Mitsubishi Electric Guide to Embodied Carbon

Information Guide 82

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Mitsubishi Electric Guide to Embodied Carbon

This is an independent guide produced by Mitsubishi Electric to enhance the knowledge of its customers and provide a view of the key issues facing our industry today.

This guide accompanies a series of seminars, all of which are CPD certified.

Contents

Introduction - Embodied Carbon

We have put this guide together to help explain what Embodied Carbon is, why it is so important and what we are doing now to ensure we can support our customers in **delivering sustainable Net Zero buildings by 2050.**

Reducing the environmental impacts of the built environment has become a priority given the climate crisis we all face. As the built environment is a significant contributor to man-made emissions, it is imperative that we better understand the main causes of these emissions and work to reduce them.

Buildings generate emissions throughout their lifetime, from design, build, use and end-of-life disposal. Much focus has been placed on reducing those emissions produced during a building's use stage - known as Operational Carbon. While operational emissions from the built environment are significant, they do not account for the emissions generated through the construction process; the manufacture, transportation, and installation of its component parts or, for the disposal of these at the end of the building's useful life. These emissions are known as **Embodied Carbon**.

To make well-informed decisions that will help to mitigate global warming, consulting engineers, architects and clients need to embrace whole-life carbon emissions. This term refers to both operational and embodied carbon emissions, from manufacturing, transportation, constructing, repairing, and maintaining a building, through to deconstructing the building and processing waste.

As a leading manufacturer of HVAC equipment, Mitsubishi Electric intend to offer a greater degree of transparency to the industry. This will enable our clients to truly assess the impact of using or specifying our equipment.

NET ZERO


CO_2

The climate change imperative

The Intergovernmental Panel on Climate Change (IPCC) is the United Nations body for assessing the science related to climate change. They provide regular assessments of the scientific basis of climate change, its impacts and future risks, and options for adaptation and mitigation through the IPCC Assessment Reports.

The 6th Assessment report presents the findings of a collaboration of hundreds of experts across many countries, cultures and disciplines and represents the clearest scientific evidence for man-made impacts on the climate.

This report addresses the most up-to-date physical understanding of the climate system and climate change, bringing together the latest advances in climate science, and combining multiple lines of evidence from paleoclimate, observations, process understanding, and global and regional climate simulations. The report also shows that human actions still have the potential to determine the future course of the climate.

The evidence is clear that carbon dioxide (CO_2) is the main driver of climate change. Reducing man made emissions can limit the trajectory of global average temperature increases and through this, avoid the worst effects of a rapidly changing climate system.

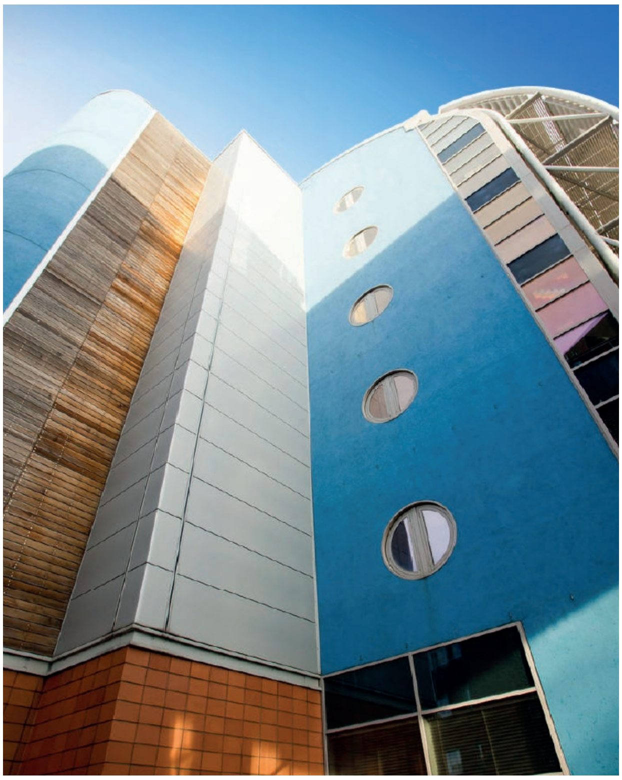
Global action

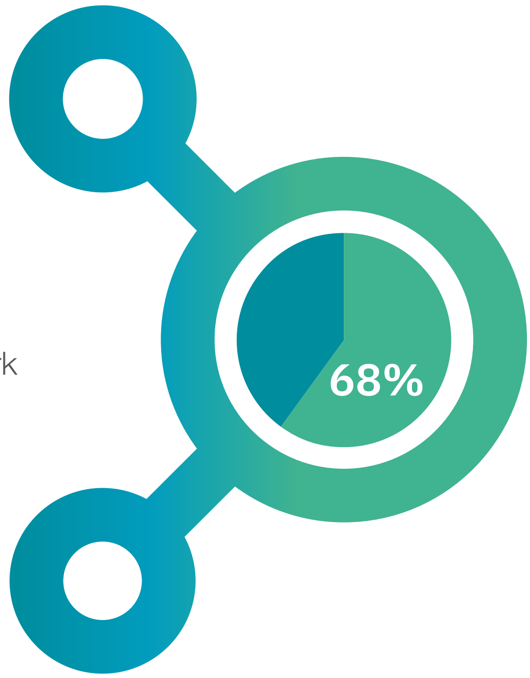
Global action is required to meet the climate change imperative. From multilateral agreements and resulting regulatory changes across different industries, to operational changes in the way companies do business and how individuals live, work, and consume, changes will be required at all levels.

International agreements have been a driving force behind our progress in reducing man-made emissions, and multilateral cooperation is a key driver of many of the changes that are being made regarding sustainability.

The Paris Agreement is a legally binding international treaty on climate change. Adopted in 2015 by 196 nation states, its goal is to limit global warming to well below 2, preferably to 1.5 degrees Celsius, compared to pre-industrial levels.

Reaching this goal will require economic and social transformation by all of its signatories. To achieve this the agreement calls for nations to carry out a process known as the 'ratchet mechanism' every five years. This will provide improved commitments to emissions reductions through their Nationally Determined Contribution (NDC).





Nationally Determined Contribution (NDC)
On 12 December 2020, the UK communicated its new National Determined Contribution (NDC) under the Paris Agreement to the United Nations Framework Convention on Climate Change (UNFCCC).

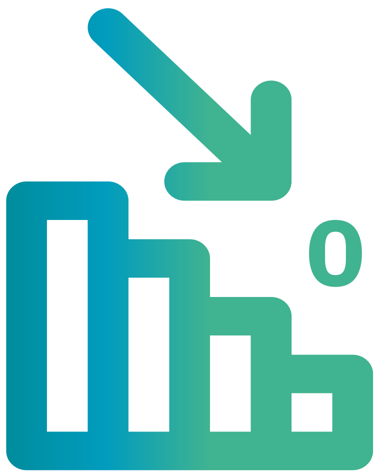
The NDC commits the UK to reducing economy-wide greenhouse gas emissions by at least **68% by 2030**, compared to 1990 levels. It also includes information on how this target was developed and is quantified, known as 'information to facilitate clarity, transparency and understanding' (ICTU).

PARIS2015 UN CLIMATE CHANGE CONFERENCE COP21·CMP11	Intended Nationally Determined Contributions	CAT analysis of NDC update	Stronger target	Economy-wide coverage
			Fixed/absolute target	Additional supporting targets
			Net Zero target	NDC aligned with Net Zero

The United Nations Framework Convention on Climate Change (UNFCCC) is the parent treaty of the Paris Agreement. States that are Parties to the UNFCCC meet annually at the Conference of the Parties (COP) event.

The COP event is where the final decisions are taken between all the countries that have signed up to the Paris Agreement.

This regular meeting looks at all the national plans, discusses whether these are sufficient to meet the goals and works to make it easier to implement them.



What is Net Zero?

Net Zero refers to a state in which the amount of greenhouse gases (GHG) being emitted into the atmosphere are balanced by processes to remove them. This is an important milestone, as the damage done to the climate is a result of the difference between our current emissions and the amount of carbon removed from our atmosphere. When a balance between these has been reached, the warming effect on our climate will stop accelerating.

The Paris Agreement highlights the need for global Net Zero carbon emissions to be reached, requiring states to 'achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century'. Net Zero is the internationally agreed upon goal for mitigating global warming, and the IPCC has concluded that this goal must be achieved by 2050 in order to limit global average temperature rises to no more than 1.5 degrees.

Pledges to be Net Zero by 2050, 2040 or even 2030 are being made and we need to **act now** and decide how we are going to achieve these milestones.

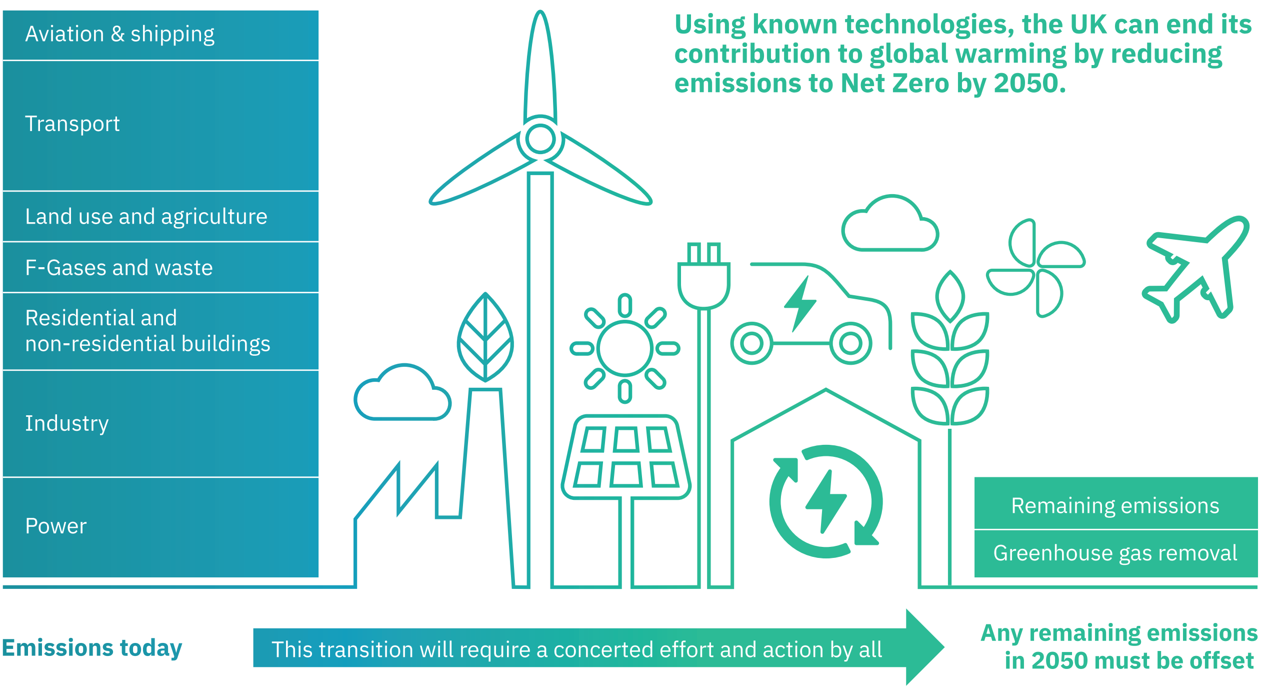
NET ZERO

There are two different routes that can help us achieve Net Zero, which work in tandem: reducing existing emissions and actively removing greenhouse gases - also known as 'Carbon Capture' or 'Carbon Sequestering'. A Net Zero target requires deep reductions in emissions across many different sectors and this requires actions from agents at every level of an economy, from nation states to companies to individuals.

Government Strategies

Country-level emissions accounting across the world is conducted on a territorial basis, with each country only counting emissions that directly arise from activity within their geographical boundary. This prevents double counting of emissions and more closely links to levers available at the country level to reduce emissions. The UK, for example, has set a Net Zero target for 2050, that relates to its territorial (or production) emissions.

The graphic below depicts the various UK contributors to emissions on the left, and the task ahead to reduce these to the levels on the right. There are some emissions that are irreducible and, by 2050, every kilogram of CO_2 equivalent greenhouse gas that is emitted in the UK will have to be offset through a form of Carbon Sequestration to achieve the balance of being a Net Zero economy.



Source: Climate Change Committee

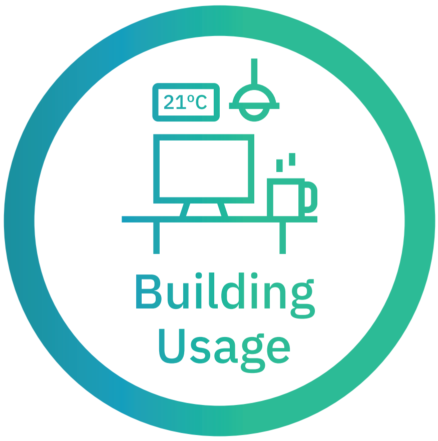
The built environment

Given that buildings contribute around 40% of greenhouse gas emissions worldwide, it is critical that architecture, engineering, and construction professionals understand the role they need to play in reducing the sector's carbon footprint and how to use the tools available to assist them. Emissions from the built environment can be separated into two categories: **Operational Carbon Emissions and Embodied Carbon Emissions.**

Operational Carbon

Operational Carbon refers to the total GHG emissions produced by a building during its useful or operational life.

These emissions arise from energy consuming activities such as the heating, cooling, ventilation, and lighting needs of the building - also known as 'regulated' emissions as they fall under **Part L of the Building Regulations 'Conservation of fuel and power'** - as well as other 'unregulated' emissions such as those from appliance use and small power plug loads from the day-to-day activities of the people using it.



To understand how a building's operational energy emissions can achieve Net Zero we must identify where the emissions are coming from:

Direct Emissions

Direct emissions are those generated in the building or on the site. A good example of this would be the burning of natural gas for the provision of heat using a traditional gas boiler. Gas is pumped into the building, burned as a fuel source and releases GHGs directly into the atmosphere as a result.

Indirect Emissions

Indirect emissions are those created due to the activities in the building but occur at a different location. This could be the emissions generated from the electricity used in the building; these emissions are not produced on the site of the building itself but are an indirect result of the building's electricity demand.

Great strides continue to be made in reducing operational carbon emissions in buildings by tackling direct and indirect sources:

	Direct	Indirect
Reduce energy demand within building e.g. using greater insulation	✓	✓
Reduce use of fossil fuel equipment on site	✓	
Decarbonise electricity grid by replacing fossil fuel with renewable generation sources		✓
Install highly energy efficient, electrically driven equipment		✓
Improve control systems to optimise operation of equipment	✓	✓
Install on-site electrical generation equipment		✓

Net Zero Carbon - Operational Energy:

“A ‘Net Zero Carbon - Operational Energy’ asset is one where no fossil fuels are used, all energy use has been minimised, meets the local energy use target (e.g. kWh/m^2/a) and all energy use is generated on-or-off-site using renewables that demonstrate additionality. Direct emissions from renewables and any upstream emissions are ‘offset’.”

CIBSE LETI Net Zero FAQ document 2022.

We have in the past focused our climate efforts on operational-energy consumption in the pathway to Net Zero. However, there is another, less obvious source of GHG emissions associated with buildings: **Embodied Carbon**

The built environment

Embodied Carbon

The definition of a ‘building’ when we consider embodied carbon is the sum of all the parts that make it; the materials used, and the equipment selected.

Embodied carbon is the total GHG emissions generated to produce a built asset. This means that to calculate the embodied carbon for a building we need to understand the environmental cost to the planet for the extraction, processing, manufacture, delivery and assembly of every single product or material used in its construction.

Throughout a building’s lifetime some maintenance or replacement of these products or materials will be necessary and this also needs to be measured as a part of calculating embodied carbon. At the end of the building’s useful life more emissions will be produced because the asset needs to be deconstructed or preferably refurbished and re-purposed. Any products that are disposed of must be part of an embodied carbon calculation.

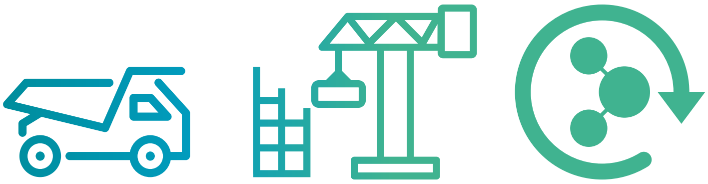
For building and construction projects to achieve true Net Zero carbon levels, the embodied carbon footprint needs to be included in the calculation or we are at risk of neglecting a large amount of upfront carbon emissions.

Net Zero Embodied Carbon

A **‘Net Zero Embodied Carbon’** asset is one where the sum total of GHG emissions and removals over an asset’s life cycle are minimised, meets local carbon targets (e.g. $kgCO_2e/m^2$) and with additional ‘offsets’, equals zero.

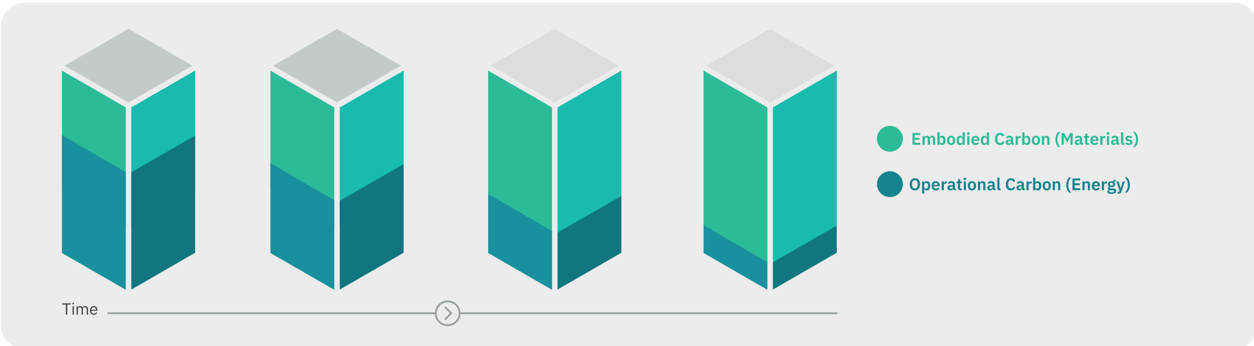
NET ZERO EMBODIED CARBON

CIBSE LETI Net Zero FAQ document 2022.



The relationship between embodied and operational carbon emissions of a building will change over its lifetime. Operational carbon will continue to reduce because of the ever cleaning electrical grid and reduction of fossil fuels.

Potential breakdown between embodied and operational carbon for new buildings over time:



The embodied carbon of a building will not reduce over its lifetime. Therefore to reduce the embodied carbon emissions of new building projects we must consider how building materials, construction practices and the Mechanical and Electrical Products (MEP) used within the building will impact overall embodied carbon and address these elements in the design stage.

Ways to reduce embodied carbon within a building:

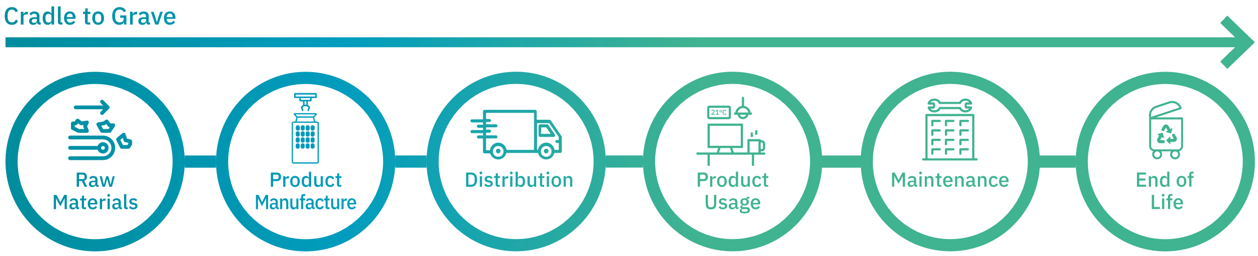
Action	Supporting Questions
Re-use existing building stock	Do we have to construct a new building? Can we re-use an existing building by refurbishing and upgrading?
Build efficiently	Can low carbon / recycled materials be used? Is the building design the most efficient use of the space and materials? Has wastage been minimised? Have efficient building practices been considered? e.g. modular build.
Sustainable supply chain	Are companies within the supply chain employing sustainable practices? Can building materials and MEP be sourced locally?
Select low embodied carbon MEP and HVAC systems	Do you have embodied carbon data for MEP on site? Are MEP being selected and deployed in the most efficient way?

By focussing on embodied carbon emissions at the design stage, our goal of Net Zero emissions may be easier to achieve as the volume of emissions that need to be offset is reduced.

The built environment

Whole Life Carbon

Only by considering both operational carbon and embodied carbon together can we understand the total emissions from a building over its lifetime. This is known as Whole Life Cycle (WLC) Carbon and this metric can be applied to the entire building and the MEPs used within it. This can also be referred to as a "Cradle to Grave" calculation.



Using WLC carbon as a measure we can get a better understanding of the trade-offs that can be made between embodied and operational carbon relating to their cumulative impact over time. A building component that delivers low operational carbon emissions over its lifetime may have higher embodied carbon emissions to begin with. Alternatively low embodied carbon products may have lower efficiency leading to higher operational carbon emissions. A WLC carbon analysis will enable us to deliver the minimum level of carbon emissions by the end of the building's useful life, thus making the Net Zero target easier to achieve.

Mitsubishi Electric Corporation's SUSTIE Net Zero-Energy Building (ZEB) test facility, Tokyo.

Working with embodied carbon in the built environment

The construction industry is just beginning to get to grips with the concept of embodied carbon for complex MEP products. Currently there is no specific requirement for embodied carbon of MEP products to be considered in building regulations or planning applications nationally, although some local authorities are starting to require this.

However, we are seeing many clients focussing on embodied carbon and trying to go beyond the legislative requirements of the industry, reducing their carbon footprint and helping to mitigate their individual impact of climate change. To assist this positive choice, industry bodies such as the UK Green Building Council (UKGBC), Royal Institute of British Architects (RIBA) & The London Energy Transformation Initiative (LETI) have come together to provide guidance on what realistic and stretch targets for the whole building embodied carbon per m^2 should be, both now and in the future.

This approach will facilitate better decision making and to provide clients with a reference to point to when requesting embodied carbon be considered in their building. Additionally forward-thinking construction companies and consultants are using their own knowledge of this subject to help grow their businesses and secure more environmentally conscious projects by considering embodied carbon within their designs.

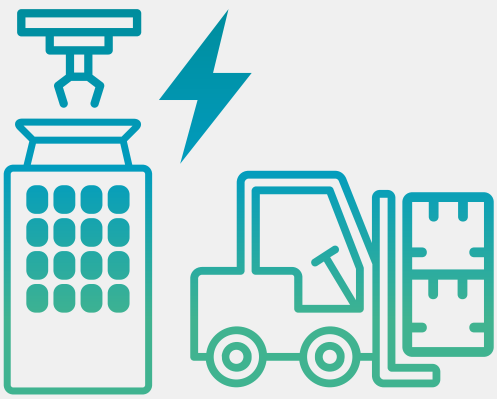
Product Data - The starting point

It has become critical for manufacturers of MEP equipment to fully understand and document the raw material makeup, manufacturing energy usage and packaging break down of their products. This information must be detailed and clear so that it can be used to calculate the amount of embodied carbon within the product.

The Product Environmental Passport (PEP) is the standard being used in France and provides a formal template that manufacturers can use to collate product build data.

At least 95% of the product's official weight must be accounted for in the PEP for the document to be valid. Every material used in the product and packaging must be accounted for with an accurate associated weight.

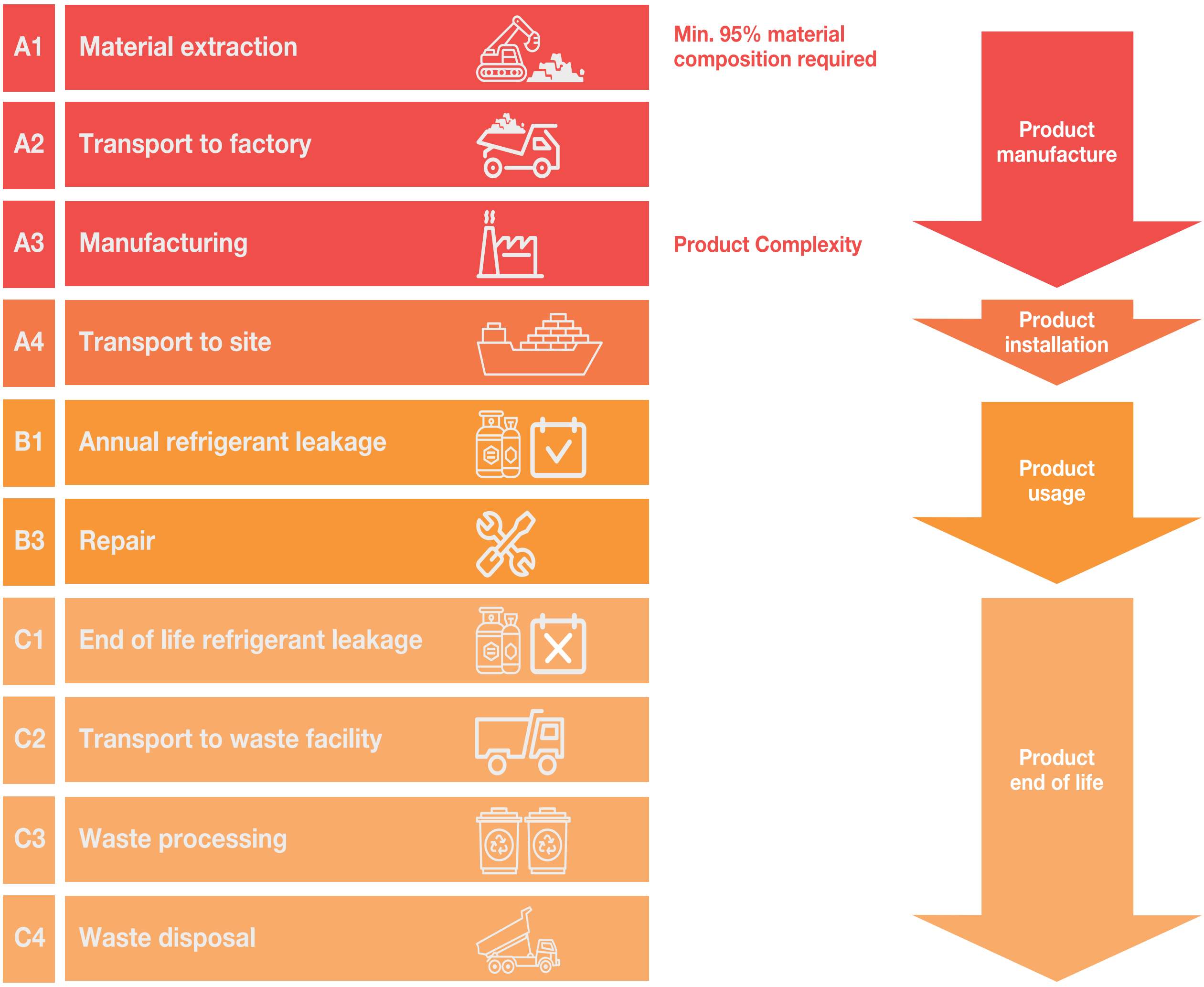
An important part of PEP is that it allows interpolation by weight between similar products within a range. As a large-scale manufacturer PEP allows us to to efficiently produce embodied carbon data for all our products.



Working with embodied carbon in the built environment

Calculating embodied carbon from product raw data

In January 2021 The Chartered Institution of Building Services Engineers CIBSE issued their latest technical memorandum on **"Embodied Carbon In Building Services: A Calculation Methodology," TM65:2021.** This document has provided much-needed guidance and consistency in embodied carbon calculations and reporting for complex MEP services. **The TM65 calculation methodology takes all the information within the PEP and groups this data into sections for calculation. As follows:**



Each of these sections are aggregated in the calculation to obtain the overall embodied carbon of the product. The value of embodied carbon is given as kg of CO_2 equivalent. The higher this value, the more embodied carbon the product has.

It is important to note that the embodied carbon of any additional refrigerant required to be added on site, for example in a VRF system, is not included in the TM65 calculation for the outdoor unit. The amount of additional refrigerant required on site for VRF systems can vary greatly, depending on pipe run and system make up. This will give different values for embodied carbon and is not suitable for standardised TM65 product data. The carbon associated with the leakage of this additional refrigerant is also not included. However refrigerant added at the factory is included, as well as any leakage of this refrigerant over the lifespan of the system.

Working with embodied carbon in the built environment

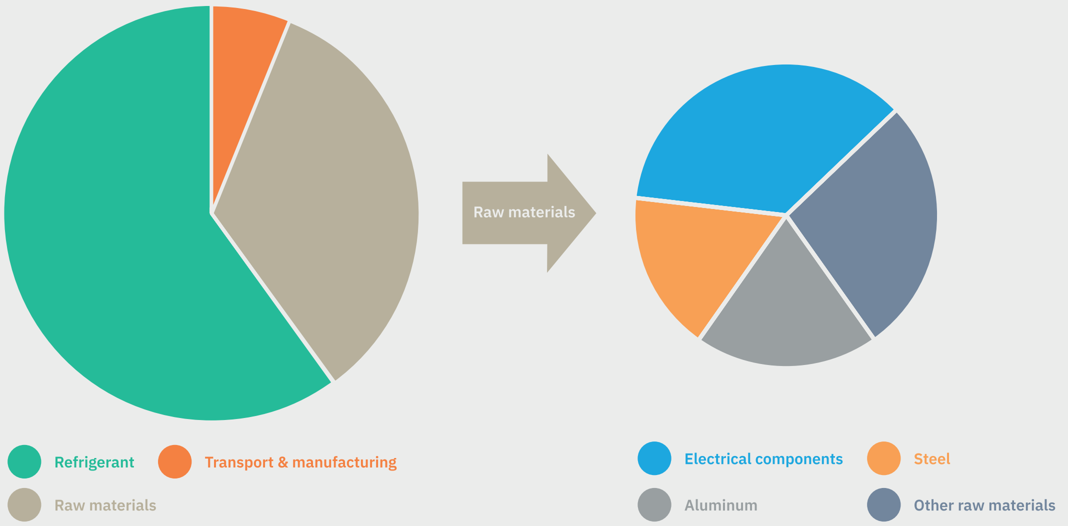
TM65 Calculation analysis - CAHV-P500YB-HPB

Inputting the product raw data from the factory (via the PEP) for a Mitsubishi Electric CAHV-P500YB-HPB commercial air to water heat pump into the TM65 calculation gives a figure of **11,273kgCO_2e** for embodied carbon. The calculation methodology allows us to investigate the contribution of individual components to a product's overall embodied carbon.

CAHV-P500YB-HPB
Embodied Carbon TM65 Calculation
Click on the icon or Scan the QR Code

TM65

CAHV-P500YB-HPB



We see that a large contributor to embodied carbon in MEP are the small electrical components and printed circuit boards. These components have a high concentration of exotic metals and plastics and carbon intensive manufacturing processes resulting in a high carbon footprint. It is difficult for manufacturers to reduce embodied carbon by focussing on these elements.

However, the choice and volume of refrigerant used has the largest impact on a product's embodied carbon. Selecting products using lower GWP refrigerants and systems that use lower refrigerant volumes will reduce a building's embodied carbon thus making it easier to offset during its lifetime.

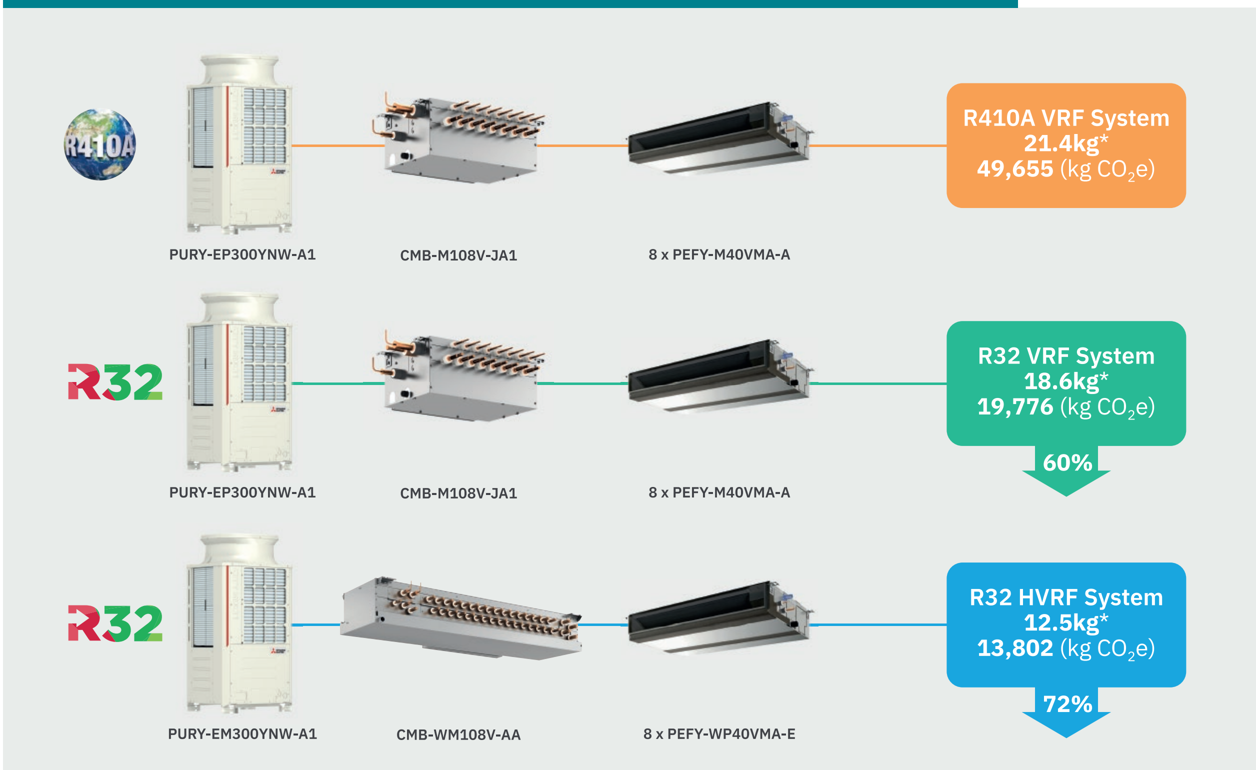
Whole System Analysis

To understand fully the embodied carbon associated with a complete system we must consider all the component parts that make up the system.

A TM65 calculation can be completed for each component giving an individual embodied carbon figure in $kgCO_2e$. These individual figures can be added together to generate an embodied carbon figure in $kgCO_2e$ for the whole system. Although the additional refrigerant charge of the outdoor unit is not included in its TM65 calculation, it is possible and essential to account for working refrigerant charge when considering the embodied carbon of a whole HVAC system.

The following example shows 3 different ways to achieve a 30kW cooling requirement using VRF systems. The output and experience for the end user will be similar when using these systems but each has a unique level of embodied carbon, primarily governed by the type and quantity of refrigerant used.

High efficiency heat recovery system delivering 30kW cooling via 8 x 4kW ducted indoor units (50m main pipe run):



Note: This calculation does not include physical pipework, structural accessories, electrical wiring and electrical accessories

*Additional refrigerant charge

Working with embodied carbon in the built environment

Whole System Analysis

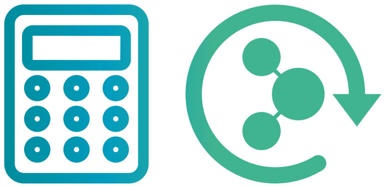
High efficiency heat recovery system delivering 30kW cooling via 8 x 4kW ducted indoor units (assumes 50m pipe run for added refrigerant).						
$kgCO_2e$	R410A VRF		R32 VRF		R32 HVRF	
Outdoor unit + Factory Charge Refrigerant	PURY-EP300YNW-A1 + 5.2kg Refrigerant	12,741	PURY-EM300YNW-A1 + 5.2kg Refrigerant	5,907	PURY-EM300YNW-A1 + 5.2kg Refrigerant	5,907
Site Added Refrigerant	+ 16.2kg Refrigerant	31,457	+ 13.4kg Refrigerant	8,412	+ 7.3kg Refrigerant	4,583
BC Box	CMB-M108V-JA1	545	CMB-M108V-JA1	545	CMB-WM108V-AA	848
Indoor Units	8 x PEFY-M40VMA-A	(8 x 614) 4912	8 x PEFY-M40VMA-A	(8 x 614) 4912	8 x PEFY-WP40VMA-E	(8 x 308) 2464
Total Embodied Carbon	49,655		19,776		13,754	
Embodied Carbon per kW	1,655		659		460	
Approximate Embodied Carbon Reduction	Baseline		60%		72%	

Note: This calculation does not include physical pipework, structural accessories, electrical wiring and electrical accessories

Significant reductions in system embodied carbon can be achieved by using lower GWP technologies such as HVRF. We are focussing our product development efforts to minimise impacts of both operational and embodied carbon.

Mitsubishi Electric is continually collating product raw material data and producing TM65 calculations. All future products will have an accompanying TM65 documents as soon as practicable after launch. TM65 calculations can be found on our Document Library here: **library.mitsubishielectric.co.uk**

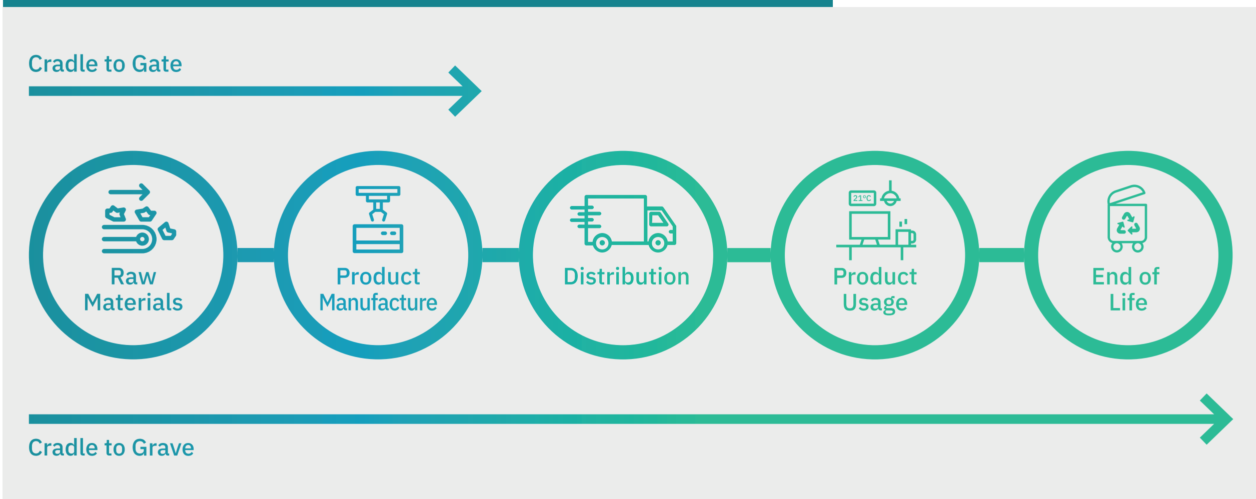
The future of embodied carbon calculation



Whilst embodied carbon is becoming ever more important, as an industry, we must not detract our focus from continually driving down operational carbon emissions from building services products, therefore allowing a Whole Life-Cycle Carbon approach to be maintained. Whole Life-Cycle Carbon is the true measure of a product or building's impact on the environment.

An Environmental Product Declaration (EPD) is a document that transparently communicates the overall environmental impact of a product or material over its whole life-cycle. Just like the TM65 calculation, EPD considers all aspects of a product's embodied carbon. In addition, operational carbon emissions are also included in the calculation methodology to give the total carbon emissions figure.

Environmental Product Declarations (EPD)



EPDs are a standardised way of providing the Whole Life-Cycle Carbon and other environmental impacts of a product.

Due to the level of detail required in the methodology and complexity of building services products and their supply chains, very few EPDs have been produced within the industry. This will change in the future as manufacturers become more familiar with the requirements of EPD. Mitsubishi Electric will work towards producing EPDs on certain product ranges as part of our commitment to improved accuracy in assessing the environmental impact of our products.

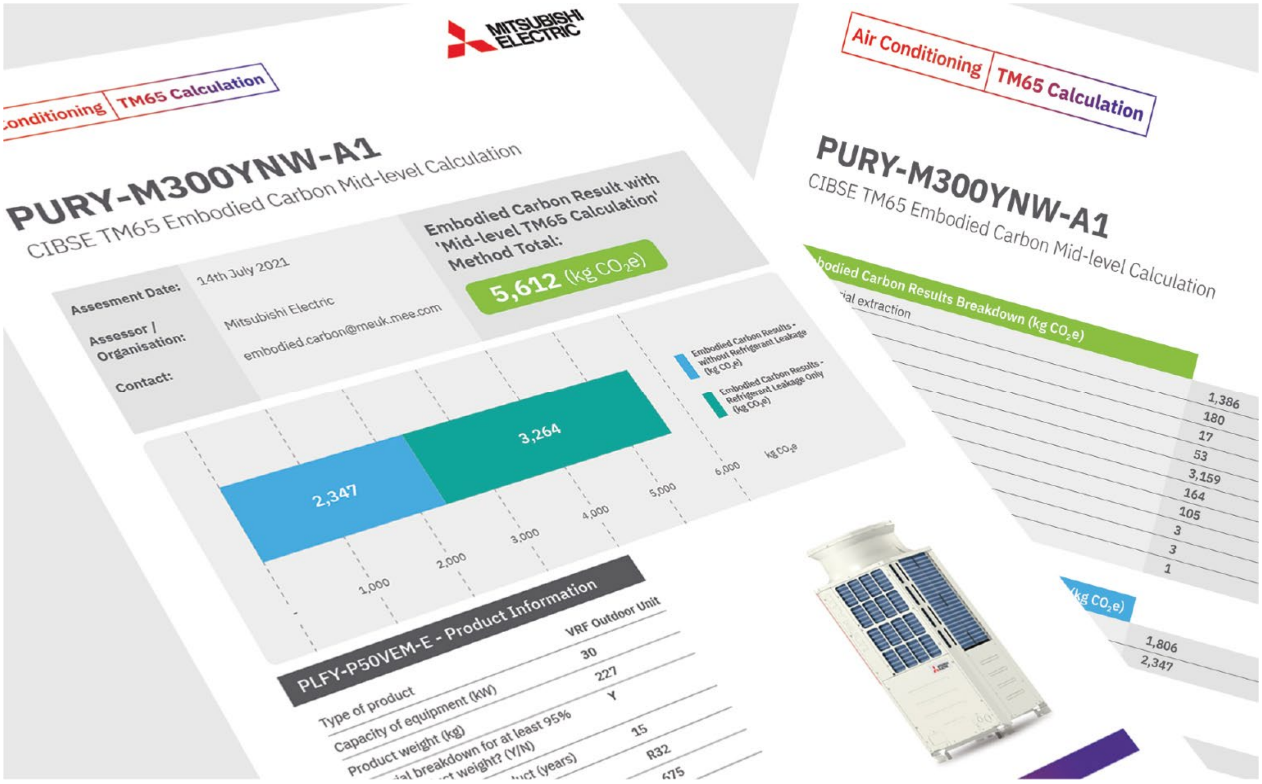
Alongside PEPs and TM65, EPDs provide a consistent method of comparing the embodied carbon of equivalent products from multiple manufacturers. Different systems and technologies from various manufacturers delivering similar outputs can also be assessed together using these standardised reports.

The future of embodied carbon calculation

Customers are now seeking EPDs, TM65 & PEPs on MEP products to feed embodied carbon data into software packages that will generate overall carbon information for the whole building. This practice will only increase going forwards. Due to the clarity of these reports, industry professionals can see the logic behind manufacturers' carbon data and make allowances in the software to best suit the project needs.

The demand for embodied carbon data of building services products is increasing rapidly. Customers and end users now expect manufacturers to provide some indication of the carbon within their products. This is a positive step for the industry as it demonstrates that multiple stakeholders want to know the overall environmental impact of their building project, and how that impact can be minimised.

Mitsubishi Electric will continue to produce embodied and operational carbon data on all our products to help the construction industry on the journey to Net Zero carbon emissions.



To receive a CPD seminar on 'Embodied Carbon', you can call your Mitsubishi Electric Regional Sales Office to arrange an in-house presentation of this information.

If you would like to receive invitations to future CPD events, please email **livingenvironmentalsystems@meuk.mee.com**

Further information

Regional Sales Offices, please call one of the numbers below:

Birmingham
Tel: 0121 329 1970

Bristol
Tel: 01454 202050

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Tel: 01924 241120

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Tel: 01506 444960

Manchester
Tel: 0161 866 6060

London South Region
Tel: 01737 387170

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Note: The fuse rating is for guidance only. Please refer to the relevant databook for detailed specification. It is the responsibility of a qualified electrician/electrical engineer to select the correct cable size and fuse rating based on current regulation and site specific conditions. Mitsubishi Electric's air conditioning equipment and heat pump systems contain a fluorinated greenhouse gas, R410A (GWP:2088), R32 (GWP:675), R407C (GWP:1774), R134a (GWP:1430), R513A (GWP:631), R454B (GWP:466), R1234ze (GWP:7) or R1234yf (GWP:4). *These GWP values are based on Regulation (EU) No 517/2014 from IPCC 4th edition. In case of Regulation (EU) No.626/2011 from IPCC 3rd edition, these are as follows. R410A (GWP:1975), R32 (GWP:550), R407C (GWP:1650) or R134a (GWP:1300).

Effective as of July 2023

Green Gateway greengateway.mitsubishielectric.co.uk