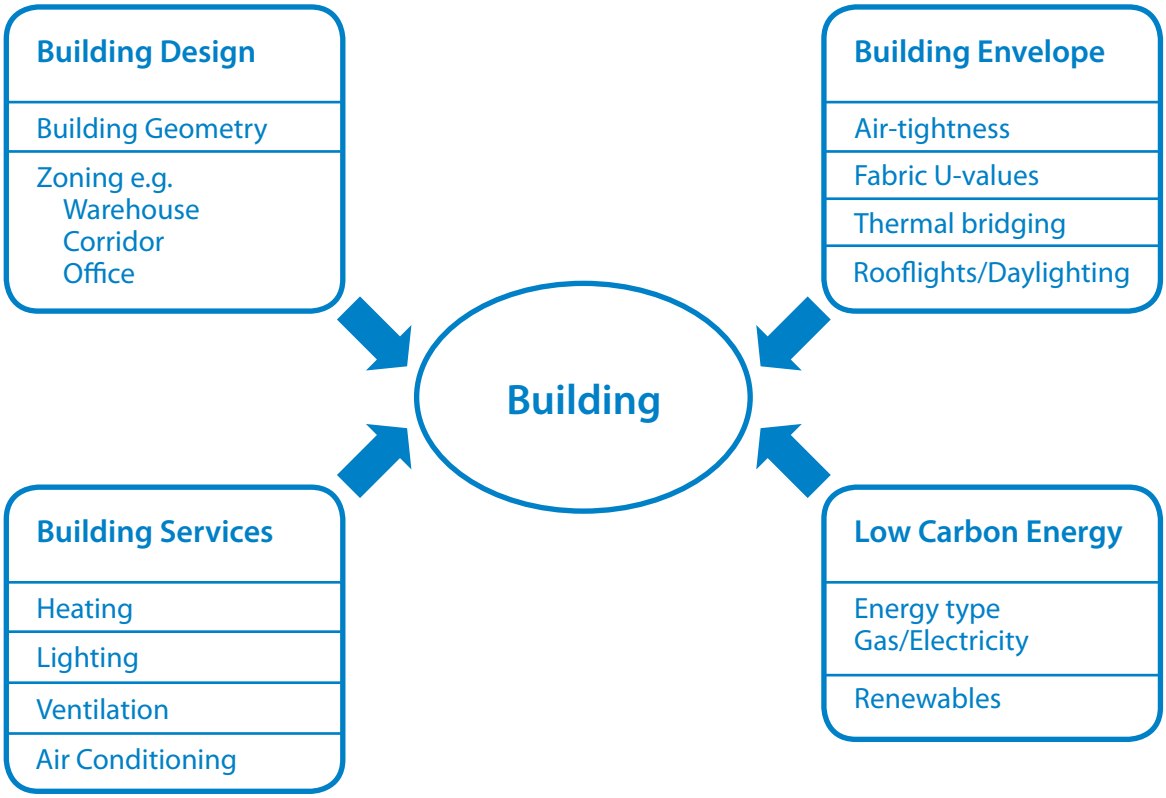
SBEM produces consistent and reliable evaluations of energy used in non-domestic buildings for Building Regulations Compliance and for Building Energy Performance Certification purposes.

For design modelling, more sophisticated modelling packages should be used.

Factors to consider for Part L 2010 compliance

When looking to achieve CO_2 emissions compliance for Part L 2010, the building designer has to consider all aspects of the building design and specification. These are summarised in the diagram below.

Figure 1. Factors affecting building CO_2 emissions



This technical paper focuses on the role of the building envelope, however this cannot be assessed on its own. Modelling using the current version of SBEM (V4.1a), along with other dynamic simulation modelling has been undertaken to assess the effect of changing building envelope and building service parameters. The effect of different energy sources and the role of renewables that can easily be integrated into the building envelope has also been considered.

Heat losses through building details

Building details such as vertical corners, the ridge, eaves, verge and junctions around windows and doors, have additional heat losses associated with them. The additional heat loss for each metre of a detail is known as the psi (ψ) value. This additional heat loss is dependant upon the type of detail, the thermal conductivity of the cladding materials and the quality of the detail design and installation.

Approved Document Part L2A places specific emphasis on the performance of building details and the additional heat losses through linear thermal bridging.

In order to demonstrate that the designer has taken reasonable provision to allow for these additional losses,
One of the following approaches should be taken:

1. A quality assured approach (checking by an approved independent third party) to enable the calculations to be used directly in the BER calculation.
2. Unchecked calculations by a person with suitable expertise using the methods set out in BR497. In this case the calculated values should be increased by 0.02W/mK or 25%, whichever is the greater, before being used in the BER calculation.
3. Unaccredited details with no linear transmittance calculations carried out. For these, the generic values given in the BRE Information Paper IP1/06 should be increased by 0.04W/mK or 50%, whichever is greater, before being used in the BER calculation.

It can be seen that there is an increasing penalty for the use of details with a lesser degree of accurate assessment of performance.

A modelling exercise has been carried out on a 2400m^2 warehouse to assess the effect of using different levels of building details upon the overall heat loss and estimated effect on the building CO_2 emissions.

Table 2. Effect of building details on heat loss and CO_2 emissions

	Modelled and accredited details	Modelled details	Generic details IP1/06 values
Thermal bridging heat loss Σl.ψ from details	162W/K	205W/K	864W/K
Total envelope loss (W/K)	2891W/K	2934W/K	3593W/K
% Heat loss by thermal bridging	5.62%	7.01%	24.07%
Approximate increase in CO_2 emissions *	Base case	+0.60%	+9.72%

* The results have been calculated assuming that lighting and heating account for 60% and 40% respectively of the building's CO_2 emissions which is typical for this type of building.

- The increase in heat lost between 'modelled and accredited' and 'modelled' details is approximately 25%. This increase is only due to the imposed penalty.
- There is very little difference in the calculated CO_2 emissions between 'modelled and accredited' and 'modelled' details.
- When 'generic details' are used the heat loss is increased by approximately a factor of 3. This is due to two reasons firstly, the fact that the generic details perform much worse than well designed modelled details and secondly the additional applied 50% penalty.
- The overall effect on the building CO_2 emissions is an increase of approximately 10% however this will vary from building to building.

As pre-finished steel has a very high thermal conductivity, this places additional emphasis on good quality design and installation. Subsequent modification of a building detail (on site) could invalidate the calculations, resulting in the same penalty as a generic building detail.

Using generic details will very significantly increase the calculated CO_2 emissions, making compliance much more difficult.

Increasing building fabric insulation

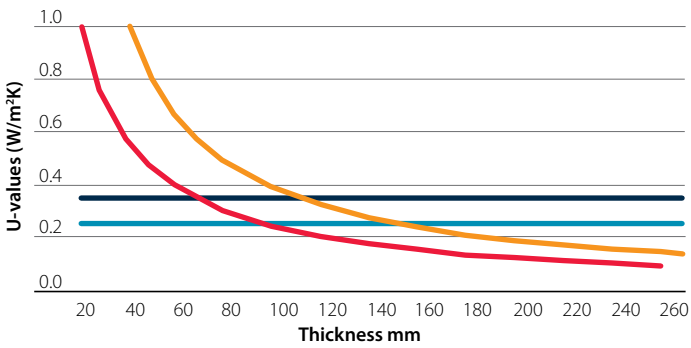
Increasing the building fabric insulation has often been the first approach taken when looking to reduce the thermal losses from a building. The designer needs to consider the implications of specifying a more highly insulated construction, against the relatively small overall reductions in CO_2 emissions which will be delivered.

The thermal transmittance of a construction is given by the U-value. This is the heat in Watts (W) passing through a square metre of construction per degree temperature difference from inside to outside. Maximum allowable U-values are given in ADL2. Increasing insulation thickness, to lower U-values, will reduce fabric losses from the building, but the benefits become proportionately less as thickness is increased. U-values are already low, so the advantage of adding more insulation is limited.

The relationship between U-value and insulation thickness is not linear. To half the U-value of an insulation product requires the thickness to be doubled. This relationship is shown in the graph below for two typical insulation materials. Actual cladding systems will vary due to factors such as repeating thermal bridging and insulation material properties.

It is always important to consult the cladding system manufacturer for actual U-values of a particular system.

Figure 2. U-value for different insulation thickness



Key

- Wall backstop value 0.35
- Roof backstop value 0.25
- Polyurethane foam
- Mineral Wool

It can clearly be seen that as we move beyond the current roof and wall backstop values, the graph is starting to flatten out significantly. Specifying thicker, more highly insulated constructions, will raise a number of issues.

1. **Significant increase in cost.**
2. **Additional loads which the building structure must be designed to accommodate.**
3. **Increased focus on local thermal bridging through spacer systems and through fasteners.**
4. **Increased weight of composite panels and associated handling issues.**
5. **Increased structural requirements on spacer bar systems.**

Reducing U-values will have a greater impact on the total heat loss and CO_2 emissions, of smaller buildings than for larger ones. This is due to the ratio of building volume to surface area. So, for typical industrial, warehouse or retail buildings, with relatively high volume, increasing insulation has much less effect than in small buildings.

Effect of changing building envelope parameters

Assessment approach

In order to assess the effect of changing building envelope parameters on the overall building CO_2 emission rate, a series of generic buildings have been modelled using SBEM. V4.1a.

These buildings are summarised in the table below.

Table 3. Generic warehouse dimensions

Building size	Area	Height to eaves	Dimensions
Small	1000m^2	4m	40 X 25m (1 bay)
Medium	4000m^2	6m	80 X 50m (2 bays)
Large	10,000m^2	6m	125 X 80m (4 bays)

To enable a meaningful comparison of the data, and to ensure that all buildings started from the same point, the base case building was taken as one which met the 2010 backstop criteria for the building envelope and had building services equivalent to the a 2010 notional building.

A series of enhancements to each element of the building envelope were then modelled to assess the effect on reducing the CO_2 emissions.

The enhanced envelope performance figures were categorised as 'good', 'better', 'best'.

This classification followed the same principles as those used by AECOM during the initial modelling work for CLG (Department for Communities and Local Government) and are tabulated below. The criteria for 'best' are based on what was deemed currently technically feasible. In many cases, this may not be practical or financially viable.

Table 4. Generic warehouse building envelope parameters

Element	2010 Notional	Backstop	Good	Better	Best
Air-tightness	5.00	10.00	7.50	5.00	2.50
Roof U-value	0.18	0.25	0.20	0.15	0.10
Rooflight U-value (12% area)	1.80	2.20	1.50	1.20	0.90
Wall U-value	0.26	0.35	0.30	0.25	0.20

In addition to SBEM assessment, the total heat losses through the building fabric have been calculated for the different size buildings with a 2010 notional building envelope specification. An alternative, more cost effective approach to achieving the same level of building envelope heat loss performance has been proposed.

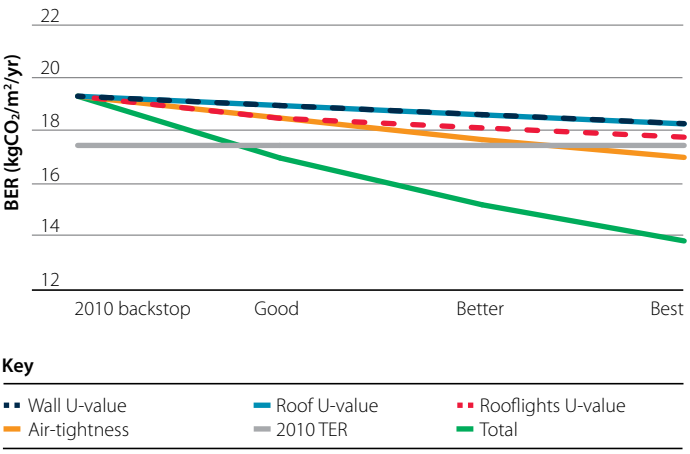
While this approach is not adequate for the whole building CO_2 assessment, it does enable the effect of changing the building envelope parameters to be easily calculated, without the need to completely specify the building services and carry out the complete SBEM calculations.

To demonstrate the improvements over 2006, the heat losses for a 2006 compliant building have also been calculated. This shows the overall reduction in heat losses, but more importantly demonstrates the main areas where the improvements have been made.

Small buildings

Whole building modelling using SBEM V4.1a

Figure 3. Small warehouse (25 x 40 x 6m): SBEM 4.1a BER comparison



Small buildings have proportionately greater building envelope surface area for the enclosed building volume and floor area. They also have proportionately more wall surface area.
The 2010 target emission rate ($kgCO_2/m^2/yr$) generated from the 2010 notional building will be higher for small buildings.

For this particular size of building, the wall area is fairly similar to the roof (excluding rooflight) area. Consequently enhancing the U-value of wall or roof elements show very similar reductions in the CO_2 emissions, due to the relatively high surface area.

When all the building envelope parameters are set at the backstop values, the amount of heat lost through the rooflights is similar to the amount of heat lost through the rest of the insulated roof construction.

Modern rooflights are able to perform much better than the backstop values and reducing the U-value can show greater reductions in CO_2 emissions than changing other elements in the design. This will be dependant upon the area of rooflights specified.

Increasing the air-tightness of the building envelope yields the greatest reduction in CO_2 emissions.

Any non linearity in the graphs is due to actual values chosen for each parameter when classifying them as 'good', 'better' or 'best'.

As SBEM version 4 will be the main compliance assessment tool, the designer will have to confirm his specification and building emission rate, by a building specific calculation.

Small buildings

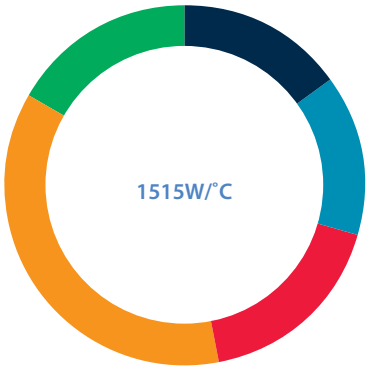
Building envelope heat losses

An SBEM assessment of a building requires the complete building envelope and services to be specified, along with the building type, location etc.

An alternative approach, to assess the impact of each element of the building envelope on thermal performance, is to calculate the building heat losses through each element.

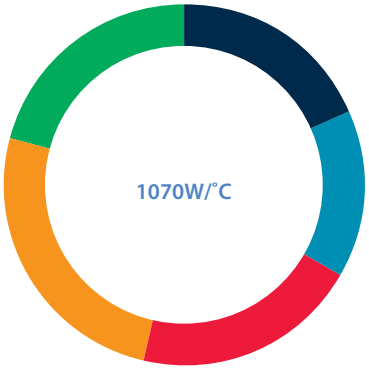
The pie charts show the actual heat loss through from specific elements and the relative quantity of heat escaping through them for each degree centigrade temperature differential between the internal and external conditions.

Figure 4. Small warehouse (40m x 25m x 6m) 2006 notional building specification



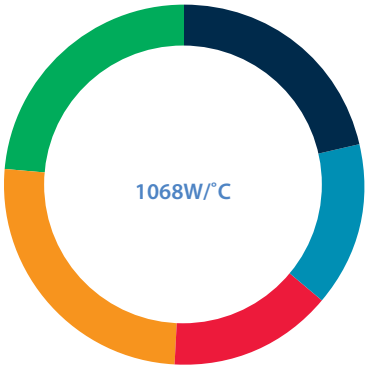
Key	Specification	Heat Loss
Walls	U-value 0.35	229W/°C
Roof	U-value 0.25	221W/°C
Rooflights	U-value 2.20	265W/°C
Air-tightness	10	550W/°C
Floor slab	U-value 0.25	250W/°C

Figure 5. Small warehouse (40m x 25m x 6m) 2010 notional building specification



Key	Specification	Heat Loss
Walls	U-value 0.26	199W/°C
Roof	U-value 0.18	159W/°C
Rooflights	U-value 1.80	217W/°C
Air-tightness	5	275W/°C
Floor slab	U-value 0.22	220W/°C

Figure 6. Small warehouse (40m x 25m x 6m) Alternative 2010 building specification



Key	Specification	Heat Loss
Walls	U-value 0.30	229W/°C
Roof	U-value 0.18	158W/°C
Rooflights	U-value 1.30	156W/°C
Air-tightness	5	275W/°C
Floor slab	U-value 0.25	250W/°C

The typical heat losses from a 2006 notional warehouse building, show how much heat is being lost through air leakage and rooflights. Moving from the 2006 to the 2010 notional building, it can be seen that to create the very large overall reduction in heat loss, the air-tightness aspect has been enhanced the most.

Is the 2010 notional specification the best way to comply?

An alternative, more cost effective solution is very difficult, as most aspects of the building envelope have been 'pushed' to their limits.

It is not practical to reduce air-tightness any lower than $5m^3/m^2/h$ on this size of building and dependant upon the complexity of design/ number of interfaces etc, it may be challenging to achieve $5m^3/m^2/h$.

The only area where significant reductions in heat loss can be made is through specifying a higher performing rooflight. There is little benefit in specifying ultra low U-value roof lights as these require an additional fourth layer and this results in a reduction in light transmission. There is also a large cost penalty when moving from a U-value of ~1.3 to $0.9W/m^2/K$.

There is only minimal scope to relax the roof and wall U-values.

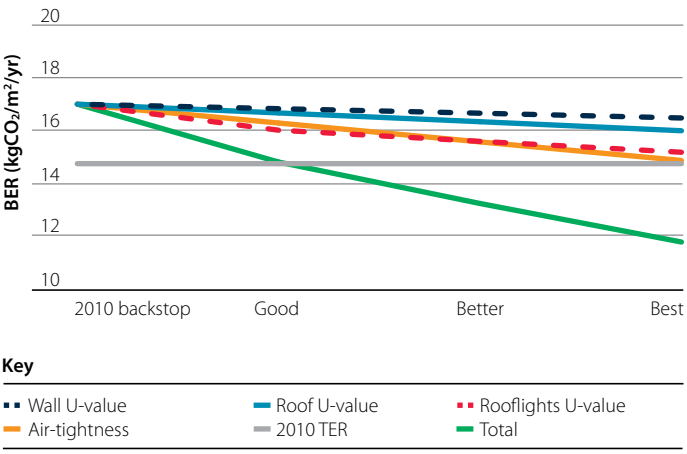
To achieve the 2010 floor slab U-value will almost certainly require under slab insulation. It is more likely that the backstop value without insulation would be used. (Note for buildings much smaller than 1000 m^2, an insulated floor slab or ring beam will be required to meet the backstop value.)

In summary, designing and ensuring that the building envelope as installed performs at a similar level to the 2010 notional building, will be challenging. The designer needs to consider the relative cost effectiveness of enhancing the building envelope performance, compared with enhancements to the building services.

Medium buildings

Whole building modelling using SBEM V4.1a

Figure 7. Medium warehouse (80 x 50 x 6m): SBEM 4.1a BER comparison



Buildings between 3000 and 5000m^2 floor area account for a significant portion of the UK's new building stock. In these buildings the roof cladding to wall cladding area ratio is much higher and is much closer to the large building, than the small building.

The modelled results are given in the graph and shown that enhancing the wall U-value only shows a very small reduction in CO_2 emissions, due to the lower relative area.

Enhancing the roof U-value shows a significant reduction in CO_2 emissions, although not as great as was seen on the small building.

Due to the lower surface area: building volume ratio, enhancing the U-values show a relatively smaller effect than on the small building and will incur greater costs.

Enhancing the rooflight U-value again shows a very significant reduction in the CO_2 emissions and is relatively straightforward.

Increasing the air-tightness of the building envelope yields the greatest reduction in CO_2 emissions.

Any non linearity in the graphs is due to actual values chosen for each parameter when classifying them as 'good', 'better' or 'best'.

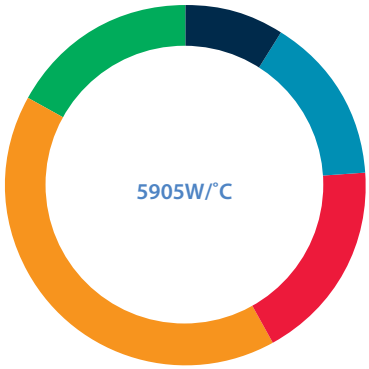
As SBEM version 4, will be the main compliance assessment tool, the designer will have to confirm his specification and building emission rate, by a building specific calculation.

Medium buildings

Building envelope heat losses

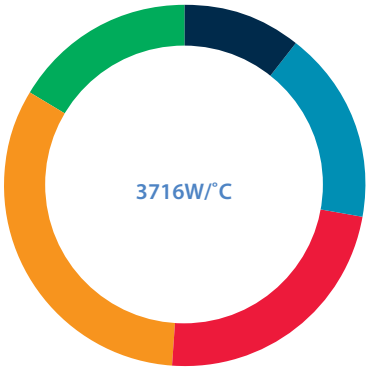
The pie charts show the actual heat loss through specific elements and the relative quantity of heat escaping through them for each degree centigrade temperature differential between the internal and external conditions.

Figure 8. Medium warehouse (80m x 50m x 6m) 2006 notional building specification



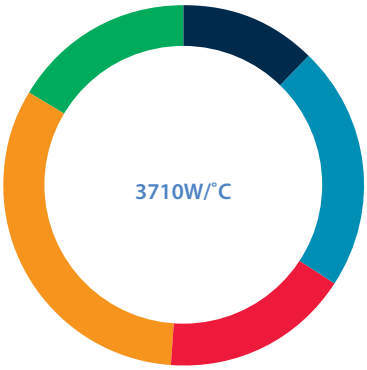
Key	Specification	Heat Loss
Walls	U-value 0.35	540W/˚C
Roof	U-value 0.25	885W/˚C
Rooflights	U-value 2.20	1062W/˚C
Air-tightness	10	2418W/˚C
Floor slab	U-value 0.25	1000W/˚C

Figure 9. Medium warehouse (80m x 50m x 6m) 2010 notional building specification



Key	Specification	Heat Loss
Walls	U-value 0.26	401W/˚C
Roof	U-value 0.18	637W/˚C
Rooflights	U-value 1.80	869W/˚C
Air-tightness	5	1209W/˚C
Floor slab	U-value 0.15	600W/˚C

Figure 10. Medium warehouse (80m x 50m x 6m) Alternative 2010 building specification



Key	Specification	Heat Loss
Walls	U-value 0.30	463W/˚C
Roof	U-value 0.23	814W/˚C
Rooflights	U-value 1.30	624W/˚C
Air-tightness	5	1209W/˚C
Floor slab	U-value 0.15	600W/˚C

The typical heat losses from a 2006 notional warehouse building, show how much heat is being lost through air leakage and rooflights.

Moving from the 2006 to the 2010 notional building, it can be seen that to create the very large overall reduction in heat loss, the air-tightness aspect has been enhanced the most.

Is the 2010 notional specification the best way to comply?

Significant reduction in heat loss can be made by specifying a higher performing rooflight, so that it is possible to relax the roof and wall U-values, and so reduce overall building envelope cost. There is little benefit in specifying ultra low U-value roof lights as these require an additional fourth layer and this results in a reduction in light transmission. There is also a large cost penalty when moving from a U-value of ~1.3 to 0.9W/m^2/K.

Air-tightness of 5m^3/m^2/h should be relatively straightforward on a building of this size, provided attention is paid to detail during construction.

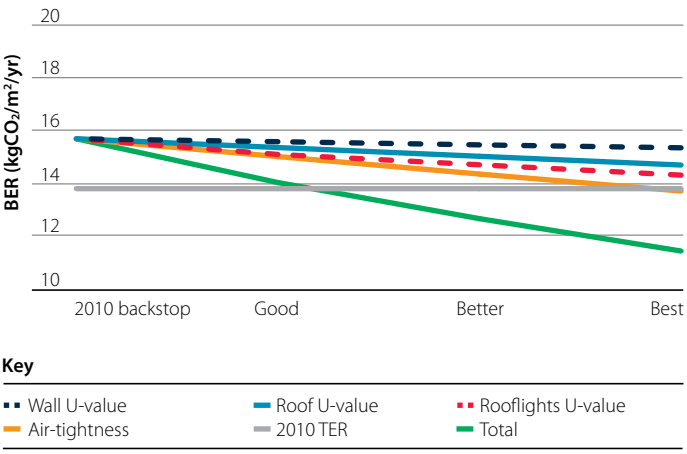
In this case the floor slab notional U-value can be achieved without insulation. (Note the notional floor slab U-value decreases with increasing floor slab size.)

In summary, there are a number of options which are now available which can significantly reduce the cost of the building envelope.

Large buildings

Whole building modelling using SBEM V4.1a

Figure 11. Large warehouse (125 x 80 x 6m): SBEM 4.1a BER comparison



Larger buildings generally have a low surface area: volume ratio, which reduces the area for heat loss; additionally they require a lower light output to achieve the same level of internal luminance. For these reasons, the target emissions rates ($kgCO_2/m^2/yr$) are lower than for smaller buildings.

Enhancing the wall U-value only shows a minimal reduction in CO_2 emissions, due to the relatively low wall surface area.

Enhancing the roof U-value shows a reasonable reduction in CO_2 emissions, however given the relatively large area of roof, this is unlikely to be a cost effective solution.

Enhancing the rooflight U-value again shows a significant reduction in the CO_2 emissions. Increasing the air-tightness of the building envelope yields the greatest reduction in CO_2 emissions. This is relatively straightforward for buildings of this size and it is quite reasonable to consider a target air-tightness of $2.5m^3/m^2/h$.

Any non-linearity in the graphs is due to actual values chosen for each parameter when classifying them as 'good', 'better' or 'best'.

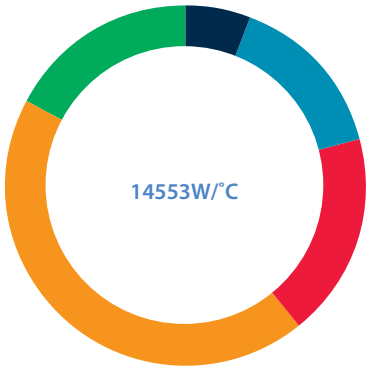
As SBEM version 4, will be the main compliance assessment tool, the designer will have to confirm his specification and building emission rate, by a building specific calculation.

Large buildings

Building envelope heat losses

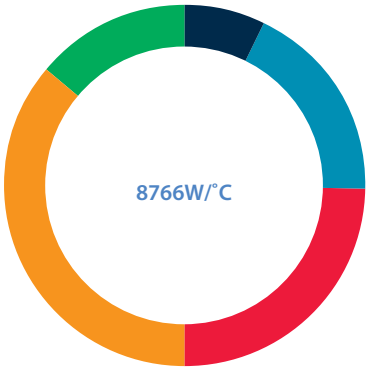
The pie charts show the actual heat loss through specific elements and the relative quantity of heat escaping through them for each degree centigrade temperature differential between the internal and external conditions.

Figure 12. Large warehouse (125m x 80m x 6m) 2006 notional building specification



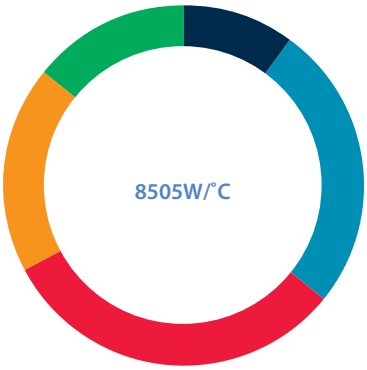
Key	Specification	Heat Loss
Walls	U-value 0.35	855W/˚C
Roof	U-value 0.25	2212W/˚C
Rooflights	U-value 2.20	2655W/˚C
Air-tightness	10	6331W/˚C
Floor slab	U-value 0.25	2500W/˚C

Figure 13. Large warehouse (125m x 80m x 6m) 2010 notional building specification



Key	Specification	Heat Loss
Walls	U-value 0.26	635W/˚C
Roof	U-value 0.18	1593W/˚C
Rooflights	U-value 1.80	2172W/˚C
Air-tightness	5	3166W/˚C
Floor slab	U-value 0.12	1200W/˚C

Figure 14. Large warehouse (125m x 80m x 6m) Alternative 2010 building specification



Key	Specification	Heat Loss
Walls	U-value 0.35	855W/˚C
Roof	U-value 0.25	2212W/˚C
Rooflights	U-value 2.20	2655W/˚C
Air-tightness	3	1583W/˚C
Floor slab	U-value 0.12	1200W/˚C

The typical heat losses from a 2006 notional warehouse building, show how much heat is being lost through air leakage and rooflights.

Moving from the 2006 to the 2010 notional building, it can be seen that to create the very large overall reduction in heat loss, the air-tightness aspect has been enhanced the most.

Is the 2010 notional specification the best way to comply?

Air-tightness performance on a building of this size is relatively straightforward and provided attention to detail during construction it should be relatively straight forward to achieve 2.5m^3/m^2/h.

It should be noted that the floor slab is part of the envelope for air-tightness calculation purposes and this will be a larger portion of the envelope for a larger building. The relative number of interfaces and more difficult to seal junctions and penetrations will also be lower, which will again contribute to an improved performance.

It can be seen that by specifying a high level of air-tightness, a similar level of performance to the notional specification can be achieved without specifying relatively expensive additional wall and/or roof insulations, so in this case, the designer may be able to relax these back to the backstop levels.

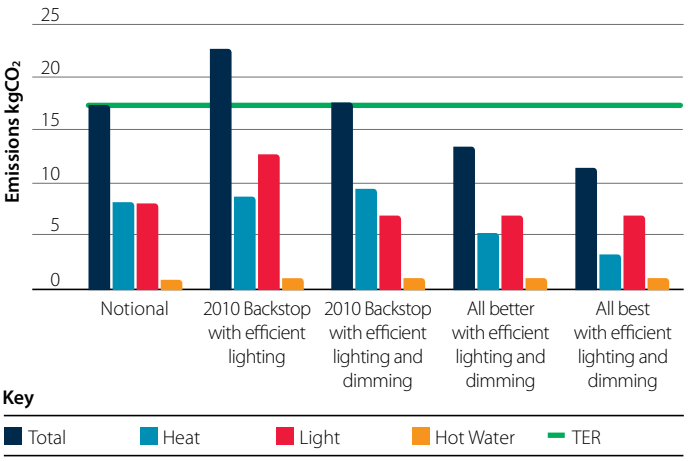
Significant reduction in heat loss can again be made through specifying a higher performing rooflight. As some manufacturers supply rooflights with better than backstop performance as standard for no additional cost, the designer may specify these which can then offset other parameters such as the building lighting and heating services.

In this case the floor slab notional U-value can be achieved without insulation. (Note the Notional floor slab U-value decreases with increasing floor slab size.)

In summary, air-tightness can be enhanced significantly and will make a very large contribution to reducing the CO_2 emissions. This will allow the designer more flexibility with other elements of the building envelope which can significantly reduce the cost.

Building services

Figure 15. Effect of building envelope and services on CO_2 emissions (small warehouse)



As well as modelling the effect of changes to the building envelope, the effect of varying the building lighting system and control has also been modelled.

In the notional building, lighting contributes approximately 50% of the buildings CO_2 emissions.

Using efficient lighting and automated dimming control will significantly reduce the CO_2 emissions. It can be seen that a building with the envelope set at backstop values can almost meet the TER by specifying a more efficient lighting system with automated dimming control. This may be more cost effective than building envelope enhancements.

Note that when dimming control is introduced, the heating load increases slightly as the lighting is not heating the building as much, this is greatly outweighed by the reduction in lighting. Heating by light is very inefficient.

Pushing envelope technology and lighting to the limit of current technical feasibility (excluding LED/OLED type lighting) indicates that a further reduction in overall CO_2 emissions, of up to ~50% beyond the 2010 standard may be feasible, however this may not be the most cost effective approach towards further CO_2 reductions.

Installation of an automatic light dimming control system, will generate significant CO_2 reductions and is essential to maximise the benefits from installation of rooflights/windows and daylighting.

Fuel CO_2 emission factors

The operational CO_2 emissions are all created by the building services; enhancing the specification of building envelope will reduce the requirement.

Table 24 in the NCM guide specifies the CO_2 emission factors per kilowatt hour for each different energy source. The most relevant fuels are detailed below.

Table 5. Fuel CO_2 emission factors

Fuel type	CO_2 emission factor $kgCO_2/kWh$
Natural gas	0.198
Grid supplied electricity	0.517
Grid displaced electricity	0.529*

* This is effectively the credit which will be generated when electricity producing low or zero carbon (LZC) technologies have been included in the design and SBEM calculation.

It can be seen that electrical services will produce approximately 2 ½ times as much CO_2 emissions as gas services for the same power. For this reason, gas fired heating systems are usually specified.

This explains why in buildings such as warehouses with relatively low heating requirements, lighting is the largest cause of CO_2 emissions.

The actual emission factors have changed since pre-2009.

- CO_2 emissions from electricity have increased by approximately 25%. This is due to changes in the national grid generating power station mix and also the transmission losses have been recalculated and revised upwards.
- There has been minimal change in the gas factors.

When installing electricity generating renewables, the slightly higher 'grid displaced electricity' factor can be claimed. This gives a slight further incentive to install electricity generating renewables as part of an overall CO_2 compliance strategy.

Low and zero carbon energy

There are many low and zero carbon (LZC) technologies now available for incorporation into the building including photovoltaics, wind turbines, hot water from solar thermal panels, heating from transpired solar collectors, heating and cooling via heat pumps and various fuels derived from biomass. Although renewable energy is 'low carbon' it is not necessarily low cost. Most of these technologies have a relatively high capital cost and long payback periods.

Two of these technologies which are most suitable for integration with the building envelope and recognised within SBEM are photovoltaic systems and transpired solar collectors.

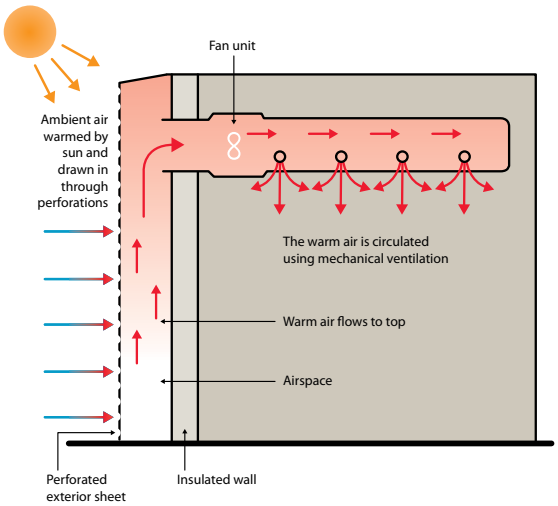
Transpired solar collectors

The transpired solar collector (TSC) is a globally proven solar air heating system that uses the sun's energy to pre heat air prior to it being drawn into the building.

The TSC is installed as an additional skin on a southerly elevation of the building.

The additional skin has thousands of tiny perforations, uniformly spaced across the full face of the collector.

Colorcoat Prisma® by Tata Steel is the material of choice for the outer skin.



How it works

- Solar radiation is absorbed by the collector, which in turn warms its surface.
- The heat from the conductor is transferred to the boundary layer of air.
- The heated boundary layer of air is then drawn through the perforated collector by a fan unit, into the specifically engineered cavity in the wall construction.
- From the air cavity, the heated fresh air can then be delivered directly into the building or as preheated air to the buildings main heating plant.

The SBEM interface has a section under building services where the exact details of the transpired solar collector can be specified.

It should also be noted that the distribution ducting will also provide a means of destratification in the building and can reduce heat losses through the roof and rooflight elements.

The energy produced is heat and so usually will offset gas heating, which has a relatively low CO_2 emission factor.

iSBEM building services section showing TSC details

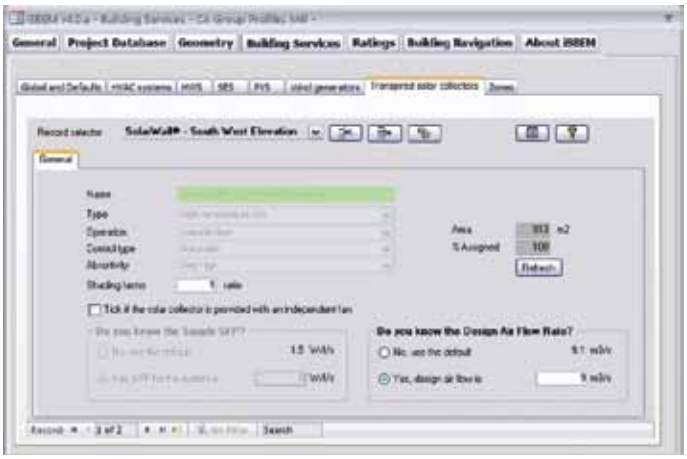
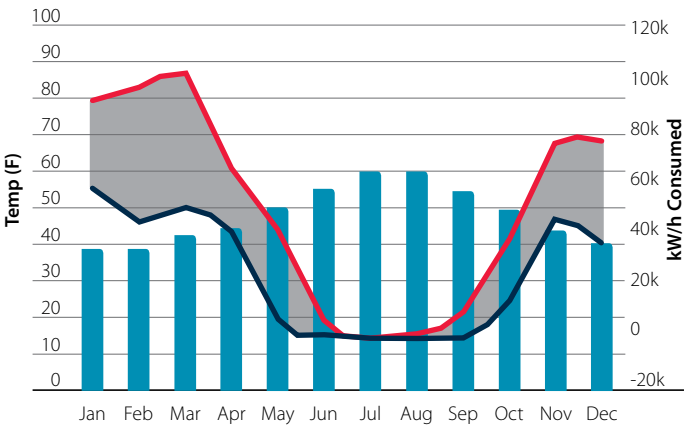


Figure 15. Reduction in gas usage due to TSC



Key

- Aspheric temperature
- Gas usage with TSC
- Typical gas usage without TSC
- 49% reduction in gas usage

Graph from CA Group rolling mill project based in Evenwood using SolarWall® by Conserval.

Independent studies of a typical transpired solar collector have shown that these reductions in gas usage for heating and associated CO_2 can be up to 50%.

The installed systems would be expected to pay back the additional costs within three to eight years dependant upon the installation and are virtually maintenance free. The TSC can easily be integrated with other heating systems.

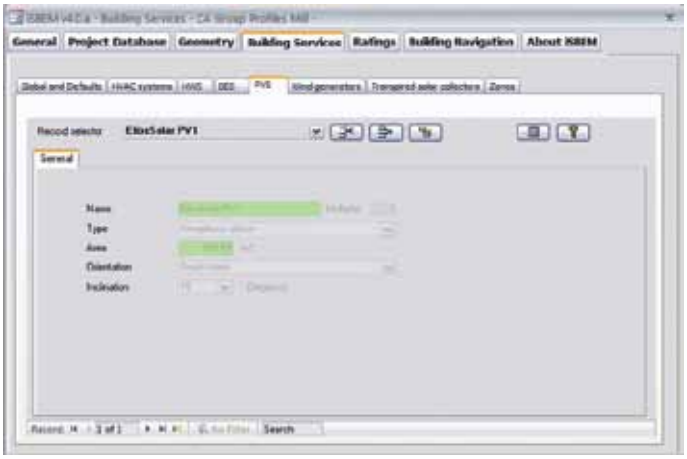
Transpired solar collectors are relatively low cost and provide a simple heating source, which as well as providing CO_2 reduction for Part L compliance, can also meet the Merton rule requirements.

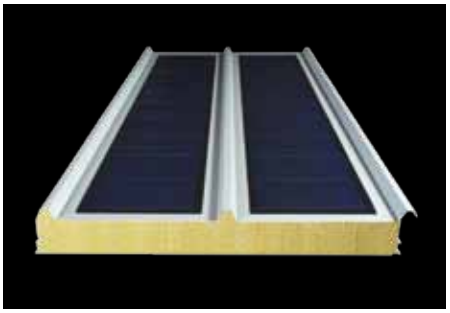
Photovoltaic panels

Photovoltaic panels (PVs) convert energy from the sun directly into electricity. This can then be credited as 'grid displaced electricity'.

The SBEM interface has a specific section under building services, where the exact details of the photovoltaic system can be specified.

iSBEM building services section showing PV details





Photovoltaic modules come in a number of different forms. Lightweight laminates and modules are most suitable for pre-finished steel buildings as these will impose the lowest additional loads on the building structure. In all cases these additional loads must be calculated to ensure that no additional reinforcement is required.

Crystalline PVs are generally quite heavy. They have a much higher output per unit area than light weight laminate systems, however provided overall roof area is not the restricting factor, the lightweight laminates allow the additional weight to be spread over a larger area.

Colorcoat Prisma® by Tata Steel is an approved substrate for Unisolar PV laminate.

Photovoltaic systems are generally very capital intensive and would not have been viable purely as a means of carbon emission reductions. Following the introduction in April 2010 of the Feed in Tariffs (FIT); PV systems can be a long term cost effective solution.

Products which are listed in the Micro-generation Certification Scheme (MCS) must be used to be eligible for the feed in tariff unless the installation is over a threshold size.

There is generally a good public perception of the benefits of PVs, so their installation can also boost the environmental image of the building owner or occupier. They can also contribute to improved BREEAM rating and lower EPC rating, with improved neutral values.

Photovoltaic systems which are MCS approved, may provide a cost effective solution to reducing CO_2 emissions, once the feed in tariffs have been taken into account.

Conclusions

Cladding systems general

1. The 2010 revision of Part L2A requires an average 25% reduction in CO_2 emissions from 2006. This is referred to as the 'Aggregate' approach.

2. The target emission rate is set by a new **2010 notional building** specification. There is no reference back to the 2002 or 2006 building with improvement factors.

3. The 2010 notional building specification provides a good starting point for the actual building specification, however it will not necessarily be the most cost effective solution.

4. For all buildings, improving the air-tightness, is the most cost effective approach to reducing building heat losses. Heat losses on industrial/commercial buildings can be reduced by approximately 10% by improving air-tightness. All Tata Steel supply chain partners provide guidance and systems to maximise this saving.

5. Increasing roof and wall fabric insulation beyond the Part L backstop values shows only limited reduction in building CO_2 emissions, and can significantly increase the envelope and building cost. Increased fabric insulation may be required for smaller buildings.

6. Small buildings have only limited scope for modification of the building envelope specification, to achieve the same performance as a 2010 notional building specification at the lowest cost. Specifying higher performance rooflights will allow some relaxation of the roof or wall U-values.

7. For medium buildings, specifying higher performance rooflights will allow some relaxation of the roof or wall U-values. Dependant upon the building, it may also be possible to achieve an air-tightness lower than $5m^3/m^2/h$.

8. For large buildings the most cost effective way to meet regulations is to allow the relaxation of U-values. Enhancing air-tightness can provide all or most of the building envelope thermal improvements required to achieve 2010 compliance.

9. Installation of efficient lighting and an automated dimming control system will produce very significant reductions in CO_2 emissions and will be more cost effective than building envelope enhancements.

10. A rooflight area of approximately 10–12% is the optimum for Part L2A compliance through SBEM. This provides a balance between installed cost, natural lighting gains, useful solar heat gains and heat losses. It also minimises the risk of excessive solar gains and overheating.

11. The use of well designed and accurately modelled building details will significantly reduce building envelope heat losses and CO_2 emissions.

12. Use of generic building details and the associated 50% penalty can increase the building CO_2 emissions by as much as 10%, which will make Part L compliance much more difficult.

13. Any deviation in the design and installation of a building detail would invalidate the modelled thermal performance, meaning that only the generic detail performance and associated 50% penalty can be claimed. The use of recommended system installers will contribute to ensuring that the building details are installed as they were designed and assessed.

14. Low or zero carbon (LZC) technologies can be easily integrated building envelopes with using Colorcoat® pre-finished steel. These systems are included in the SBEM calculation database and also meet the requirements of the "Merton Rule" for 10% renewables.

For more information on our supply chain partners visit **www.colorcoat-online.com**

References

The following documents, standards and modelling packages have been used to prepare this Colorcoat® Technical Paper.

1. Approved Document L of the Building Regulations.
2. National Calculation Methodology NCM.
3. Simplified building energy model SBEM.
4. Specification for the 2010 notional building (envelope parameters).
5. The EU Energy Performance of Buildings Directive (EPBD).
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7. NEN 2916:1998 (Energy Performance of Non-Residential Buildings).
8. BR 497 Thermal transmittance and temperature factors.
9. BRE Information Paper IP1/06.
10. Future thinking paper for non-dwellings version 3a April 08.
11. Table 24 in the NCM guide specifies the CO_2 emission factors per kilowatt hour for each different energy source.
12. Evenwood CA rolling mill 'Solarwall transpired solar collector'.
13. Merton rule compliance.
14. Micro-generation Certification Scheme (MCS).
15. BREEAM . Building research establishment environmental assessment methodology.

Colorcoat® Supply Chain Partners

1. All Tata Steel supply chain partners supply roof and wall cladding systems, which meet the Part L2 A '2010 notional building' specification for new build.

2. All Tata Steel supply chain partners can provide guidance on the design and specification of the building envelope, to provide a more cost effective solution than the 2010 notional building specification for Part L compliance.

3. All Tata Steel supply chain partners provide building details designed and modelled to reduce the associated heat losses from the building. The use of these details will provide a performance, significantly better than the industry standard. A building designed and built using these high performance details will have a CO_2 emission rate within 1% of one using fully accredited details.

4. Colorcoat Prisma® by Tata Steel is the product of choice for the use in transpired solar collector systems which provide a low carbon heating solution and is an approved substrate for use with Unisolar PV laminate. This combination is registered with the micro generation certification scheme (MCS) and is eligible for feed in tariffs.

For more information on our supply chain partners visit **www.colorcoat-online.com**

The Colorcoat® brand

The Colorcoat® brand provides the recognised mark of quality and metal envelope expertise exclusively from Tata Steel. For nearly 50 years Tata Steel has developed a range of technically leading Colorcoat® products which have been comprehensively tested and are manufactured to the highest quality standards. These are supported by a range of services such as comprehensive guarantees, colour consistency and technical support and guidance.

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