MITSUBISHI ELECTRIC

# HVAC Retrofit - Considerations for Commercial Buildings:

## Setting the Stage for Efficiency and Sustainability

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# Introduction

**The UK's great building retrofit movement is underway.**

Across the country, building owners are working to prepare their properties for the UK's low-carbon future, with a range of retrofit projects focused on improving building performance.

**What's more, we need to accelerate the retrofitting of our existing commercial building stock if we are to meet the Net Zero 2050 goals. A report by property consultant JLL[1] estimates that the UK must increase the pace of retrofits by 5% each year, requiring double the levels seen in the past decade.**

This means lowering the carbon footprint and reducing energy consumption across a vast section of buildings. We must also have the skills in the construction workforce to deliver buildings for our low carbon future.

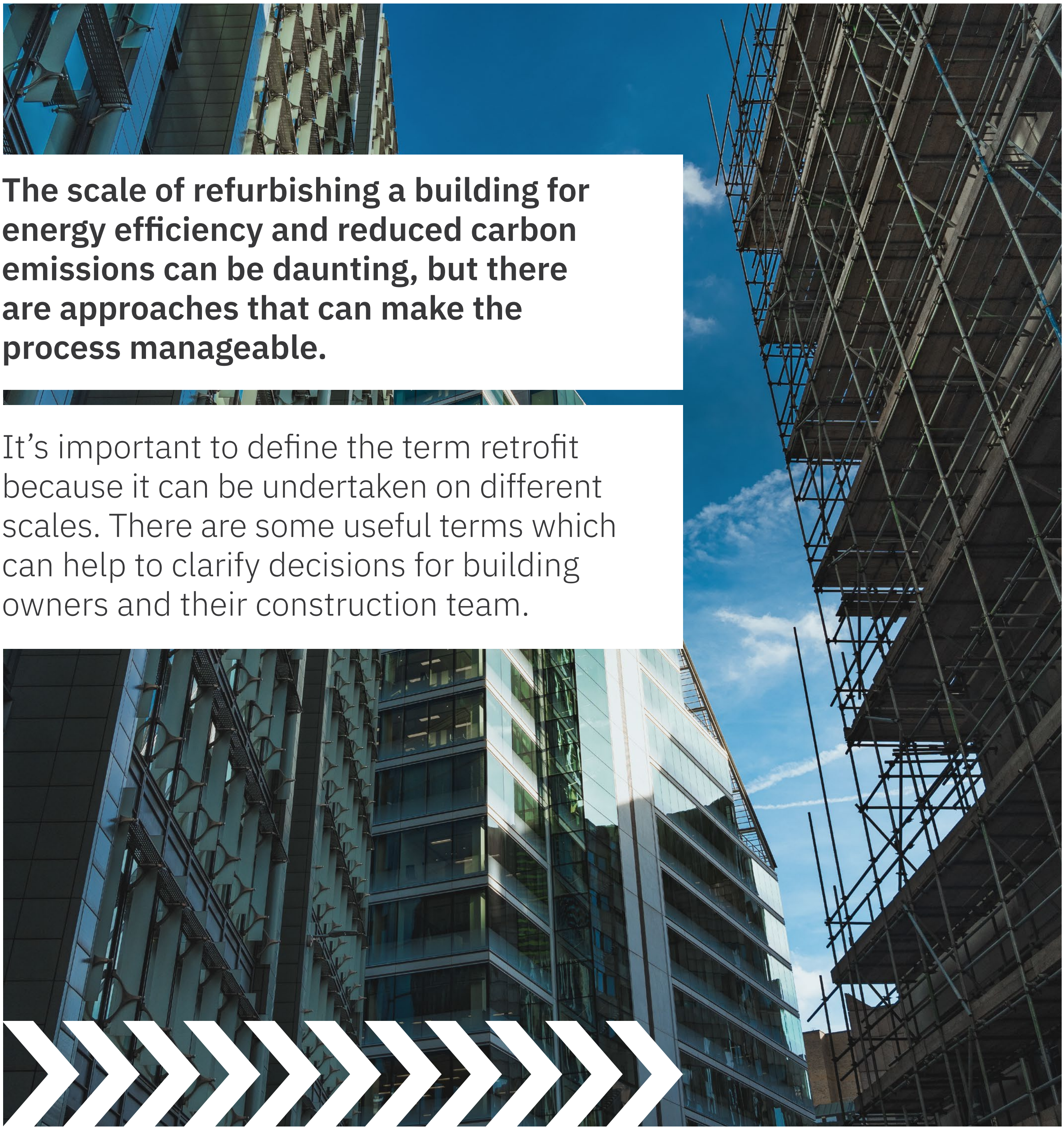
Efficiency and sustainability are the watchwords for these projects, as private and public sector landlords strive to achieve new regulatory standards and meet the demands of increasingly environmentally conscious tenants. They are also preparing their properties for changes in the UK climate as we experience altered weather patterns such as hotter summers and wetter winters.

**This guide aims to provide building owners with an understanding of the principles of retrofitting, helping them to plan improvements to their property that suit their budget, timeline, and sustainability goals.**

**It will also support HVAC contractors who are discussing options with their clients as they join the retrofit revolution for efficient and sustainable buildings.**

**This guide includes links to other Mitsubishi Electric publications that provide in-depth information on some of the complex issues mentioned here.**

# 1: What does 'retrofit' mean?



**The scale of refurbishing a building for energy efficiency and reduced carbon emissions can be daunting, but there are approaches that can make the process manageable.**

It's important to define the term retrofit because it can be undertaken on different scales. There are some useful terms which can help to clarify decisions for building owners and their construction team.

# 1

## Light Retrofit

**A light retrofit is one which focuses on optimising building performance.**

The approach is likely to spotlight a single feature, such as lighting upgrades or improved building controls to enhance building energy performance. It can also include packaged HVAC upgrades, such as replacing fan coil units, radiators, or pipework.

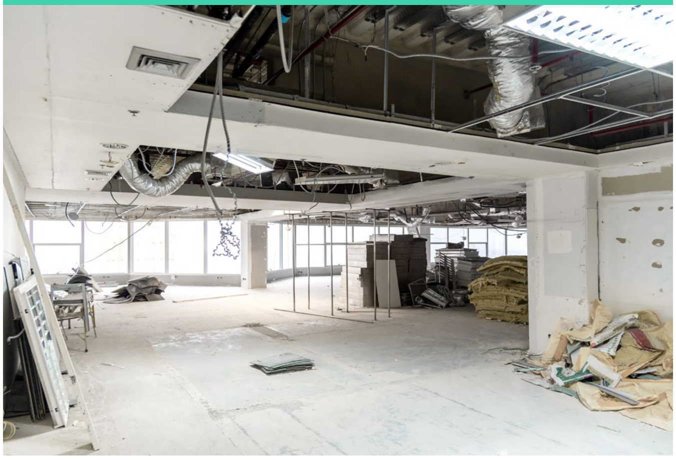
Overall, light retrofit involves minimal disruption to building occupants, often without a building shutdown. The benefit of a light retrofit is that it's possible to focus on one area of a building and offers the opportunity to retrofit a whole building in a phased approach, for example floor-by-floor.

## Deep Retrofit

**As the name implies, this process involves more substantial refurbishment of a building which encompasses significant changes to building services or even structure.**

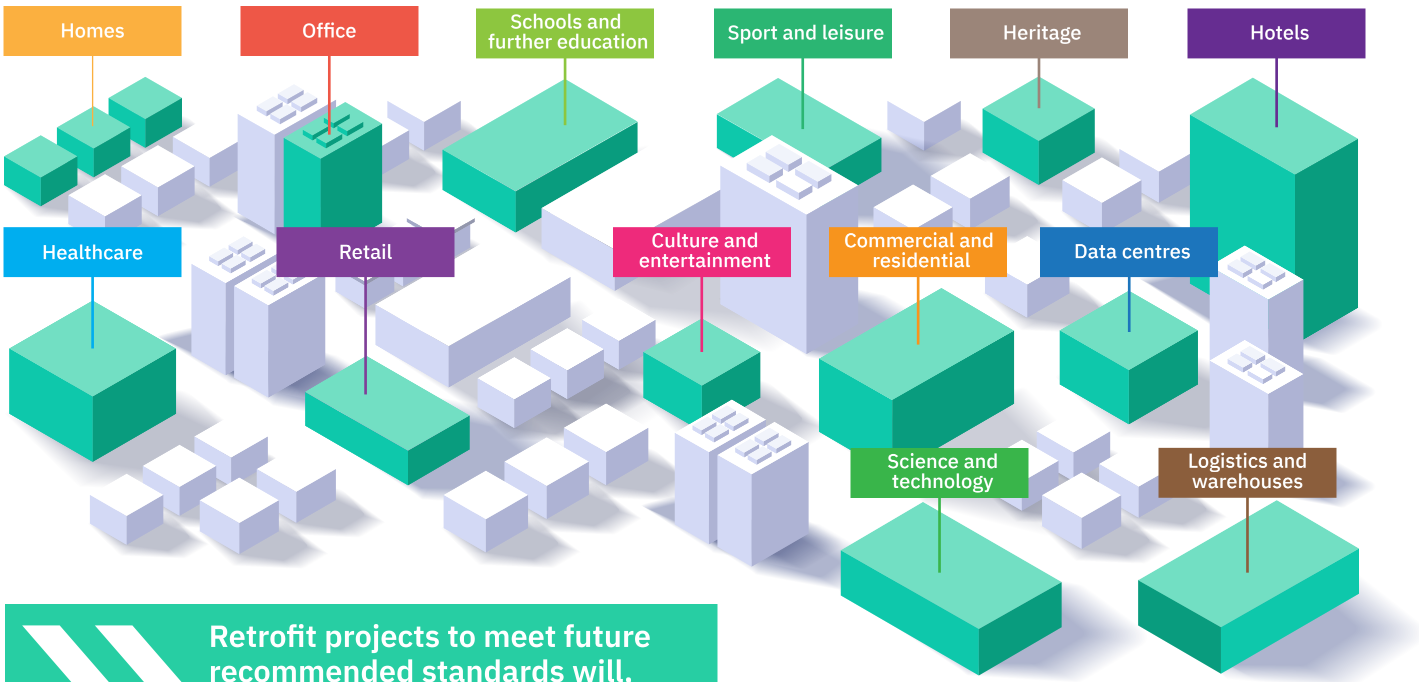
Major plant replacement may be considered deep retrofit, but generally a deep retrofit is defined by its scale and impact. Deep retrofit is more likely to be required for buildings that need large energy savings to comply with energy efficiency regulations such as MEES (Minimum Energy Efficiency Standards). A deep retrofit can be carried out in one project or as a series of activities over time.

Projects which fall into the deep retrofit category include façade replacement to improve building airtightness, insulation of walls and complete replacement of gas-fired boilers in electrification projects.



Another important point to bear in mind is that retrofit will look different depending on the type of building where the project is being delivered. This is not only because buildings have widely different designs and operations but also because it's likely that different targets will be set in future legislation.

For example, the **UK Net Zero Carbon Buildings Standard**, is currently being developed by a range of organisations including CIBSE, the Carbon Trust, RICS, UKGBC and others. **Several sectors have been identified where the Standard would establish building performance targets and limits for each:**




**Retrofit projects to meet future recommended standards will, therefore, reflect the targets and requirements for each sector.**

# 1

## Net Zero Carbon Buildings

### A shared definition

**Although there is growing interest in achieving 'net zero carbon' buildings, there is currently no legal definition (i.e. one that is set out in Building Regulations, for example).**

However, a number of leading organisations in the construction and property sector have come together to establish a science-based definition so that building owners, designers and contractors can share and understand a common terminology.

The UK Net Zero Carbon Buildings Standard (UKNZCBS), currently being developed by a group of leading construction and property organisations, defines a net zero building as:

> "A building whose operational and embodied carbon performance is within limits which allow the UK built environment to stay within its own allocation of remaining carbon budget in order to limit warming to 1.5ºC."


**Useful links to further reading:**

- Mitsubishi Electric CPD Guide to UK Net Zero 2050 Roadmap and the Built Environment
- Mitsubishi Electric CPD Guide to The Sustainable Buildings Landscape
- Ask ME about the UK Net Zero Carbon Buildings Standard on Apple Podcasts

# Critical steps in retrofit

It may be the case that a building owner undertakes a light retrofit before a deep retrofit or phases a deep retrofit into smaller projects. In either case, there are **two critical early steps:**

## 1. Planning

## 2. Tracking and optimisation

**These go hand-in-hand. It is vital to understand the building in its current state before thinking about taking action.**

First steps include gathering data on current energy use and compiling detailed information about key plant in the building. It is also important to know what challenges may lie ahead, as these may provide 'trigger points' for retrofitting.

For example, if the building is a university there are opportunities to carry out work during vacation periods, but some buildings may be occupied year-round. In an office building, it may be the end of a tenancy with an occupant changeover.

It may be useful to consider investing in building energy modelling and carbon assessment of the building.

Identifying where embodied carbon may be reduced (e.g. by reusing materials or through the use of lower-GWP refrigerants in HVAC systems) can be helpful.

This is also a good point to check local planning requirements before making decisions about retrofit projects. For example, some Local Authorities are encouraging the use of approaches such as ambient loops or heat networks. In addition they may have set carbon targets for buildings or projects over a threshold size.

Tracking and optimisation mean that data on energy use must be collected during and after retrofit.

**Reducing the carbon emissions of existing buildings is a process of continuous improvement and data collection is a vital part of delivering that.**

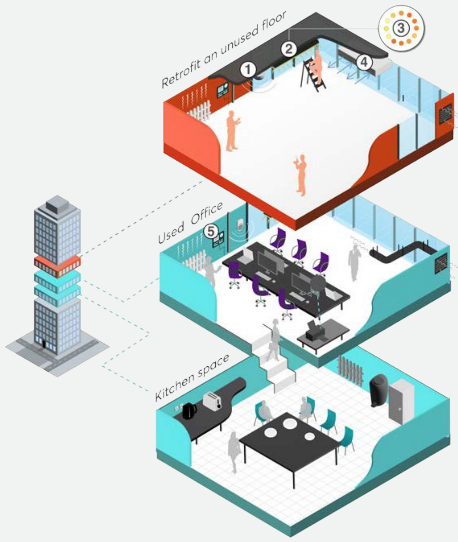
# Retrofit strategy

**Planning**

## Tracking and Optimisation

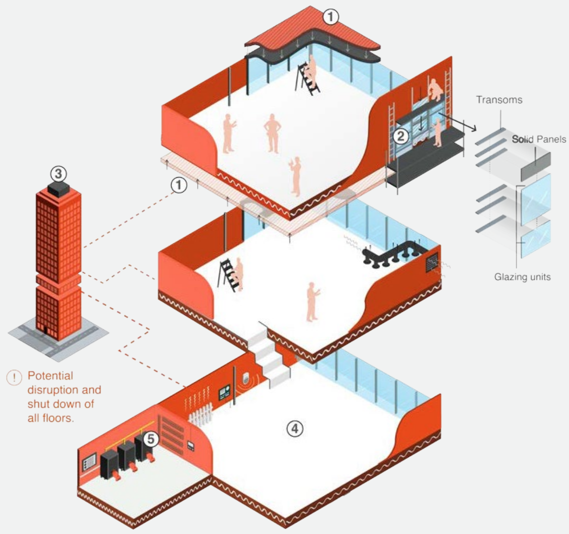
- Energy Performance Measuring
- Control Improvements
- Occupier Engagement

## Light Retrofit




- Limited Disruption Measures
- Preparatory Works (for Deep)
- Building Services Works

## Deep Retrofit




- Significant Works / Changes
- Reconsider Building as a System
- Building Fabric Improvements
- Building Services Major Works

(Diagram from the UK Green Building Council Delivering Net Zero publication)

## Useful links to further reading:

- **Whole Life Carbon Brochure** (Mitsubishi Electric)
- **Energy Efficiency and Carbon Reduction for the Retail Industry** (Mitsubishi Electric & The British Retail Consortium)
- **Energy Efficiency and Carbon Reduction in Retail Warehousing** (Mitsubishi Electric & The British Retail Consortium)
- **Energy Efficiency and Net Zero Guide for University Estates** (Mitsubishi Electric)
- **Lower Carbon Classrooms White Paper** (Mitsubishi Electric)

# Some important definitions

**When thinking about retrofitting for efficiency and sustainability, it is useful to have some definitions, particularly regarding the concept of carbon in buildings**.

## Embodied carbon:

Measures the carbon emissions resulting from the manufacture, transportation and installation of materials and equipment used in a building. Embodied carbon also includes emissions created during maintenance, repair and replacement of any part of the building (or equipment) and during dismantling or demolition.

Information on the embodied carbon of a product can be supplied by a manufacturer in the form of an Environmental Product Declaration (EPD) or calculated using CIBSE’s TM65 tool.

## Operational carbon:

Refers to direct and indirect emissions produced when the building is in use. Direct emissions may include the use of on-site fossil fuels (e.g. gas or oil boilers). Indirect emissions are the result of energy use in the building, including by HVAC systems.

**Together, these factors make up the whole life carbon (WLC) profile of a building**.

### Useful links to further reading:

**Mitsubishi Electric CPD Guide to Whole Life Carbon in the Built Environment**

**Mitsubishi Electric CPD Guide to Embodied Carbon**

**Mitsubishi Electric CPD Guide to Operational Carbon in New and Existing Buildings**

# Energy Use Intensity (EUI)

## The link between energy use and carbon emissions

**There is a strong link between energy efficiency and reducing the whole life carbon of a building. So it's important to consider these factors in tandem.**

Energy Use Intensity (EUI) measures a building's energy use in terms of kilowatt hours per meters squared per annum (kWh/m$^2$/annum). This figure provides a useful target for energy use that relates to lower operational carbon emissions.

When multiple fuel sources are being used to deliver that energy (such as gas via a boiler for heating and electricity via a chiller for cooling), converting these different energy consumptions into a single metric of kilowatt hours of electric equivalent (kWhee) helps to provide comparison across different buildings using different fuel types.

For example, **RIBA's 2030 Climate Action Challenge** sets EUI targets for operational energy in different types of building. Offices are expected to achieve less than 75 kWh/m$^2$/y by 2025 and less than 55 kWh/m$^2$/y by 2030. For schools, those figures are less than 70 kWh/m$^2$/y and less than 60 kWh/m$^2$/y respectively.

The **NABERS UK rating scheme** (for offices) also uses EUI as its key measure for benchmarking and allocating ratings, regarding this as the most transparent approach to demonstrating a building's energy performance.

### Useful links to further reading:

**Mitsubishi Electric CPD Guide to Operational Carbon in New and Existing Buildings**

**Mitsubishi Electric Solution Overviews:**

**Bivalent Heating Systems**

**Cascade High Temperature Heat Pumps**

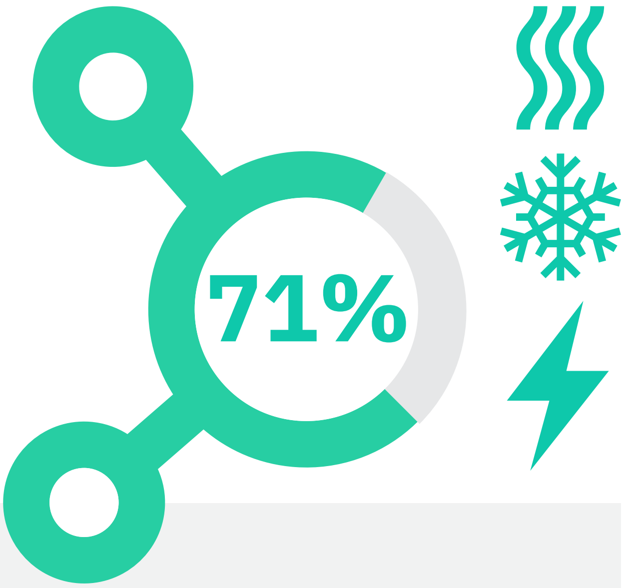
# 2: Retrofit and HVAC

**HVAC systems significantly impact a building's embodied and operational carbon emissions**

# 2

## Even in buildings which don't use fossil fuels on site, the use of electricity generated from gas or coal-fired power stations results in emissions.

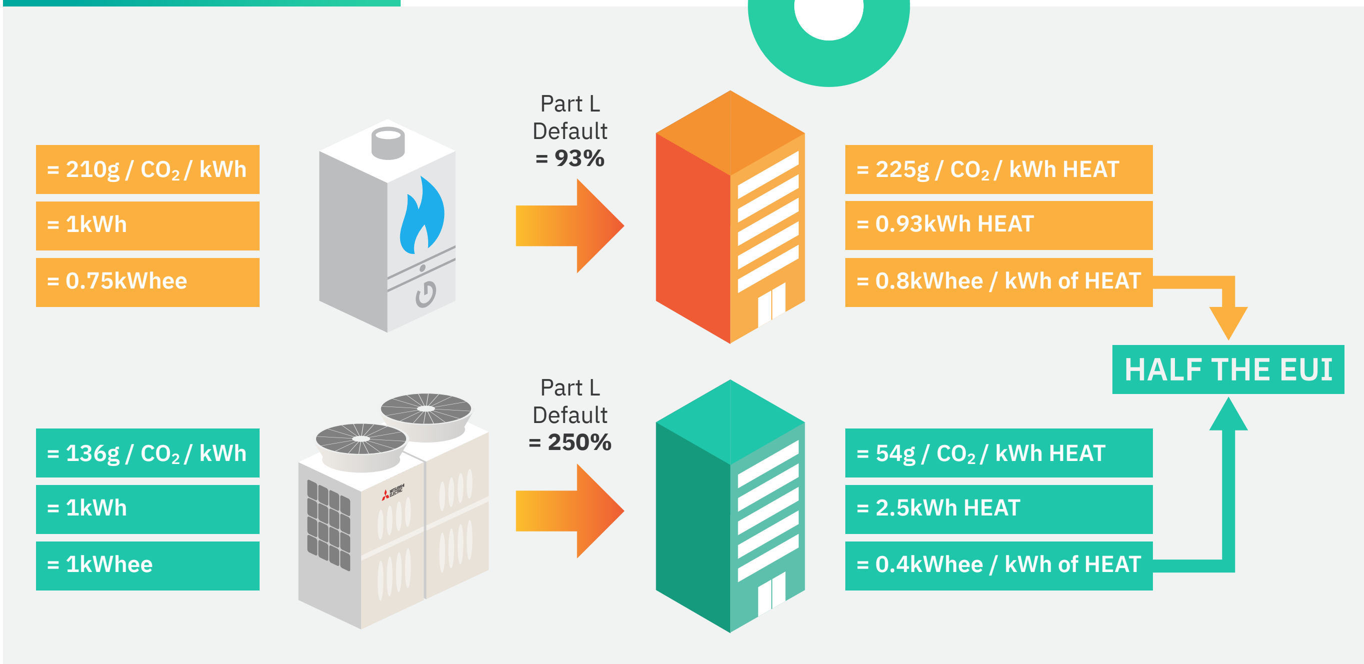
**The UKGBC's Net Zero Roadmap states that 71% of the UK's built environment emissions are created from the energy used to heat, cool and power buildings.**




This is an important point because it highlights how crucial it is not simply to switch from fossil-fuel use but to do so in an energy efficient way.

Swapping gas for electric heating, for example, must be accompanied by consideration of how operational energy use can be reduced as part of that process.

### Possible example:



HVAC systems are also part of a building's embodied carbon emissions. This impact can be more challenging to calculate since it requires an assessment of carbon emissions produced during material extraction, equipment manufacture, transportation, repair and replacement.

CIBSE has developed a tool which can be used to calculate embodied carbon in HVAC products (TM65: Embodied carbon in building services a calculation methodology 2021). This document highlights a key point about the carbon impact of retrofit projects.

In new build projects, the embodied carbon of MEP (mechanical, electrical, plumbing) systems could account for 2% to 27% of embodied carbon, depending on the type of project.

However, this proportion can rise in refurbishment projects, particularly where major building elements such as facades are not being updated.

**In this case, the embodied carbon of MEP could be around 75% of the whole project.**

Again, this highlights the importance of considering the whole life carbon impact of specified HVAC equipment.

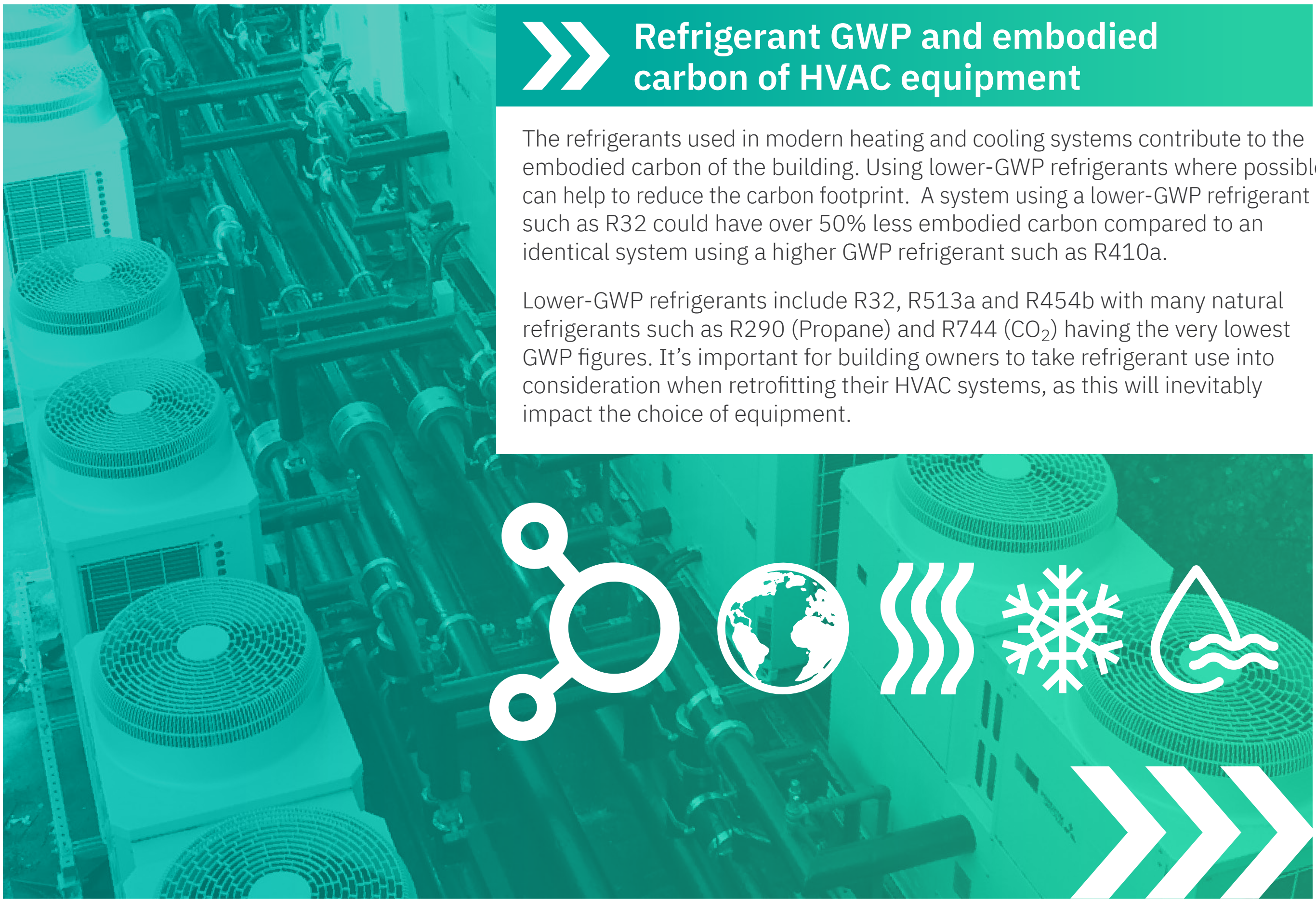
Manufacturers are also being asked to provide Environmental Product Declarations (EPDs) to help specifiers and installers identify the embodied carbon footprint of their products. These can be used in place of the TM65 approach if available.

Undertaking HVAC retrofit can, therefore, help achieve both energy efficiency and carbon reduction if it's planned and executed effectively. A wide range of energy efficient HVAC options are available on the market today, so there are options for different project requirements and building types. This guide outlines a number of these. As with all retrofit projects, there are certain considerations to bear in mind for HVAC refurbishment, which will impact system selection and design. Mitsubishi Electric has been involved in many of these projects, and we recommend careful thought is given to:

**Availability of plant space:** Unlike new-build projects, finding the space for replacement plant can be more challenging as it can't be designed in from the start.

**Disruption to building operations:** If an entire building can't be shut down for refurbishment, it can be useful to consider a floor-by-floor approach, which in turn may impact the type of equipment selected. For instance, using modular equipment which could see a single module installed to serve a single floor or even part of a floor with additional modules added later to create a larger system.

**Electrification of heating and hot water systems:** Assessment and possible upgrade of the electrical supply to the building may be necessary. It may be useful to consider a bivalent solution, for example, which uses electric heat pumps in tandem with gas boilers that are phased out over time.



## Refrigerant GWP and embodied carbon of HVAC equipment

The refrigerants used in modern heating and cooling systems contribute to the embodied carbon of the building. Using lower-GWP refrigerants where possible can help to reduce the carbon footprint. A system using a lower-GWP refrigerant such as R32 could have over 50% less embodied carbon compared to an identical system using a higher GWP refrigerant such as R410a.

Lower-GWP refrigerants include R32, R513a and R454b with many natural refrigerants such as R290 (Propane) and R744 ($CO_2$) having the very lowest GWP figures. It's important for building owners to take refrigerant use into consideration when retrofitting their HVAC systems, as this will inevitably impact the choice of equipment.

# 3: Key Considerations for HVAC Retrofit

# 3

## Plant space

Air source heat pumps (ASHP) offer the most flexibility of application along with high efficiency and ease of installation.

However, they require access to outdoor ambient air and must also have suitable space around them to allow maintenance. It's also important to consider future replacements of HVAC equipment across the lifetime of the system and the building. Allowing space for future retrofits is also critical.

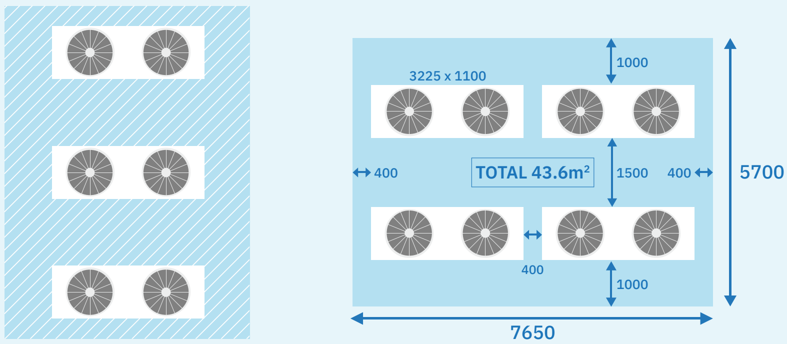
As a result, considering whether the building has the necessary plant space to accommodate an ASHP system is essential when planning a retrofit of the heating or cooling system. Different ASHPs with different capabilities, available water flow temperatures, refrigerants, efficiencies and noise levels require a wide range of plant space sizes.

**Working with customers with our wide range of heat pumps across many projects has enabled Mitsubishi Electric to understand these challenges. The examples below indicate a typical total plant space requirement (including maintenance access) for the two main types of ASHP available on the market, modular and single units.**

### Example of 300kW modular ASHP footprint

The typical footprint of modular ASHP falls between approx. 9-24m² per 100kW of heating capacity with the median being around 16m².

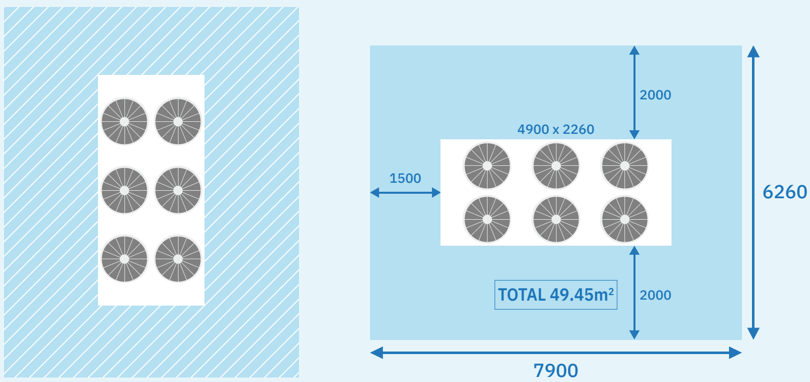
***Note*** *- modular systems often have better overall kW/m² ratios compared to single large capacity units due to smaller service space requirements.*




### Example of 300kW single ASHP footprint

The typical footprint of a single large capacity ASHP falls between 12-42m² per 100kW of heating capacity with the median being around 25m².

***Note*** *- larger capacity single units (>200kW) often have better kW/m² ratios than smaller units due to similar service space requirements of smaller capacity units.*



# Power supply

The efficiency of an ASHP is predominantly affected by the temperature of water being delivered and the ambient air temperature. The amount of power the unit will consume to provide heat at any point in time is directly related to its efficiency, therefore a wide range of efficiencies and associated power consumption occurs across the year as the ambient temperature changes.

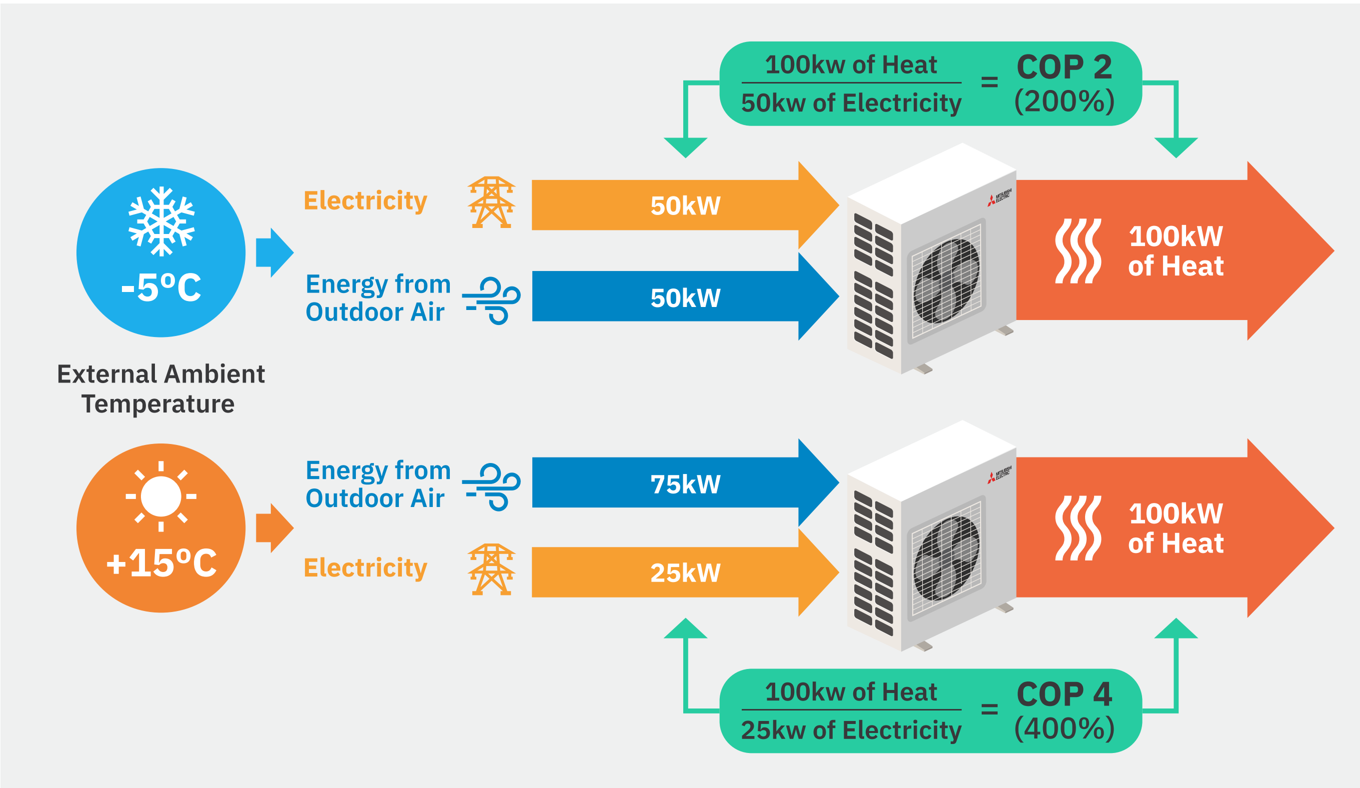
While efficiency is best considered as a seasonal/annual average (SCOP), electrical input requirements must be considered at a defined worst case fixed condition (COP).

ASHPs consume more power when outdoor air temperature is low, therefore a typical worst-case condition considered in the UK is at -5ºC external ambient temperature.

A typical SCOP for an ASHP delivering 55ºC water flow temperature across a whole winter heating season might be approximately 3 (300%). This indicates that the weighted average electricity consumption is around 33kW for every 100kW of heat delivered.

However, at the worst case condition of -5ºC external ambient temperature might be approximately 2 (200%), so for every 100kW of heat delivered, the ASHP will consume around 50kW of electricity - an increase of around 50% compared to the weighted average SCOP figure.

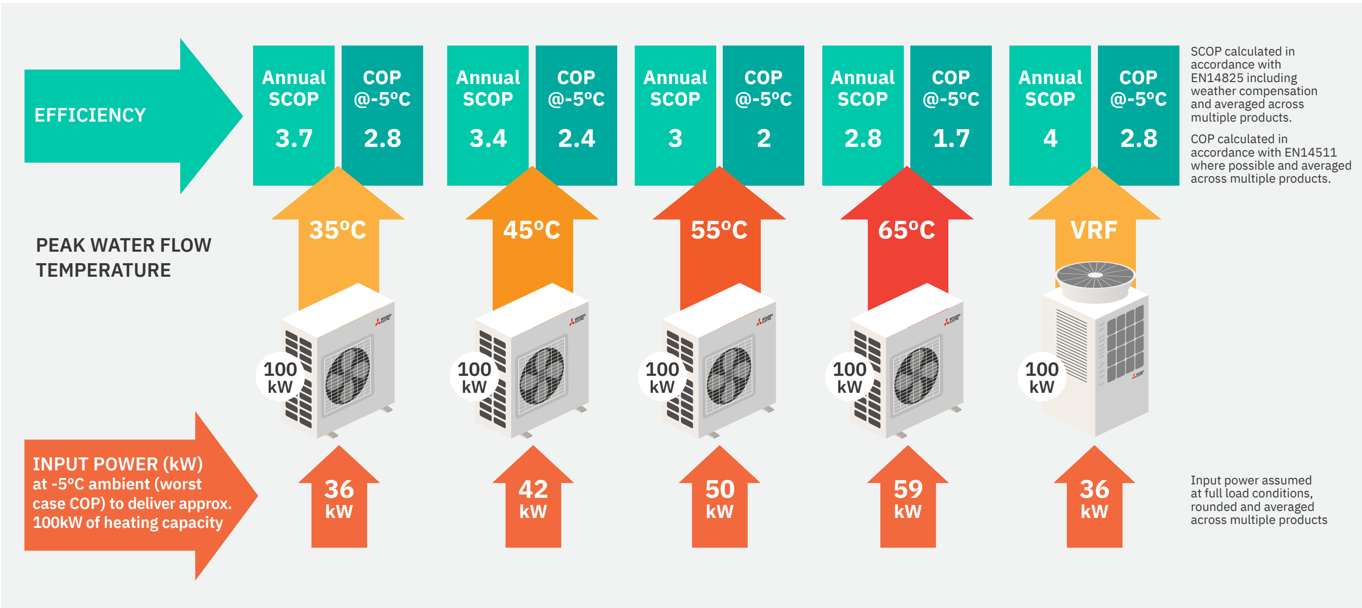
**It's very important to bear these points in mind when selecting a heat pump for your project to ensure that sufficient power supply is available at the worst case conditions you intend to operate the unit in. Consideration should also be given to the capabilities of the ASHP to ensure that it is able to deliver the required capacity and water flow temperature at any condition you intend to operate it in.**



# 3

There are other factors that affect power supply requirements such as whether the ASHP uses fixed speed or variable speed compressors, whether the flow temperature is adjusted to optimise efficiency for different ambient conditions (weather compensated) and how hard the ASHP unit is working compared to its maximum output capabilities (part load conditions).

The simplified examples below indicate different typical seasonal (SCOP) and worst case (COP) efficiencies for ASHPs delivering different peak water flow temperatures. The diagram also shows their associated electrical power inputs to assist with early-stage assessment of likely ASHP power supply requirements.




## Optimising systems

**Retrofit projects provide an opportunity to optimise system performance.**

This can support long-term energy efficiency while lowering the building's operational carbon footprint. Several technologies and approaches are available that can be considered for light or deep retrofit.

HVAC control systems are a readily-available technology that can be applied at any scale, including a room-by-room phased retrofit. This could include ensuring that heating and cooling systems default to 'off' when a space is empty (e.g. in meeting rooms).

At a more advanced level, controls can be used to monitor domestic hot water (DHW) use in a building and adjust storage volumes automatically to minimise standing heat losses.

# 4: Summary and Conclusions

# 4

**The retrofit revolution is here to stay and moving faster every year.** Building owners who engage with the process of retrofitting for energy efficiency and improved carbon performance will put themselves ahead of the game.

By allowing themselves more time to find the best approach for their building, they will be able to plan their priorities instead of having decisions forced on them by changing legislation or financial obligation. The time to retrofit is now, not when a building is at imminent risk of becoming a stranded asset.

**Mitsubishi Electric has worked with clients on HVAC retrofits, which have resulted in lower energy use and reduced carbon footprints for heating, cooling and hot water systems. Not only that, clients retrofitting these systems today are already benefitting from reduced energy costs and better-performing systems.**

If you'd like to learn more about how we can help with your retrofit projects, or have questions about a project you're working on, get in touch with our Net Zero Design Team at:

**sustainable.construction@meuk.mee.com**

**Sustainability & Construction Team**

# Reasons to Retrofit

## PREPARE FOR THE LOW-CARBON FUTURE

- Meet new carbon/energy regulations
- Reduce on-site gas/oil

## ALIGN WITH BUILDING'S CARBON REDUCTION GOALS

- Private/public sector targets

## FUTURE PROOF BUILDINGS

- Building may not meet current or upcoming regulations/guidance
- Market demand for more sustainable space

## REDUCE LONG-TERM OPERATIONAL COSTS

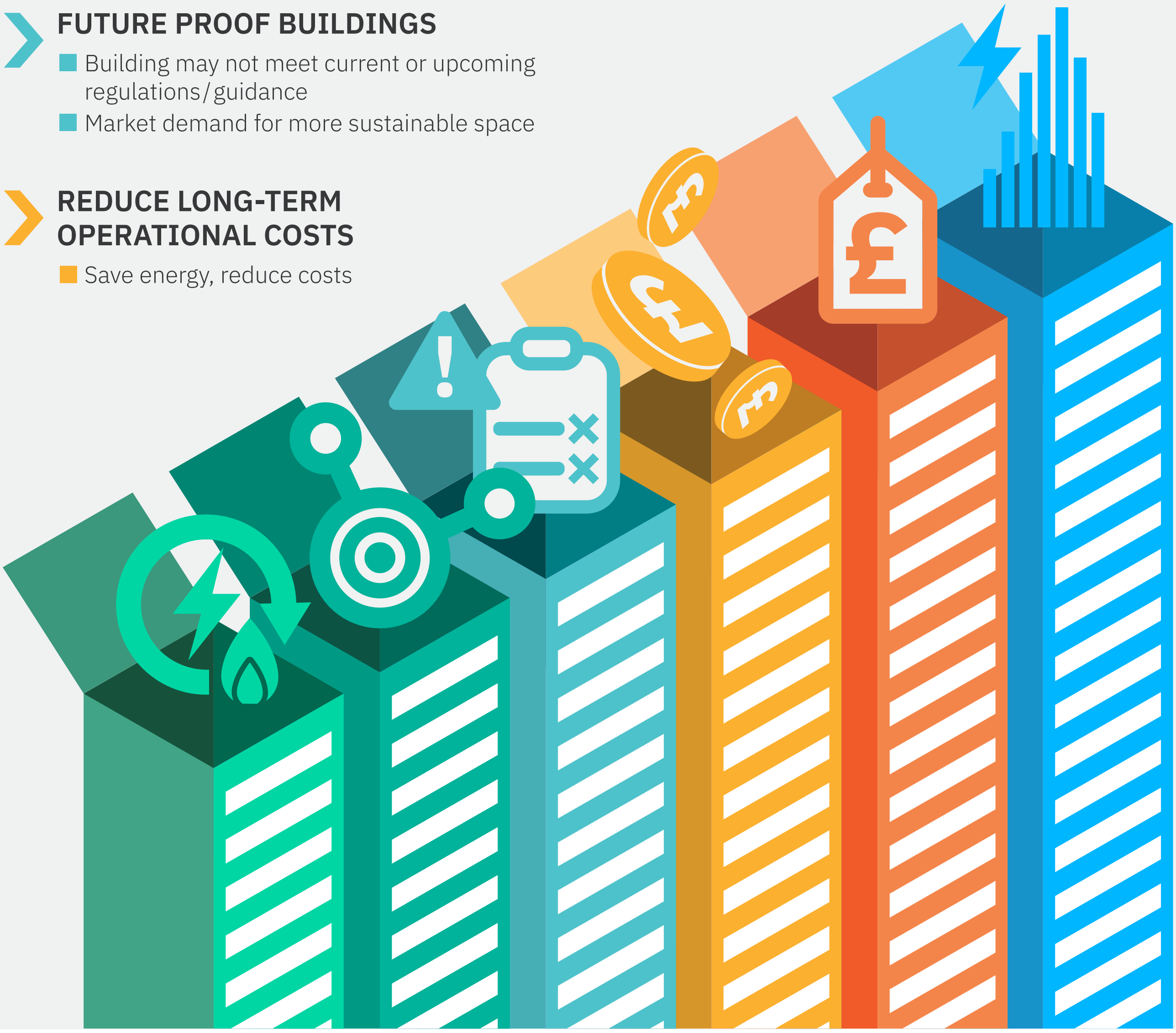
- Save energy, reduce costs

## ENHANCE LONG-TERM BUILDING VALUE

- Tenants pay more for sustainable buildings

## GAIN INSIGHTS INTO BUILDING PERFORMANCE

- Gather data on the building
- Continuous improvement over time



## Useful links to further reading:

**Mitsubishi Electric Commercial Heating Brochure**

**Mitsubishi Electric Stranded Assets White Paper**

**Mitsubishi Electric Solution Overviews:**

**Bivalent Heating Systems**

**Cascade High Temperature Heat Pumps**

## References:


**1. JLL: Environmentally sustainable real estate attracts higher prices**

https://www.jll.co.uk/en/newsroom/environmentally-sustainable-real-estate-attracts-higher-prices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**Note:** The fuse rating is for guidance only and 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), R290 (GWP:3), R32 (GWP:675), R407C (GWP:1774), R134a (GWP:1430), R513A (GWP:631), R454B (GWP:466), R454C (GWP:148), 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).