The Building Envelope Authority

Guidance Documents

January 2022

GD39 SUSTAINABILITY AND DURABILITY OF METAL ROOFING AND CLADDING SYSTEMS

SECTION 2: SUSTAINABILITY IN CONSTRUCTION

2.1 Sustainability background

Over the past 40 to 50 years there has become an ever-increasing awareness of environmental issues and the need for sustainable development. Everything we do, make, use and discard all interact in complex ways to the physical conditions and life on our planet. Modern industry and transportation are dependent on energy and minerals, and we are becoming more aware that the use of this energy and the mineral resources do have environmental consequences globally.

Sustainable development can mean many different things to many different people but probably the most well-known definition was provided by the Brundtland Commission, Our Common Future in 1987: ***"****Sustainable Development is - Development that meets the needs of the present without compromising the ability of future generations to meet their own needs."*

Another way of looking at sustainable development is through what is known as the 'three pillars of sustainability' (also known as the 'triple bottom line'); environmental sustainability, economic sustainability and social sustainability. All pillars must be in balance and if any one of them is weak then the whole becomes unsustainable. Binding these all together any sustainable initiative must be seen as bearable, equitable and viable.

Over the years there have been several international summits, treaties and agreements such as the Rio De Janeiro Earth Summit (1992), Kyoto Protocol (1997) and, more recently, the Paris Agreement (2015) where commitments to climate change, reduction of greenhouse gases and keeping global temperature rise this century below 2°C (preferably 1.5°C) above pre-industrial levels have been agreed.

The national action plans on how countries will achieve this target known as Nationally Determined Contributions (NDC) where required, to be put in place by 2020 and which were reviewed at the COP26 conference in Glasgow in November 2021, hosted in partnership by the United Kingdom and Italy.

As part of its NDC the UK government has made a commitment in the Climate Change Act (2008) to reduce greenhouse gas emissions initially by 80% of 1990 levels and latterly in an amendment, a ‘Net Zero Carbon’ target by 2050, i.e., the reduction of greenhouse emissions by at least 100% of 1990 levels (net zero) by 2050.

In the UK, the construction sector and the built environment have a massive environmental impact in terms of resource and energy usage, production of emissions and waste generation. They reportedly account for 45% of total greenhouse gas emissions with a further 10% from materials production. Approximately 32% of landfill waste comes from the construction and demolition of buildings and more worryingly it is estimated that 13% of products delivered to site end up in landfill without being used. There is therefore the need for sustainability in both building design, building construction and building use to considerably reduce these figures and contribute to meeting national targets for emissions reduction

The government targets over the years have translated into changes to, and introduction of, several policies, initiatives, strategies and regulations for the built environment. One of these has been regular updates to the Building Regulations in relation to conservation of fuel and power with the main emphasis being on the progressive reduction of carbon dioxide (CO_2) and other greenhouse gas emissions from buildings.

There are also initiatives such as Zero Avoidable Waste (ZAW) in construction which is aimed at the overall reduction of waste, and the minimisation of waste to landfill to improve material resource efficiency and which can play a significant role in national carbon reduction targets.

2.2 Conservation of fuel and power

UK Building regulations relating to conservation of fuel and power (e.g., Part L in England and Wales) are now based on a holistic design approach to whole building performance, rather than an elemental approach.

The objective of this is to reduce CO_2, and other greenhouse gas emissions from all buildings. This involves assessing the overall carbon footprint of the building.
Guidance and methodologies to show compliance with the regulations are contained within support documents such as Approved Documents in England and Wales, Technical Handbook in Scotland and Technical Booklet in Northern Ireland.

An example of one of these support documents is Approved Document L2A – *Conservation of fuel and power in new buildings other than dwellings* (for use in England). The same requirements for CO_2 reductions typically apply throughout the various support documents although there are some differences between the methodologies and limiting values for the building fabric and building services etc.

Although the regulations are performance based rather than prescriptive based and deal with the overall CO_2 emissions at building level there are limiting values in the support documents on design flexibility for the building fabric (e.g., maximum U-values and airtightness) and building services and requirements to control the effects of solar gains to reduce the need or installed capacity of air conditioning.

Periodic updates and amendments to the regulations and support documents have required progressive reductions in CO_2 emissions.

Proposed future changes to these and other regulations (e.g., for ventilation) to meet the net zero target by 2050 could place the emphasis on a ‘primary energy’ metric. This will consider upstream production activities (e.g. extraction, transportation, transmission etc.) of a fuel type as well as the efficiency of use of the fuel within the building. It is hoped that this will achieve a more accurate measure of overall energy usage and efficiency. The reduction of a carbon dioxide (CO_2) emissions metric would still be retained as a secondary metric.

2.3 Zero Avoidable Waste (ZAW)

The construction sector, both buildings and infrastructure together, is the biggest producer by volume of waste in England. The overall reduction of waste, and the minimisation of waste to landfill is vital to improve material resource efficiency and will play a significant part in national carbon reduction.

Zero Avoidable Waste (ZAW) in construction means preventing waste being generated at every stage of a project’s lifecycle; from the manufacture of materials and products, the design, specification, procurement and assembly of buildings and infrastructure through to deconstruction.

At the end of life, products, components and materials should be recovered at the highest possible level of the waste hierarchy, see figure 2.1, e.g. reused before being recycled, whilst ensuring minimal environmental impact.

An interactive Routeman has been prepared by the Green Construction Board (GCB), in collaboration with Defra and BEIS. The Routemap aims to catalyse actions by all parts of the supply chain to reduce and ultimately eliminate all avoidable waste.
It identifies the action that everyone involved in the construction sector, both public and private, can take to help deliver a lower carbon, more efficient industry.

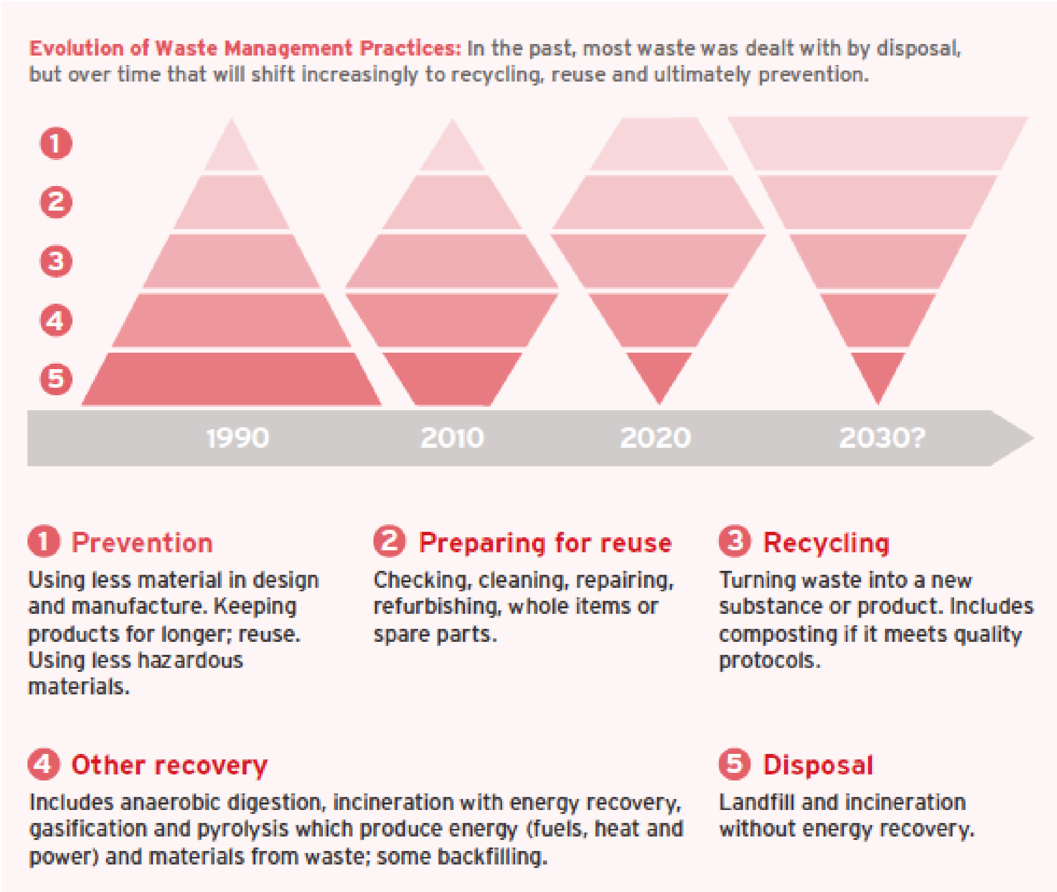


Figure 2.1 – The waste hierarchy and its evolution
(CLC/GBC – Zero Avoidable Waste in Construction)

Steel and aluminium are the most common materials used in metal building envelopes and offer significant advantages. They are produced from materials that have high recycled content from both pre-consumer and post-consumer scrap and can both be reused or recycled repeatedly without losing their qualities as a building material. Percentage wise recovery rates of metals are in the high 90%.

2.4 Drivers for sustainability in construction

The awareness of sustainability issues is constantly growing and have been driven both by government and society as a whole. Due to the concerns of the impact of climate change this has led to companies striving to act and operate in a more sustainable manner.
Most companies, especially larger ones, now report on their Corporate Social Responsibility (CSR), a major element of which is the carbon footprint of a company's activities and their efforts to reduce it. Often sustainability and their CSR are used as a means of branding and marketing of a company.

This CSR can also translate into the requirement for more sustainable buildings which are cost effective to operate throughout their intended design life. Sustainability would need to be considered at all stages of the building procurement process by all involved parties from inception, through specification and design, to construction and hand over and considering its lifetime operation (including maintenance, refurbishment and planned replacement) and ultimately its demolition and disposal.

Often there will be a desire that the sustainability and environmentally friendliness of a building is demonstrable and goes beyond the basic requirements of building regulations, standards etc. This can usually be achieved using an environmental assessment methodology or rating system, for example BREEAM (Building Research Establishment Environmental Assessment Method) in the UK, which can assist in reducing the environmental impacts that a building might have by measuring and quantifying its potential environmental performance and help compare different options, e.g., building envelope materials and systems, lighting, heating and ventilation etc. There may also be a desire to achieve a certain level of certified rating under the assessment system such as BREEAM Excellent or Outstanding.

The use of assessment methods and rating systems for new buildings can help encourage clients, developers and design teams to design and construct more sustainable buildings which are more energy efficient, climatic responsive, material and resource efficient, have healthier indoor environments for occupants and limit waste emissions and pollution.

To feed into these environmental assessment systems there is a requirement for information on the environmental impacts that a given material, component, product or system has over its life cycle. This can be achieved by undertaking a Life Cycle Assessment (LCA) and publishing the results in an Environment Product Declaration (EPD).

The overall goal of an EPD is to communicate verifiable and accurate information on the environmental aspects of products that are not misleading. An EPD also provides the basis of a fair comparison of the environmental performance of product, systems etc.

MCRMA members can support, contribute to and enhance a building project's sustainability objectives and requirements through all stages of the procurement process through assistance with developing energy efficient building envelope solutions utilising metal roofing and cladding systems which can offer low maintenance, durability, high recycled content and recyclability. The products and systems can be backed up with LCAs and EPDs to demonstrate their environmental impact and contribute to the accumulation of credits within environmental assessment systems.

2.4 Life Cycle Assessment (LCA) And Environment Profile Declaration (EPD)

A construction product will have an impact on the environment such as raw material usage, energy usage and release of emissions, through all stages of its life. This is known as its life cycle.

This life cycle of the product is often referred to as 'cradle to grave', where the 'cradle' is the extraction of raw materials and the 'grave' is the product's disposal and will take into account the product's use over the building's life expectancy (usually taken as 60 years).

The 'cradle to grave' life cycle will typically include various phases such as:

- Raw material extraction
- Manufacturing and processing
- Transportation (which can occur between other phases)
- Construction and installation
- Use
- Maintenance and repair
- End of life recycling and disposal

A variation to the 'cradle to grave' life cycle is a 'cradle to cradle' life cycle where the disposal stage is replaced with a recycling process that produces material suitable for manufacturing a new product. This life cycle approach can also be referred to as 'closed loop recycling' and features in the circular economy concept which can be defined as "an economic system aimed at eliminating waste and the continual use of resources."

At the end of a building's useful life the 'cradle to cradle' circle closes, and the end of life options need to be considered. Built-up metal roofing and cladding systems can be deconstructed into their component parts with relative ease.

Steel and aluminium are the most common materials used in metal building envelopes and, despite the energy associated with the initial manufacture of these materials, they offer significant advantages when considering the entire system life cycle. They can both be reused or recycled repeatedly without losing their qualities as a building material. The recovery infrastructure for metal recycling is highly developed and highly efficient and has been in place for decades. Aluminium also has a high intrinsic scrap value which also gives a financial incentive to recycle. Percentage wise recovery rates of metals used in construction is in the high 90%.

Metal roofing and cladding sheets are manufactured from materials with a high recycled content from both pre-consumer scrap (i.e. scrap produced during all processing stages) and post-consumer scrap. Aluminium is also available produced from 100% post-consumer scrap, bringing it to the forefront of the 'circular economy' concept.

The mineral wool insulation core of the built-up system contains zero ozone depleting substances which have low global warming potential and no added greenhouse gases, making it easily dealt with. Mineral wool does not have to be treated as special or hazardous waste and can be completely recycled into virgin product. Increasing amounts of recycled materials, both pre-consumer and post-consumer, are used in the manufacture of mineral wool products, typically between 30% to 60% depending on the quality and availability of local supplies.

The concept of life cycle assessment (LCA) originated in the late 1960s when it became clear that the only sensible way to examine industrial systems was to examine their performance. An LCA can be undertaken to assess the environment impacts of a product over this life cycle to a given methodology (in compliance with ISO 21930) considering the following 13 issues:

- Climate change
- Water extraction
- Mineral resource extraction
- Stratospheric ozone depletion
- Human toxicity

- Ecotoxicity to freshwater
- Higher level nuclear waste
- Ecotoxicity to land
- Waste disposal
- Fossil fuel depletion
- Eutrophication
- Photochemical ozone creation
- Acidification

LCAs can take one or two forms either a generic LCA based on industry averaged data for common forms of products/systems or a manufacturer's own LCA for a specific product/system.

The results of an LCA are published in an Environment Product Declaration (EPD) which is developed in a common Type III declaration format to the principles and procedures given in ISO 14025. The overall goal of an EPD is to communicate verifiable and accurate information on the environmental aspects of products that are not misleading. An EPD also provides the basis of a fair comparison of the environmental performance of products.

Manufacturers' own LCAs and EPDs allow their products/systems to be compared to the generic profiles. They are also often broken down further into 'cradle to gate' and 'gate to gate' life cycles. 'Cradle to gate' LCAs assess the environmental impacts of a product prior to it leaving the factory gate and does not consider subsequent life cycle phases. 'Gate to gate' LCAs only consider the environmental impacts during the manufacturing and processing of the product. These forms of LCAs can be useful for a manufacturer as a means of identifying internal processes for environmental improvements.

In the UK, the generic EPDs along with many manufacturers' own EPDs were initially developed using BRE's Environmental Profiles Methodology 2008. The UK generic EPDs form the basis of elemental specifications in the Green Guide to Specification. Other manufacturers have developed EPDs based upon the methodology in EN 15804 which has become the de-facto standard for EPDs. Both these methodologies follow the principles and procedures for a Type III environmental product declaration given in ISO 14025.

MCRMA members can provide EPDs for their products and systems based on LCAs. Figure 2.2. shows extracts from a typical example of an MCRMA member's third party assessed EPD to ISO 14025 and EN 15804.

Environmental Product Declaration
as per ISO 14025 and EN 15804

Owner of the declaration:	Mitsubishi Polyester Film GmbH
Publisher:	Kiwa BCS Öko-Garantie GmbH - Ecobility Experts
Programme holder:	Kiwa BCS Öko-Garantie GmbH - Ecobility Experts
Declaration number:	EPD-ALPOLIC-078-EN
Issue date:	11.10.2019
Valid to:	10.10.2024

ALPOLIC™ Composite Panels

This Environmental Product Declaration (EPD) refers to 1 m^2 of composite metal from Mitsubishi Polyester Film GmbH. The thin sheets consist of two thin aluminium sheets on both sides and a thermoplastic or mineral-filled fire-retardant core. This makes them suitable for curtain walls, rain protection systems and other architectural cladding applications.

ALPOLIC™
MITSUBISHI POLYESTER FILM

5. LCA: Results

The following tables show the results of the impact assessment indicators, resource use, waste and other output streams. The results presented here refer to the declared average product.

Description of the system boundary (X = Included in LCA; MND = Module not declared)																
Product stage			Construction process stage		Use stage							End of life stage				Benefits and loads beyond the system boundaries
Raw material supply	Transport	Manufacturing	Transport from manufacturer to place of use	Construction-installation process	Use	Maintenance	Repair	Replacement	Refurbishmen	Operational energy use	Operational water use	De-construction / demolition	Transport	Waste processing	Disposal	Reuse-Recovery-Recycling-potential
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
x	x	x	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	X	X	MND

Results of the LCA –Environmental impact: 1 m^2 ALPOLIC™ Composite Panel				
Parameter	Unit	A1 – A3	C3	C4
Global warming potential	[kg CO_2-Eq.]	2.52E+01	2.31E-02	9.17E-03
Depletion potential of the stratospheric ozone layer	[kg CFC11-Eq.]	8.35E-09	2.21E-13	9.19E-14
Acidification potential of land and water	[kg SO_2-Eq.]	9.73E-02	1.46E-04	4.97E-05
Eutrophication potential	[kg $(PO_4)^{3}$-Eq.]	1.63E-02	3.68E-05	7.66E-06
Formation potential of tropospheric ozone photchemical oxidants	[kg Ethen-Eq.]	3.32E-03	1.12E-05	3.27E-06
Abiotic depletion potential for non fossil resources	[kg Sb-Eq.]	1.26E-05	3.77E-08	3.03E-09
Abiotic depletion potential for fossil resources	[MJ]	3.42E+02	4.03E-01	1.09E-01
Results of the LCA –Resource use: 1 m^2 ALPOLIC™ Composite Panel				
Parameter	Unit	A1 – A3	C3	C4
Renewable primary energy as energy carrier	[MJ]	7.87E+01	3.10E-02	1.28E-02
Renewable primary energy resources as material utilization	[MJ]	0.00E+00	0.00E+00	0.00E+00
Total use of renewable primary energy resources	[MJ]	7.87E+01	3.10E-02	1.28E-02
Non renewable primary energy as energy carrier	[MJ]	2.39E+02	4.13E-01	1.12E-01
Non renewable primary energy as material utilization	[MJ]	1.57E+02	0.00E+00	0.00E+00
Total use of non renewable primary energy resources	[MJ]	3.96E+02	4.13E-01	1.12E-01
Use of secondary material	[kg]	1.60E+00	-	-
Use of renewable secondary fuels	[MJ]	-	-	-
Use of non renewable secondary fuels	[MJ]	-	-	-
Use of net fresh water	[m^3]	2.702E-01	6.27E-04	1.43E-04
Results of the LCA –Output flows and waste categories: 1 m^2 ALPOLIC™ Composite Panel				
Parameter	Unit	A1 – A3	C3	C4
Hazardous waste disposed	[kg]	8.92E-04	2.95E-08	2.57E-09
Non hazardous waste disposed	[kg]	4.01E+01	2.15E-02	5.40E-01
Radioactive waste disposed	[kg]	2.12E-02	4.01E-06	1.57E-06
Building materials for re-use	[kg]	-	-	-
Materials for recycling	[kg]	7.84E+00	-	-
Materials for energy recovery	[kg]	5.16E-02	-	-
Exported energy	[MJ]	-	-	-

Page | 7 Mitsubishi Polyester Film GmbH – ALPOLIC™ Composite Panels

Figure 2.2 – Example of an MCRMA member's EPD

2.3.1 BRE Green Guide to Specification

Generic product LCAs and EPDs form the basis of the BRE (Building Research Establishment) Green Guide to Specification (Green Guide). Initially published in 1996 as a simple to use 'green guide' to the environmental impacts of common building materials and products. It has undergone regular updates and expansion with the final hard copy 4th edition being published in 2009 after which it was developed and updated as an online version (www.thegreenguide.org.uk/).

The online version (BRE Green Guide 2008) provides guidance for specifiers, designers and their clients on the relative environmental impacts of many elemental specifications for roofs, walls, floors etc. The Green Guide is used as part of BREEAM (BRE Environmental Assessment Method) to assess the credits for materials specification, alongside other BRE on-line tools such as IMPACT.

Manufacturers can also obtain BRE Green Guide 2008 ratings for their materials, products and systems using BRE's Environmental Profiles Methodology for use in BREEAM etc. Details of these ratings are published on BRE's Green Book Live website (www.greenbooklive.com).

The relative environmental impacts of various construction materials and elements have been examined for different generic building types in the following six categories:

- Domestic
- Healthcare
- Industrial
- Commercial buildings e.g. offices
- Retail
- Educational

Materials and components are arranged on an elemental specification basis covering a number of elemental categories including:

- External wall construction
- Internal walls and partitions
- Roof construction
- Ground floors
- Upper floors
- Windows
- Insulation
- Landscaping
- Floor finishes

The individual elemental specifications based on 1 square metre of construction each have an individual elemental number and a rating for each of the 13 environmental issues as indicated in the section on LCAs and EPDs taken over a 60-year period. There is also a summary rating. These Green Guide ratings are ranked A+, A, B, C, D and E with A+ representing the best environmental performance (lowest impact) and E being the worst (highest impact). The ratings for an individual element specification may also differ slightly based on the building type.

Earlier versions of the generic element specifications in the on-line Green Guide. The Ecopoint score a single unitless score and is a summary of the environmental impact of the element specification obtained from the combined results of a life cycle assessment against the 13 environmental issues. For example, 100 Ecopoints is taken as the environmental impact of one western European citizen over one year. The higher the Ecopoints an element specification has, the worse the environmental impact of that specification. Current versions of individual manufacturers' specifications will still probably have an Ecopoint score.

As there is a drive to reduce CO_2 emissions from all buildings, the current versions of the generic element specifications give an overall equivalent kg of CO_2 emissions over the 60 period for 1 square metre of the element. Again, this is obtained from the combined results of the life cycle assessment against the 13 environmental issues and the higher the value, the worse the environmental impact of that specification.

The Green Guide although current is in the process of being discontinued. BRE has introduced the BRE EN 15804 Scheme for EPDs which is running concurrently with the existing EPD scheme. From 2021 the Green Guide will no longer be used in BREEAM to assess the credits for materials specification. Current Green Guide environmental ratings will remain valid for BREEAM schemes already in process but any new EPDs will need to comply with the EN15804 version; it has stated that the Green Guide will remain online until 2025.

2.3.1.1 Metal roofing systems and BRE Green Guide to Specification

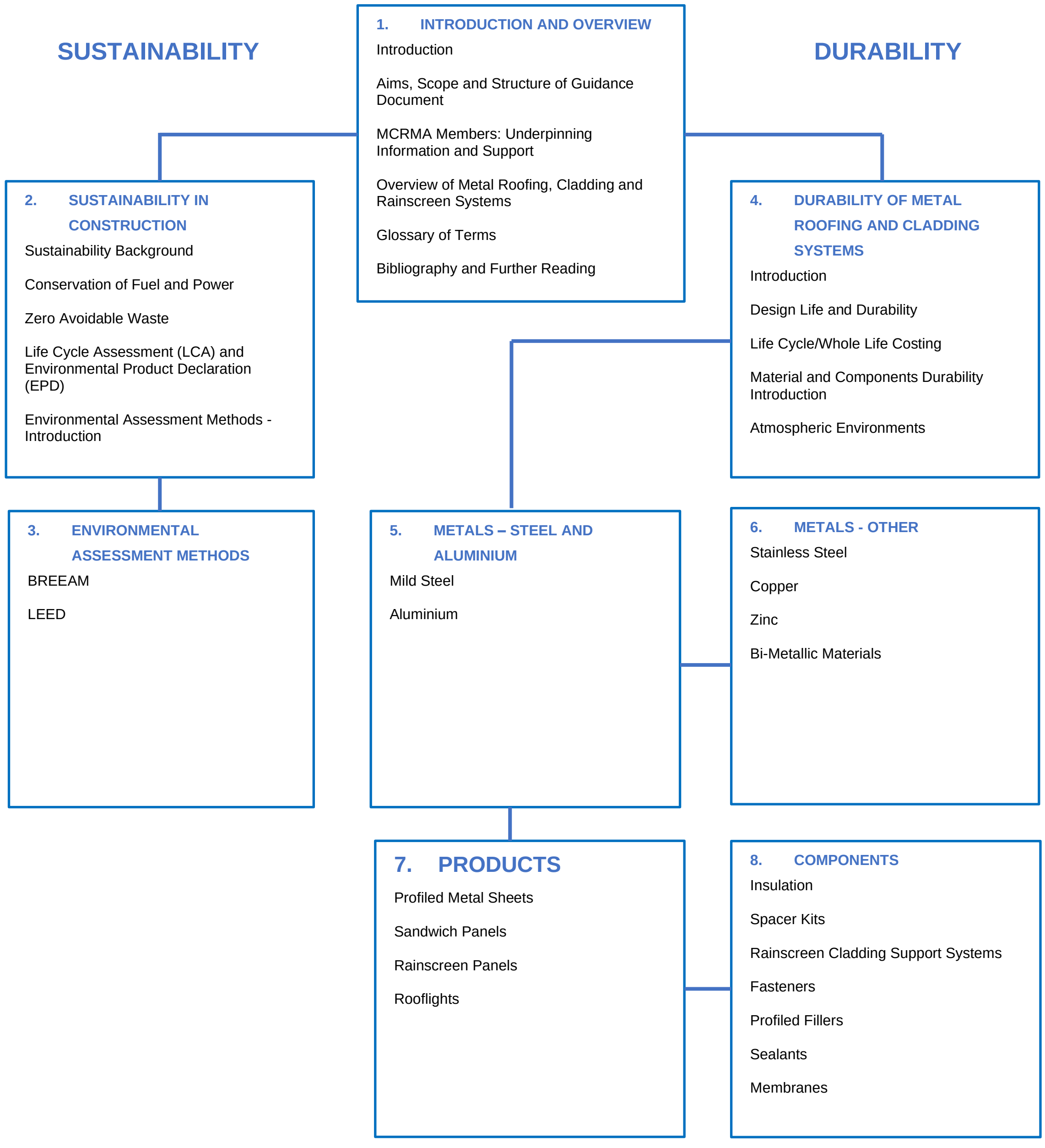
Metal roof systems are generally included in element type *Low Pitched Roofing* of the *Roof Construction* element category and all have an A+ or A summary rating.

Table 2.1 gives an overview of a selection of built-up double skin insulated (mineral based) metal roof systems supported on galvanised steel rafters and joists for non-domestic building types.

Element Number	Outer Sheet	Liner Sheet	kg of CO_2 eq. (60 years)	Summary Ratings for Non-Domestic Building Types				
				Health	Industrial	Commercial	Retail	Education
1212550001	Uncoated aluminium standing seam	Steel	68.0	A+	A+	A+	A+	A+
1212550002	Coated aluminium	Coated aluminium	85.0	A	A+	A+	A	A+
1212550003	Uncoated aluminium standing seam	Aluminium	85.0	A	A+	A+	A	A+
1212550004	Coated aluminium standing seam	Steel	93.0	A	A+	A+	A	A+
1212550005	Uncoated aluminium	Uncoated aluminium	62.0	A+	A+	A+	A+	A+
1212550006	Uncoated aluminium standing seam	Aluminium	85.0	A	A+	A+	A	A+
1212550010	Coated steel	Coated steel	100.0	A	A+	A+	A	A+
1212550012	Copper standing seam	Steel	90.0	A	A	A	A	A

Table 2.1 Summary of BRE Green Guide for Specification Ratings for Built-up Metal Roofing Systems (www.thegreenguide.org.uk/).

2.5 STRUCTURE OF GD 39



Pictorial overview of MCRMA guidance document GD39: Sustainability and durability of metal roofing and cladding systems

2.6 GLOSSARY OF TERMS

BRE Green Guide to Specification Generic product LCAs and EPDs form the basis of the BRE (Building Research Establishment) Green Guide to Specification (Green Guide). Initially published as a simple to use 'green guide' to the environmental impacts of common building materials and products. It has undergone regular updates and expansion as an online version which provides guidance for specifiers, designers and their clients on the relative environmental impacts of many elemental specifications for roofs, walls, floors etc.

BREEAM (Building Research Establishment Environmental Assessment Method) A voluntary scheme which can be used to assess the environmental performance of most types of building (new and existing). Developed by BRE (Building Research Establishment) it is the world's longest established environmental assessment system and is used internationally as well as in the UK.

COP (Conference of the Parties) 26 The 26th Meeting of the Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC). The COP26 conference was held in Glasgow in November 2021 hosted in partnership by UK and Italy. Previous notable COP conferences took place at Kyoto (COP3) in 1997 and Paris (COP21) in 2015. These and other conferences have led to commitments to climate change, reduction of greenhouse gases and keeping global temperature rise this century below 2°C (preferably 1.5°C) above pre-industrial levels have been agreed.

CSR (Corporate Social Responsibility) The self-regulated responsibility of companies to society in areas such as the environment, the economy, employee well-being etc. Most companies, especially larger ones, now report on their CSR, a major element of which is the carbon footprint of a company's activities and their efforts to reduce it.

Environmental assessment method/rating system A methodology and/or rating system where various environmental impact factors are assessed against given criteria and points/credits are awarded. The total number of points/credits obtained will provide an indication of the environmental friendliness of a building design and its operation. The use of environmental assessment methods and rating systems can help encourage clients, developers and design teams to design and construct more sustainable buildings which are more energy efficient, climatic responsive, material and resource efficient, have healthier indoor environments for occupants and limit waste emissions and pollution.

EPD (Environment Profile Declaration) The results of an LCA are published in an EPD which is developed to a common format e.g., to the principles and procedures given in ISO 14025. The overall goal of an EPD is to communicate verifiable and accurate information on the environmental aspects of products that are not misleading. An EPD also provides the basis of a fair comparison of the environmental performance of products.

Greenhouse Gases Greenhouse gas emissions from human activities strengthen the greenhouse effect, causing climate change. Some of the gases occur naturally in the atmosphere, while others result from human activities. The seven greenhouse gases which contribute directly to climate change are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF_3). The largest contributor to global warming is carbon dioxide (CO_2) which makes it the focus of many climate change initiatives.

LCA (Life Cycle Assessment) An assessment of the environment impacts of a product over its life cycle to a given methodology e.g., compliance with ISO 21930, considering several environmental issues. This life cycle of the product is often referred to as '*cradle to grave'*, where the *'cradle'* is the extraction of raw materials and the *'grave'* is the product's disposal and will consider the product's use over the building's life expectancy. A variation is a '*cradle to cradle'* life cycle where the disposal stage is replaced with a recycling process that produces material suitable for manufacturing a new product. LCAs are often broken down further into '*cradle to gate*' and '*gate to gate*' life cycles which can be useful for a manufacturer as a means of identifying internal processes for environmental improvements.

LCC (Life Cycle Costing) An LCC will consider all relevant costs over the defined life of a building covering construction costs, operation and occupancy costs, maintenance costs, renewal costs, and end of life costs as well as any environmental costs.

LEED (Leadership in Energy and Environmental Design) Green Building Rating System A voluntary, standard for developing high-performance, sustainable buildings developed by the US Green Building Council (USGBC). Although developed in and for the USA it is used internationally including the UK.

NDC – Nationally Determined Contributions National action plans on how countries will meet their commitments to climate change, reduction of greenhouse gases and rise in global temperature.

Net Zero Carbon/Net Zero Total greenhouse gas emissions going into the atmosphere e.g., from a particular process are equal to (or less) than the removal of greenhouse gases out of the atmosphere.

WLC (Whole Life Costing) A WLC will cover all the costs in an LCC as well as non-construction costs and incomes.

ZAW (Zero Avoidable Waste) The prevention of waste being generated at every stage of a project's lifecycle, from the manufacture of materials and products, the design, specification, procurement and assembly of buildings and infrastructure through to deconstruction. At the end of life, products, components and materials should be recovered at the highest possible level of the waste hierarchy, whilst ensuring minimal environmental impact.

2.7 BIBLIOGRAPHY AND FURTHER READING

The following is a list of support documents and publications that were used in the development of this guidance document, and which will provide further reading on the subject.

Approved Document B Volume 2 – *Buildings other than dwellinghouses – Fire Safety (for use in England)*

Aurubis – *Copper Book for Architecture*

BES 6001 – *BRE Framework Standard for Responsible Sourcing*

BRE BR502 – *Sustainability in the built environment: An introduction to its definition and measurement*

BRE Digest 489 – *Wind loads on roof-based photovoltaic systems*

BRE Information Paper IP 13/10 – *Cool roofs and their application in the UK*

BREEAM – *BREEAM UK New Construction – Non-domestic Building (United Kingdom) – Technical Manual – 2014*

BREEAM – *BREEAM UK New Construction – Non-domestic Building (United Kingdom) – Technical Manual - 2018*

BS ISO 15686-5:2017 – *Buildings and constructed assets. Service life planning. Life-cycle costing*

BS 7543:2015: *Guide to durability of buildings and building elements, products and components*

BS EN 1990: 2002+A1: 2005 (incorporating corrigenda December 2008 and April 2010) – *Eurocode – Basis of structural design*
NA to BS EN 1990: 2002+A1: 2005 (Incorporating National Amendments No.1) – *UK National Annex for Eurocode – Basis of structural design*
BS EN 15804: 2012+A2:2019 (incorporating corrigenda February 2014 and July 2020) – *Sustainability of construction works – Environmental product declarations – Core rules for the product category of construction products*
BS EN ISO 14001:2015 – *Environmental management systems. Requirements with guidance for use*
BS EN ISO 9001:2015 – *Quality management systems. Requirements*
BS EN 14782:2006 – *Self-supporting metal sheet for roofing, external cladding and internal lining. Product specification and requirements*
BS 5427:2016+A1:2017: *Code of practice for the use of profiled sheet for roof and wall cladding on buildings*
BS EN ISO 12944-2 *Paints and varnishes. Corrosion protection of steel structures by protective paint systems. Classification of environments*
BS 476-22:1987 – *Fire tests on building materials and structures. Part 22: Method for determination of the fire resistance of non-loadbearing elements of construction*
BS EN 506:2008 – *Roofing products of metal sheet. Specification for self-supporting products of copper or zinc sheet*
BS EN 1172:2011 – *Copper and copper alloys. Sheet and strip for building purposes*
BS EN 988:1997 – *Zinc and zinc alloys. Specification for rolled flat products for building*
BRE – *BRE Building Elements: Roofs and roofing: Performance, diagnosis, maintenance, repair and the avoidance of defects - Third Edition*
BSSA – *Stainless Steel and Sustainable Construction*
CAB – *Aluminium & sustainability: a 'cradle to cradle' approach*
CLC/GBC – *Zero Avoidable Waste in Construction*
CLC/GBC – *The Routemap for Zero Avoidable Waste in Construction*
Constructing Excellence – *Sustainable Construction: An Introduction*
Constructing Excellence – *Whole Life Costing*
CP 143-5:1964 – *Code of practice for sheet roof and wall coverings. Code of practice for sheet roof and wall coverings. Zinc*
CPA – *COP26 – An Introduction*
CPA – *Net Zero Carbon – What on Earth does it mean?*
CPA - *A guide to understanding the embodied impacts of construction products*

CWCT Technical Note 33 - *Breather membranes and vapour control layers in walls*
CWCT – *Guidance on built-up walls*
Euro-Inox – *Technical Guide to Stainless Steel Roofing*
Euro-Inox – *Cleaning Architectural Stainless Steel*
Hydro – *Circular economy – the design perspective. From theory to implementation*
International Molybdenum Association (IMOA) – Which *stainless steel should be specified for exterior applications?*
ISO 21930:2017 - *Sustainability in buildings and civil engineering works — Core rules for environmental product declarations of construction products and services*
ISO 14025:2006 - *Environmental labels and declarations — Type III environmental declarations — Principles and procedures*
MCRMA Article – The factors to consider when installing PV panels
MCRMA Membership Charter
MCRMA Guidance Document GD01 – *Built up systems and spacer stability*
MCRMA Guidance Document GD08 – *An introductory guide to rainscreen support systems*
MCRMA Guidance Document GD11 – *Fixings and fastenings for rainscreen systems*
MCRMA Guidance Document GD12 - *Composite flooring systems: Sustainable construction solutions*
MCRMA Guidance Document GD17 – *A guide to site installation of insulated roof panels*
MCRMA Guidance Document GD19 – *Effective sealing of end laps in metal roofing constructions*
MCRMA Guidance Document GD21- *Thermal performance of buildings: non-domestic construction*
MCRMA Guidance Document GD22 – *Installing renewables on metal roofs: A checklist*
MCRMA Guidance Document GD28 – *Mineral wool insulation installation: Best practice guide*
MCRMA Guidance Document GD 33 – *Fasteners for metal roofing and wall cladding: design, detailing and installation guide*
MCRMA Guidance Document GD 34 – *The definition of cladding within the construction sector*
NARM Technical Document NTD09 2014 - *Rooflights: glass, polycarbonate or GRP?*
NARM Technical Document NTD15 2018 - *A guide to rooflights for profiled sheeted roofs*
NFRC – *Profiled sheet roofing and cladding – The NFRC guide to design and best practice (Blue Book)*
NFRC Technical Bulletin 36 – *Performance standards of building strip sealants in metal clad buildings*

RICS NMM3 - *New rules of measurement: Order of cost estimating and cost planning for building maintenance works*

RICS Guidance Note – *Life cycle costing*

UK Government – *COP26 Explained*

USGBC – *LEED v4 for Building Design and Construction*

USGBC – *LEED v4.1 for Building Design and Construction*

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