Transforming Existing Hotels to Net Zero Carbon

ARUP gleeds IHG HOTELS & RESORTS Schneider Electric

Transforming Existing Hotels to Net Zero Carbon Version 2

Since its release in May 2021, Transforming Existing Hotels to Net Zero Carbon has been updated to consider new scenarios using the most recently published BEIS data on energy prices available in the public domain. In addition, financial model assumptions and the approach to capex, calculations and, the accrual of energy/carbon savings due to multiple interventions have been amended. In particular, the authors would like to draw readers' attention to the revised internal rate of return (IRR) on page 13. Reference has also been made to the substantial developments in the wider decarbonisation space since first publication, details can be found on page 55.

Forewords

It is widely acknowledged that this decade needs to be one of climate action. Without taking bold steps now, we will not be able to achieve the net zero carbon target set for 2050 and avert climate catastrophe.

But why focus this white paper on existing hotels? For the simple reason that they must be part of the solution. Approximately 80% of the buildings that will be in use in 2050 already exist today, which includes hotels. Failing to improve our existing hotels is not an option. Similarly, a comprehensive programme of zero carbon new-build hotels between now and 2050 would also be problematic; the embodied carbon associated with construction, such as through material extraction, transport and assembly, would be significant.

Legislation is driving us slowly to net zero by 2050 but the complexities of stakeholder relationships in the ownership and operation of hotels creates potential inertia to their decarbonisation. For hotel operators, increased awareness of environmental issues is changing their corporate and leisure customers' expectations and catalysing their response to the climate emergency. As well as being an increasing part of their brands, decarbonisation also creates financial benefits for operators via the reduced operational costs stemming from energy efficiency.

However, hotel owners' decision-making is typically influenced by other factors, with asset value and rentable income being important drivers for their investment decisions. The risk is that within the current decision-making framework, investment in decarbonisation is chronically undervalued. As well as the obvious climate implications, there is further risk of hotels becoming stranded assets, having lost their economic value well ahead of their anticipated useful life. Indeed, there are signs that some institutional investors are divesting carbon intensive hotel assets as the likelihood of global carbon regulation mounts, creating uncertainty for long-lived carbon-intensive hotels.

Through the examination of a typical UK business/leisure hotel, we hope that this paper will provide insight and challenge inertia where it occurs.

The reduced use of hotels over the last year of lockdowns gave us a once in a lifetime opportunity to look at a hotel's carbon footprint with negligible human influence, enabling in-depth analysis that will improve the industry's understanding of how we can transform existing hotels to be net zero.

We must use a range of approaches to achieve net zero hotels; no one single approach to reducing carbon emissions will be enough on its own. Our research shows that operational measures, improvements to the thermal performance of the building, improvements to the efficiency of systems and a transition to low carbon energy all need to be adopted.

In addition, this paper makes recommendations for the phasing of improvements, based on what is feasible for a hotel in terms of cost, refurbishment cycle and materials/systems interdependencies, giving hotels a framework on which to plot a path to net zero carbon.

At Arup, we are guided by an enduring set of values that were first articulated by our founder over 50 years ago. I believe two of these values are particularly relevant to this paper: firstly, 'Total Design', a concept that underlines the value of collaboration to achieve optimum results, and is central to why we embarked on this work in partnership. Secondly, 'Social Usefulness', and a recognition of the important role designers and engineers have to play in challenging the status quo, propelling us towards net zero carbon.

Simon Gill
UKIMEA Hotels and
Leisure Business Leader
Arup

Forewords

A year of COVID-19 lockdowns and restrictions has brought about incredibly challenging circumstances that are affecting us all. The hospitality and hotel industry has been affected significantly and while there is now cause for optimism, the last year has taught us that nothing can be taken for granted. We are seeing the consequences of Climate Change being played out on our screens every day and the devastating reduction in biodiversity across the planet is cause for deep concern. The concept for this paper and collaborative research was borne out of this concern and a desire to make a positive and tangible difference. Gleeds is passionate about the future of our planet and we are committed to creating a sustainable built environment for the people and communities that live on it. We know there is a need for "Change-at-Scale" and we know that we must start now if we are to realise the greenhouse gas reduction targets set out in the Paris Agreement, as well as legislation in the UK and other signatory nations.

Hotel development across the globe is vast; recent years have seen enthusiastic adoption of sustainable design principals focused on reducing the operational energy use of these new buildings. Meanwhile, existing hotel properties have continued operating year-on-year and their energy efficiency and consumption have been largely ignored.

Not only that, much of the existing hotel stock predates the era of climate awareness and is operating with significantly lower energy efficiency and higher consumption levels than is currently considered acceptable.

Adapting and retrofitting existing buildings to lower GHG emissions is critical and needs to be embraced as part of the hotel sector's "Routemap to Zero Carbon", particularly as expectations of hotel investors, owners, staff and guests shift towards greener, more sustainable models of investment, business operation and living. This paper identifies opportunities throughout a hotel building's maintenance cycle that improve performance and reduce energy use, using both physical interventions and intelligent review of building operations and use. The real-life case study considers realistic, pragmatic interventions, associated energy and carbon reductions, energy bill savings and indicative payback periods for each intervention, and identifies measures that can be implemented over the building's life cycle as part of a planned lifecycle maintenance and replacement regime.

Gleeds recognises that we are at a seminal point and we have a real chance now to make the changes necessary to avert the Climate Crisis. We are proud to have contributed to this important and timely research, and are committed to supporting our Clients in maximising the value of investments made on improving energy efficiency and value of their built assets and portfolios.

Gillian Breen
Director
Gleeds

Forewords

As a global hospitality company, IHG Hotels & Resorts has hotels at the heart of thousands of communities all over the world, touching the lives of millions of people every day.

It's a tremendously privileged responsibility and one that we embrace daily, guided by our purpose of True Hospitality for Good – an aspiration which prioritises caring for our guests and colleagues, recognising and respecting one another, protecting the environment and giving back to our communities.

With hotels in more than 100 countries and ambitious growth plans for our brands, we passionately believe that the world is meant to be explored. We also believe in the importance of operating sustainably to help preserve our planet for all generations to travel and explore.

We do not believe that these are mutually exclusive propositions.

IHG's "Journey to Tomorrow" is a 10-year action plan to help guide our actions as a responsible business and our contributions toward the United Nations Sustainable Development Goals. Core to these efforts is a commitment to continue creating more sustainable guest stays by reducing our energy use and carbon emissions in line with climate science.

The hotel industry's ubiquity and global footprint presents a challenging, but ripe opportunity to reduce emissions at scale. This is an undertaking which will require a holistic approach across the hotel lifecycle – from developing more efficient design prototypes and identifying ways to innovate construction processes, to finding ways in which we can enhance processes and implement structural improvements at our existing hotels to curb emissions, as outlined in this white paper.

This research is emblematic of the type of solutions-oriented collaboration and best-practice sharing which will be required across the industry as we collectively seek to make a positive difference over the next decade, and beyond.

Guided by our purpose, we are committed to working side-by-side with those who stay, work and partner with us, to help shape the future of responsible travel for all – supporting our people and making a positive difference to our local communities, while preserving our planet's beauty and diversity long into the future.

Catherine Dolton
Chief Sustainability
Officer & VP Global
Corporate Responsibility
IHG

Forewords

Schneider Electric believes that buildings of the future need to be safe, healthy, and people-centric. They need to be resilient enough to remain operational through unexpected events. And they need to be hyper-efficient and sustainable to respond to our changing needs, helping us stay productive while helping our planet.

The tourism industry is a major global employer with one in ten jobs supported by the sector, and global tourism post-COVID-19 is expected to continue to grow rapidly to pre-COVID-19 levels by 2023 according to the UNWTO/ ITF. That's good news for the industry, but bad news for the planet. Of all commercial real estate classes, hotels have the highest energy intensity. New buildings are leveraging greener design techniques and materials. However, to protect brand image and asset value, as well as meet global emissions targets by 2050, all existing hotel stock must also begin transitioning to net-zero carbon.

However, there is currently very little support and few resources available to help investors choose the best approach and calculate the financial investment required. We hope the novel research presented in this paper – which has been based on computational analysis and real-world hotel data, with support of leading hotel operator IHG – we can help to answer these important questions.

Many hotel owners and developers now understand they need to consider the risks and costs associated with climate change. Fortunately, as this white paper and analysis concludes, there are now many opportunities in existing and new hotel assets to achieve short and long term financial and sustainability gains.

For example, prior to the pandemic, guest rooms were typically unoccupied 70% of the time, yet accounted for up to 80% of energy consumption. A program of active energy management, supported by a digital energy data collection and analytics platform, enables automated load management, more effective energy procurement, predictive maintenance, and other strategies. Integrating a guest room management system with smart room controllers opens the door to occupancy-based energy management, and it gives maintenance staff the ability to identify and troubleshoot problems remotely. In turn, operational efficiency is improved, guests are happier, and energy savings of 18%, as was the result of this case study, can be realized.

As was implemented in this real-world hotel case, hotels of the future will use more autonomous and proactive approaches to achieving their sustainability, operational, and guest satisfaction goals over the entire lifecycle of their property assets. For example, installing onsite renewable energy generation can help offset utility costs as well as supply new loads like electric vehicle chargers and provide backup power in an emergency. Efficiency can be improved by moving toward greater electrification, replacing fossil-fueled loads like space and water heating. And smart, connected electric technologies can help produce, store, distribute, and share power more intelligently for greater efficiency and reliability.

These are just some of the opportunities available to help transition a hotel asset to net zero carbon operation.

Schneider Electric, a global specialist in energy management and automation, has partnered with three leading global companies to support this important research to find a route to decarbonising the hotel and tourism industry. We are pleased to align with Arup, a global design and consulting firm; global hospitality leader IHG; and internationally recognised cost consultant Gleeds, for this project. The combined expertise of these partners makes this case study extremely powerful for the hotel industry. It is an excellent practical illustration of how the right plan, technology, and execution can help hotels achieve net-zero carbon goals with a significant return on investment.

Michael Sullivan
Buildings Segments President
Schneider Electric

Contents

Framework

Definitions

Net Zero Carbon

The UK Green Building Council (UKGBC) set out a framework in 2019 for delivering buildings in line with the aims of the Paris Agreement in ‘Net Zero Carbon Buildings: A Framework Definition’. We have adopted these definitions for this paper.

Operational carbon (energy):
“When the amount of carbon emissions associated with the building’s operational energy on an annual basis is zero or negative. A net zero carbon building is highly energy efficient and powered from on-site and/or off-site renewable energy sources, with any remaining carbon balance offset.”

Embodied carbon (construction):
“When the amount of carbon emissions associated with a building’s product and construction stages up to practical completion is zero or negative, through the use of offsets or the net export of on-site renewable energy.”

Whole life carbon:
“When the amount of carbon emissions associated with a building’s embodied and operational impacts over the life of the building, including its disposal, are zero or negative.”

This requires reporting of carbon from the maintenance, repair, refurbishment and end-of-life stages of a building’s lifecycle.

Adjusted RevPAR

Adjusted RevPAR, ARPAR or adjusted revenue per available room, is calculated by dividing the variable net revenues of a hotel by the total number of available rooms.

Active Measures

Active measures are those which seek to improve the efficiency of mechanical cooling, heating, ventilation and lighting.

Capital Expenditure (CAPEX)

Money used to add to or improve a property beyond common repairs and maintenance.

Domestic Hot Water (DHW)

Domestic hot water is water heated for purposes such as cooking, cleaning or personal hygiene, but not space heating.

Energy Use Intensity (EUI)

Energy Use Intensity (EUI) represents the total primary energy (gas, electricity or any other fuel) needed for all the uses in the building throughout a year, including regulated and non-regulated uses. This parameter expresses the overall energy efficiency of the building before any renewable energy provision. It is expressed in kWh/m^2

Internal Rate of Return (IRR)

The Internal Rate of Return (IRR) is the discount rate that makes the net present value (NPV) of a project zero. This can also be understood as the expected compound annual rate of return that will be earned on a project or investment.

Regulated Energy

Regulated energy is energy consumption that is associated with the operation of fixed building services. This consists of space heating, space cooling, auxiliary fan power, lighting, and domestic hot water.

Paris Proof

The ‘Paris Proof’ methodology was first pioneered by the Dutch Green Building Council and determines the energy demand reduction required for an economy to be powered entirely with zero carbon energy by 2050, in order to meet obligations under the Paris Agreement.

Passivhaus

Passivhaus is a voluntary standard for energy efficiency in a building, resulting in ultra-low energy buildings requiring very little energy for space heating or cooling.

Passive Measures

Passive measures are those which use a building’s layout, fabric, and form to reduce or remove the need for mechanical cooling, heating, ventilation and lighting demand.

Thermal Load Intensity (TLI)

The Thermal Load Intensity (TLI) parameter represents the total thermal load (in terms of space heating and cooling) required to keep the room temperature within comfort rages throughout the year per unit of floor area. This parameter does not depend on the building services efficiency, nor ventilation heat recovery. It is expressed in kWh/m^2.

Unregulated Energy

Unregulated energy consumption is defined by the Building Research Establishment (BRE, 2012) as energy consumption which is not ‘controlled’. For the purposes of this study, the unregulated energy demands are comprised of lifts, small power and plug loads.

Vehicle-to-Grid

A system in which plug-in electric vehicles communicate with the power grid and either return electricity to the grid or throttle their charging rate to counter weather induced fluctuations in renewable energy supply.

VRF

Variable refrigerant flow (VRF), also known as variable refrigerant volume (VRV), is an HVAC technology that use refrigerant as the cooling and heating medium.

Executive summary

In a world where the climate is changing, how can an existing hotel building be transformed to net zero carbon? Is it even possible?

Hotels account for around 1% of global carbon emissions. With 80% of 2050 building stock already existing today[1], we must prioritise decarbonising what we already have.

After it is built, the majority of emissions associated with a hotel building are related to on-site energy consumption, therefore this will be the main focus of this paper.

This white paper tackles the operational net zero carbon challenge for existing hotels, using a real-life case study to demonstrate the impact of each stage in the journey. It sets out a high-level framework, prioritising different interventions throughout the lifecycle.

Already there is evidence that hotels with poor energy efficiency are worth less than those which have excellent efficiency ratings. As countries move to net zero, hotels are going to need to maintain pace and those that do not are likely to be less profitable. Nevertheless, even without these wider dynamics we show that energy efficiency investments and decarbonisation can be financially attractive.

The scope of this paper

To explore opportunities to decarbonise existing hotels and drive operational energy to net zero carbon, we used a typical business or holiday hotel as a test case.

We built a dynamic thermal model of the hotel, matching the characteristics of the real asset as closely as possible.

We calibrated the model using metered operational energy data. This included data gathered during COVID-19, where there was little to no occupancy, which provides valuable insights into how and where energy can be saved.

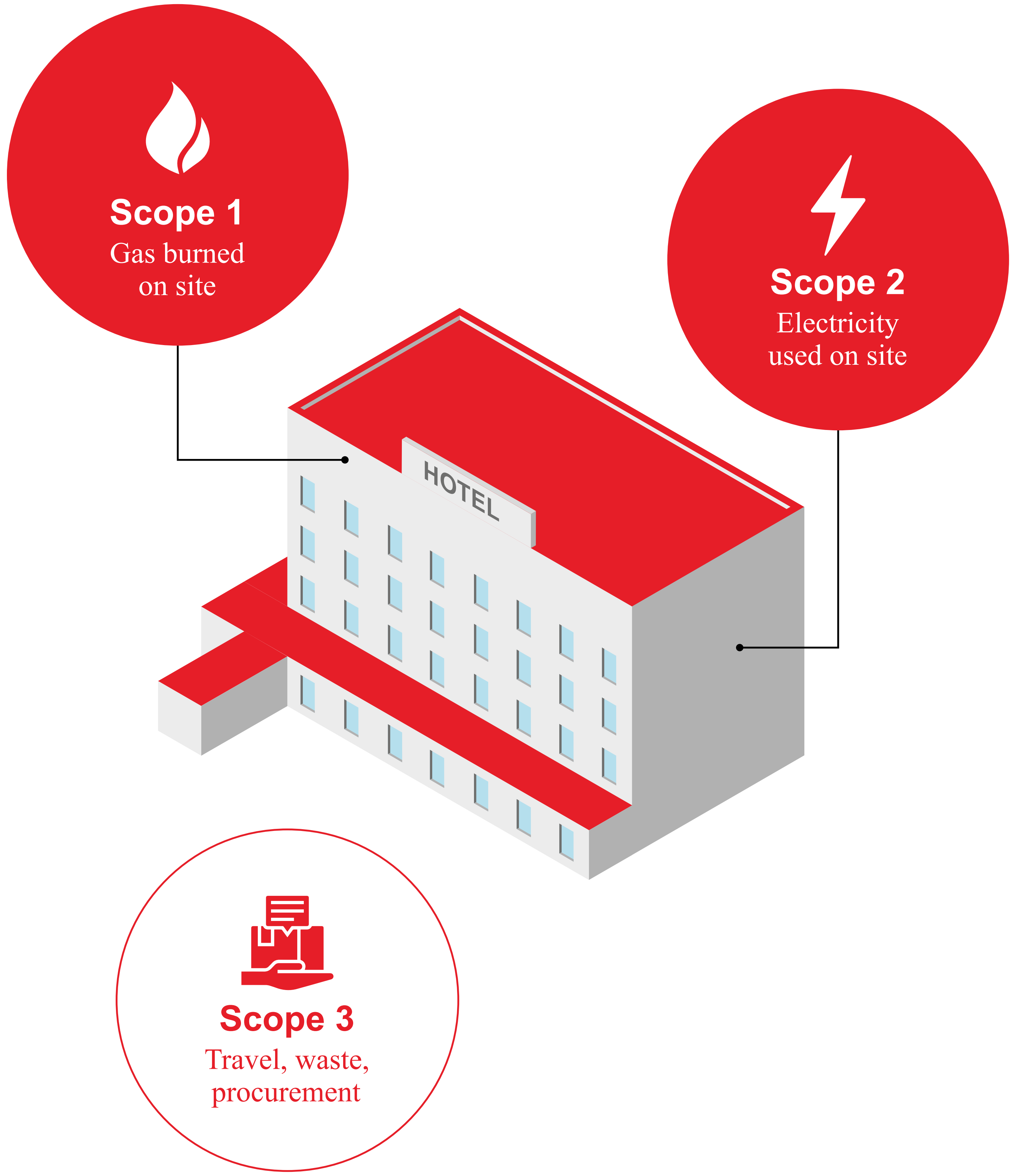
We then used the model to assess the economic viability and carbon impact of potential interventions. The findings reduce complexity, prioritising interventions for a successful net zero carbon hotel in operation.

Three main objectives of the white paper are to:

- Achieve net zero carbon emissions in operation.
- Deliver occupant comfort.
- Balance operational savings with the costs of interventions.

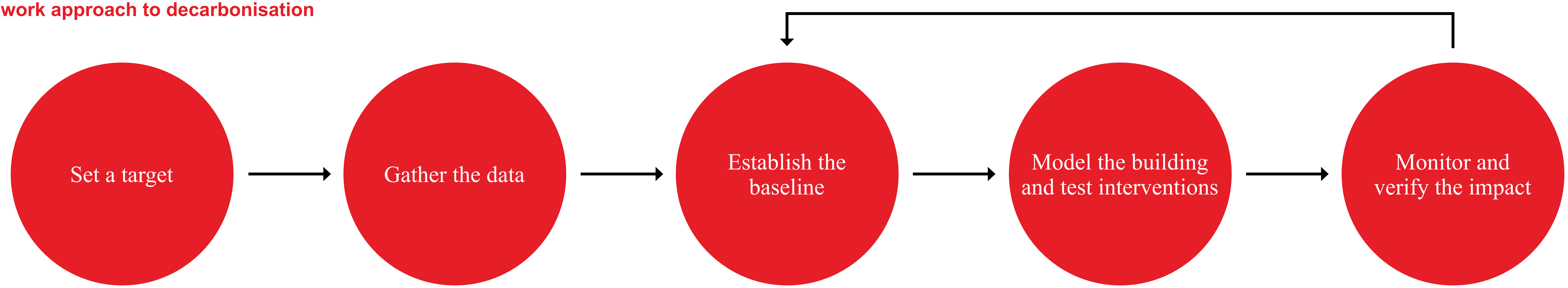
For our study, the focus is on reducing operational energy to achieve net zero carbon. We also consider the embodied carbon impact of interventions, and how that compares to building new.

Carbon emission factors are highly dependent on generation sources. Countries with higher reliance on fossil fuels to generate electricity will have worse carbon emissions factors. There is therefore considerable variance globally.



Executive summary

Framework approach to decarbonisation



Set a target

Define the scope of net zero and establish how fast you want to get there.

Case study hotel: Target to achieve net zero carbon in operation by 2050.

Gather the data

To achieve net zero carbon, you need to identify and understand how your specific building operates and its maintenance and replacement lifecycle.

Case study hotel: Typical UK business or leisure midscale, full service hotel built in the 1960s. Although not all hotels are the same, we selected it due to the potential for replication of the methodology and findings.

Establish the baseline

Understand where and how energy is used in the building.

Case study hotel: Heating the pool and pool hall used nearly a quarter of all energy; catering and domestic hot water each accounted for around a fifth.

Model the building and test interventions

Creating energy and cost models allow you to test the impact, and evaluate the cost of different interventions, to determine what is suitable and feasible.

Monitor and verify the impact

Checking the actual impact of the interventions helps inform you of what works well, establishes a new baseline and helps calibrate your models.

Executive summary

The interventions in the case study

Control and monitor

Changing how you run the hotel to reduce energy consumption is the most cost effective and, arguably, easiest way to cut carbon – from how you book rooms, to when you cool and heat spaces.

Case study hotel: operational changes could reduce energy use by 18%, saving £58,000 annually and cutting carbon by 150 tonnes.

Passive measures

Improve the thermal performance of the building fabric to prevent energy being wasted.

Case study hotel: Improving the performance of the guest room façade and pool hall glazing could reduce energy use by 11%, saving £26,000 annually and cutting carbon by 86 tonnes.

Active measures

Improve the efficiency of your systems. Switch from fossil fuels, such as gas, to increasingly lower carbon energy sources, such as electricity.

Case study hotel: Upgrading the air conditioning (variable refrigerant flow) system, replacing boilers with a ground source heat pump, fitting energy efficient lighting and upgrading kitchen equipment could reduce energy use by 37%, saving £36,000 annually and cutting carbon by 271 tonnes.

Transition to low carbon energy

Generate renewable energy on site. Help decarbonise the National Grid by shifting demand.

Case study hotel: Introducing on site renewables could reduce energy demand on the grid by 3% and save £13,000 annually.

Certified offsets

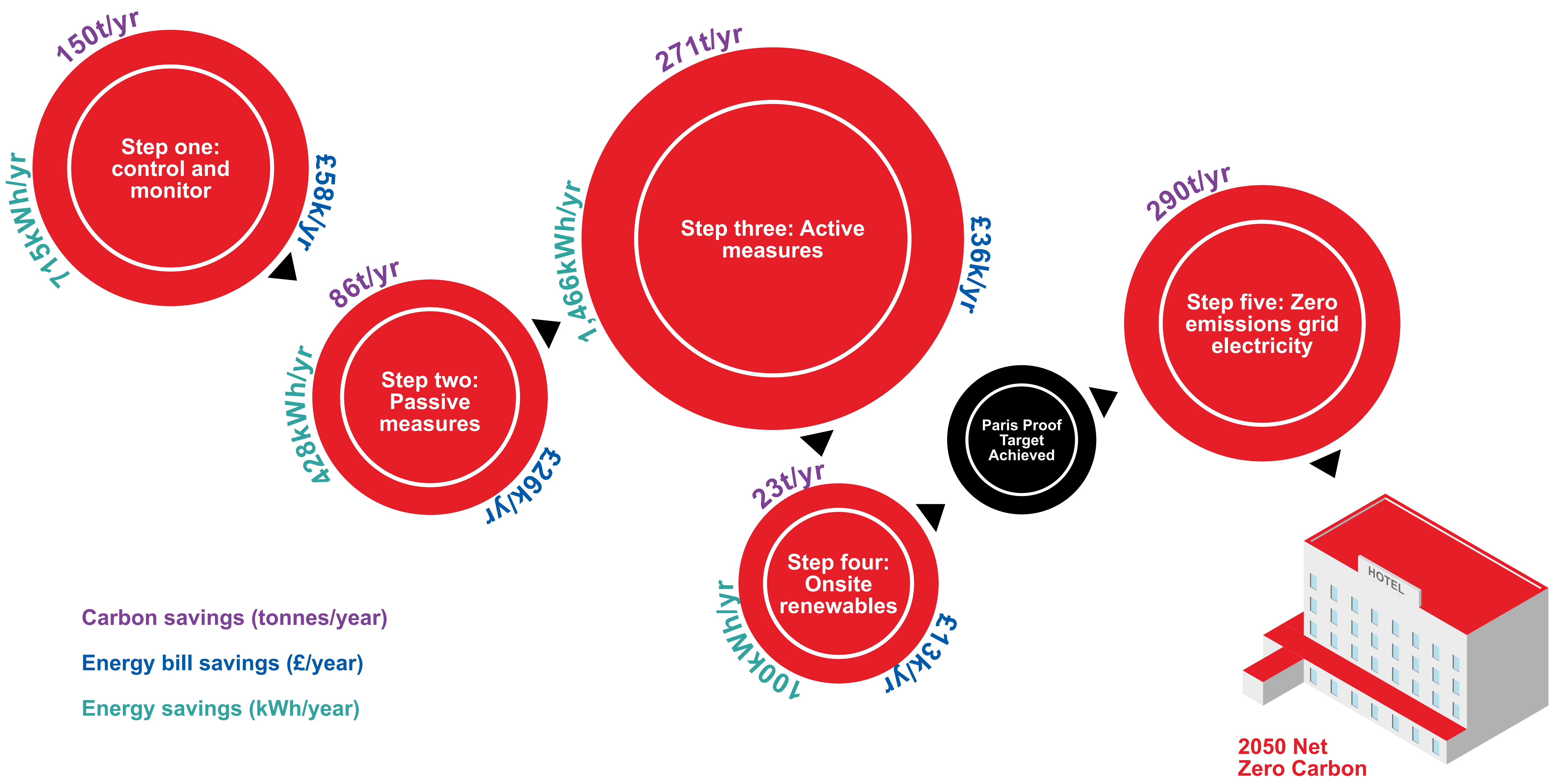
Source quality certified offsets for what remains.

The business case

- The identified interventions could achieve a simple payback period of 14-15 years and a 30-year rate of return of 9-10%.
- However, if an Adjusted Revenue Per Available Room (ARPAR) of £1/night can be realised, due to the improvements, a return of 15% could be achieved over the same period.
- Taking into consideration an ARPAR of £1, theoretically a refurb and dispose after 5-year strategy boosts this rate of return to 32%.
- These calculations do not account for government grants, incentives or the cost of any future energy price increases, potential taxes and levies. If these were to be considered, the returns would be higher

Framework to achieve net zero carbon hotels

Based on our case study hotel, our analysis identified an optimal path to net zero carbon based on an assessment of carbon reduction, cost, refurbishment cycle and materials/systems interdependencies.



Executive summary

The findings

When assessed against the Paris Proof Target, the case study hotel was able to achieve net zero carbon in operation. With the net zero measures selected, the combination of energy bill savings and higher room income more than offsets the investment costs. Furthermore, based on the modelling undertaken, if the hotel was sold at year five, the marginal increase in the sale price will exceed the CAPEX of the net zero works, meaning the hotel owner will make a profit in all the scenarios modelled.

Even before considering the wider benefits of improving the sustainability of the hotel (e.g. higher room rates or the retention of customers who might have switched to greener hotels), over a period of 30 years an energy saving return of 9-10% may be achievable – subject to assumptions about asset replacement and renewal. The investments selected and summarised on page 59 could achieve a simple payback of approximately 14-15 years, meaning that all the costs of the selected interventions (before any costs of financing) could be repaid within this period. The base case return is calculated by considering the costs of the proposed interventions and the resulting projected annual energy bills savings only. The results are shown in the graph opposite.

As well as the base case, we evaluated two further scenarios:

a) energy cost savings based on 2021 energy prices, rather than the base case 2019 energy costs, and

b) a £1 increase in the Adjusted Revenue Per Available Room (ARPAR) resulting from the hotel leveraging its “green credentials” and its comfort being enhanced as a result of the improvements.

For each of the three scenarios, the financial returns over a 30-year period including the costs of the measures and the energy bill savings were assessed under two options:

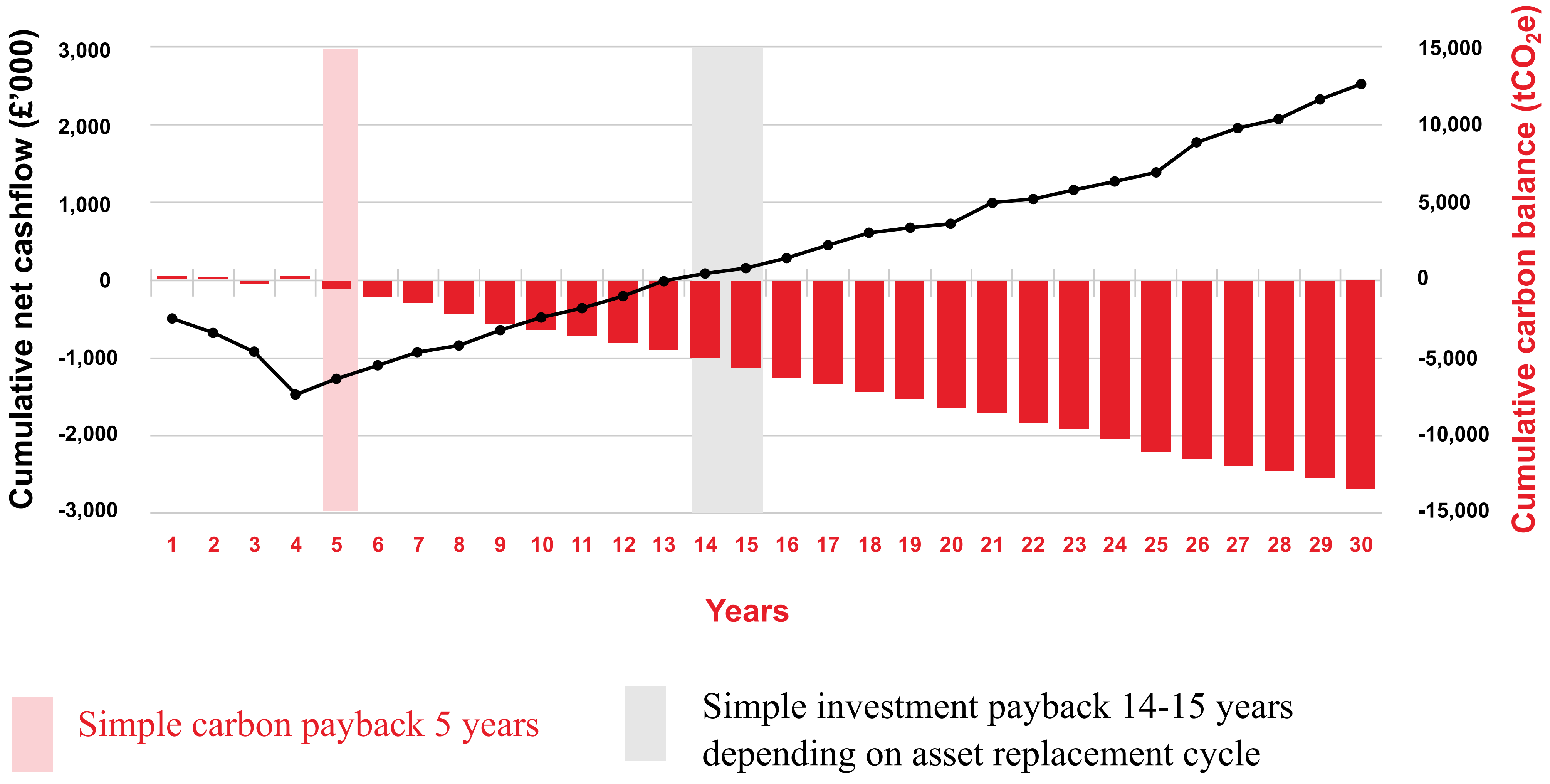
1) Retaining the hotel (a ‘hold’ strategy)

2) selling the hotel at the end of the fifth year (an ‘invest and dispose’ strategy), by which time the full energy bill savings will be apparent.

The recommended energy efficiency decarbonisation options in the report are assumed to have been completed within the first four years. It is worth noting that when assessing the financial costs and savings from interventions, we have not considered any government grants or incentives, or potential carbon taxes and levies, and instead just focussed on the energy cost savings. Yet, on the journey to net zero, governments will need to incentivise the switch to electricity and are likely to increase carbon taxes or introduce other financial inducements to shift away from gas. This, along with the wholesale price increase of energy, will only increase returns on energy efficient low-carbon investments.

Demolishing and re-building the hotel might allow a further reduction in the energy use intensity of the building over what is achievable with retrofit. However, the approach and suggested interventions outlined in this report would allow five existing hotels to be retrofitted for the same embodied carbon impact of building new, and at a lower cost too.

Net cash flow and carbon balances of the identified investment proposition (2019 prices)



This graph shows the cumulative effect of capital investment and the resulting energy savings associated with the energy conservation measures (ECMs) explored in this white paper.

It also illustrates the cumulative effect of the embodied carbon cost of the ECMs and the resulting carbon payback.

The case study hotel is considered net zero carbon when it meets its Paris Proof Target once its ECMs are implemented - circa year five in this example. A certified renewable power purchase agreement will be required while the electrical grid continues to decarbonise.

Executive summary

The pre-tax, pre-finance returns for the "hold" and "invest and dispose" strategies, for the base case and the additional two scenarios are shown in the table opposite.

Four further investment assumptions were made:

- Hotel investors target an 8% 'capitalisation rate' (shortened to 'cap rate'). Cap rates are used to value long-life hotel investments. They are a close proxy to investors' target real pre-tax, pre-finance returns[2]. By assuming a long term general inflation rate of 2%, the nominal pre-tax, pre-finance target would be about 10%;
- At various points in time, hotel owners need to make decisions on whether to replace fixtures and fittings on a like-for-like basis or select other options. Using our judgement of the economic lifespans of assets and the hotel's own replacement policy, some assets would need to be replaced two or three times during the 30-year analysis period;
- To calculate the financial returns from our proposed interventions, the model therefore considers the annual differential costs and savings compared to like-for-like replacements;
- A hotel valuation is a combination of many factors, but in the option of the "invest and dispose" strategy, the valuation uplift is based on the theoretical net cash flow savings.

The three scenarios:

Base case: Investments using the hotel's actual 2019 energy costs, throughout the 30 year period. of 13.3p/kWh for electricity and 2.3p/kWh for gas.

Scenario 1: The base case updated to real 2021 energy prices throughout the 30 years. The UK Government reports 'Small/ Medium' electricity consumers (500 – 1,999MWh electricity p.a.) paid 15.75p/kWh for electricity in 2021, and 'Small' gas consumers (278 – 2,777MWh gas p.a.) paid 3.012p/kWh[3].

Scenario 2: The base case allowing for a £1 increase in the Adjusted Revenue Per Available Room (ARPAR) as a result the hotel being able to market its 'green credentials' and/ or being more comfortable to stay in. ARPAR is the difference between the money charged to hotel guests and the variable costs associated with the guest's stay, e.g. cleaning, laundry, lighting the room and any food and drink consumed. An ARPAR uplift could be the product of either higher room rates, higher occupancy rates or a combination of the two.

The main conclusions are that even before considering the price increase of energy ahead of general inflation, the selected combination of investments appear attractive, particularly if the ARPAR can be increased even by a modest amount of £1. Further, if investment returns of the 30-year 'hold' strategy exceed the assumed target 8% 'cap rate', then returns from these energy efficiency interventions could be amplified if the hotel is sold at the end of the fifth year.

IRR Scenario Comparison

	IRR with 'hold' strategy (%)	IRR with hotel sale at end of year 5
Base case with actual 2019 energy prices	10%	10%
Scenario 1: Base case with 2021 energy prices	12%	20%
Scenario 2: Base case and £1 ARPAR increase	15%	32%

In effect the energy efficiency and decarbonisation actions are attractive to hotel purchasers, and (everything else being identical) the seller has been able to capture, through a higher sale price, the energy savings it would have obtained through the 'hold' strategy more quickly.

Hotel

Introduction

Why net zero carbon now?

The world is waking up to the urgency and scale of response required to mitigate the worst impacts of climate change.

Several countries, including the UK, have committed to moving their economies to net zero carbon. Climate science shows that, to halt climate change, emissions must stop; reducing them is not enough. The longer this takes, the more the climate will change.

The Intergovernmental Panel on Climate Change published its Special Report on Global Warming of 1.5°C (SR15) in 2018. This revealed that limiting global warming to 1.5°C would reduce challenging impacts on ecosystems and human health and wellbeing. However, increases of 2°C and above risk exacerbating extreme weather events, rising sea levels, diminishing Arctic sea ice, coral bleaching and loss of ecosystems, among other impacts. SR15 also showed that, to limit global warming to 1.5°C, emissions need to fall by about 45% from 2010 levels by 2030, reaching net zero around 2050.

The UK's Climate Change Act 2008 (2050 Target Amendment) Order 2019 requires the Government to reduce the UK's net greenhouse gas emissions to zero by 2050.

Hotels have a part to play

Research by Natural Climate Change, published in 2018, found that tourism's global carbon footprint was four times higher than previously estimated, accounting for about 8% of global greenhouse gas emissions.

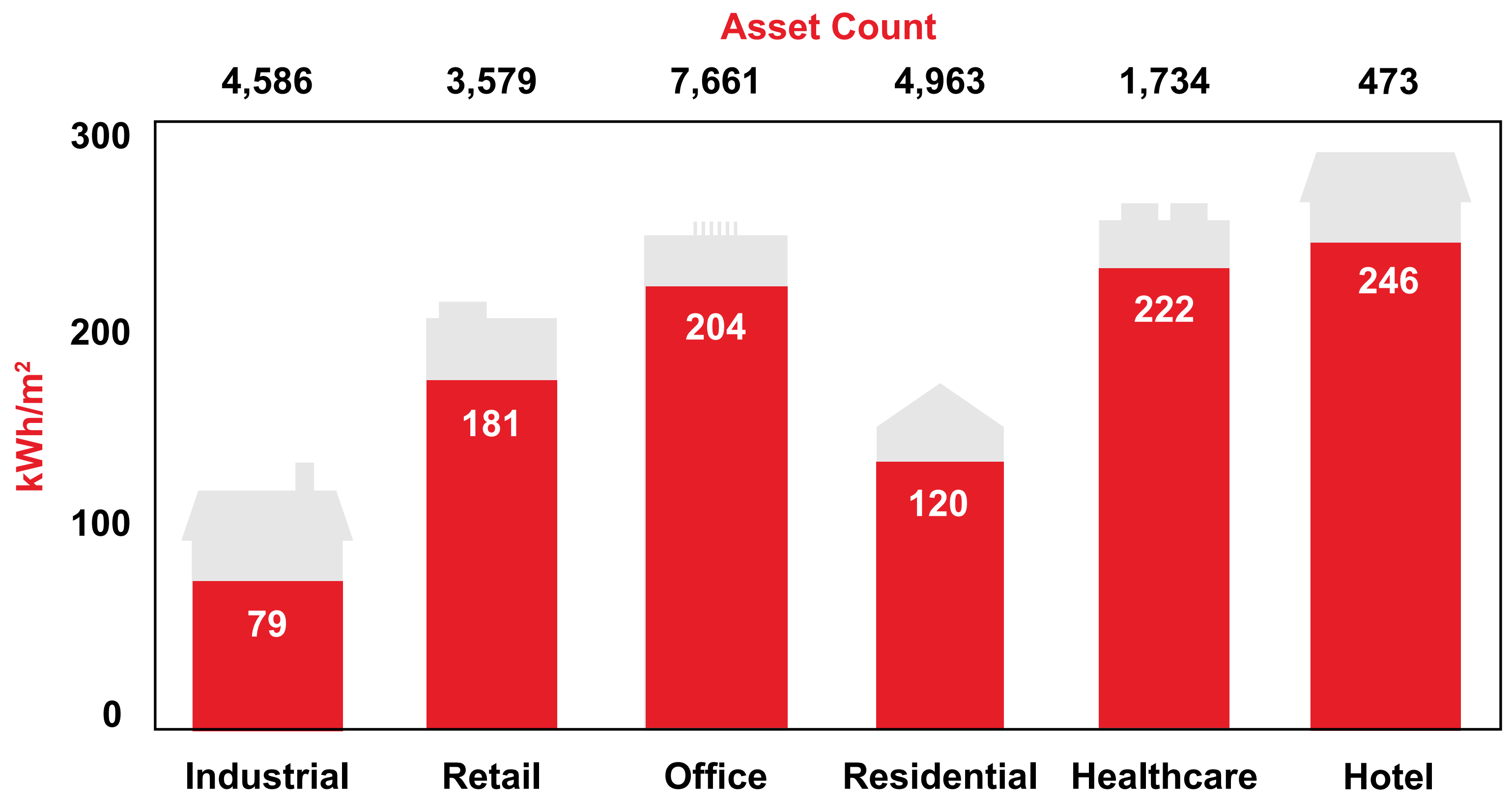
Between 2009 and 2013, tourism's carbon footprint increased from 3.9 to 4.5 billion tonnes of carbon ($GtCO_2e$), with the hotel sector accounting for almost a quarter of all these emissions. While the COVID-19 pandemic has significantly impacted tourism, recovery and growth are expected in the coming years.

> Prior to the pandemic, nearly three quarters of travellers stated they intended to stay at least once in 'eco-friendly' accommodation within the upcoming year, and 70% said knowing accommodation was eco-friendly would make them more likely to book to stay, even if this was not what they set out to look for.[4]

Research by the Sustainable Hospitality Alliance found that the hotel industry needs to reduce its carbon emissions by 66% per room by 2030, and by 90% per room by 2050 to ensure that the growth forecast for the industry does not correspondingly increase carbon emissions.

Developers and owners need to be aware that market expectations of the carbon performance of hotels is changing rapidly. Leisure and corporate travellers alike are placing greater emphasis on the green credentials of the hotels they use.

GRESB 2019 Real Estate Results show that hotels have the highest energy intensity, compared with other asset classes. Carbon intensive hotel assets risk becoming stranded assets if action is not taken to decarbonise them.[5]



Growing value and closing the performance gap

The market is not yet consistently accounting for carbon intensity in hotel property valuations. However, GRESB is in the process of incorporating stranding risk assessment into its reporting, which is likely to encourage the market to connect carbon performance and asset value.

Introduction

In the United States, LEED and Energy Star certified buildings have 16% higher transaction prices than others, with a $1 saving in energy costs from thermal efficiency yielding about $18 in increased valuation.[6]

Looking at real estate investment trusts (REITs), Energy Star certified properties account for 5 to 7% of their property portfolios.[7]

The NABERS energy rating scheme, launched in Australia in 1998, is reported to have halved the average energy use intensity (EUI) of commercial property. Most commercial properties with high NABERS rating in Australia benefited from a higher value premium, typically ranging from 8 to 21%, depending on location. Those with a low rating suffer a discount of up to 13%.[8]

The Better Buildings Partnership launched the UK version of NABERS, in 2020. Initially focusing on offices, it is expected to expand to cover other asset classes, including hotels. The UK's design-for-compliance culture is a significant contributor to the performance gap between design intent and actual building performance.

The rating systems in Australia and in the UK currently focus on operational carbon. Until there is an equivalent for embodied carbon, it is difficult to link whole life carbon impacts to asset value.

Studies show energy and sustainability certification reduces operating costs and property risks and increased the value of commercial property by an average of nearly 15%.[9]

The hotel industry

The hotel market is fragmented, often with different organisations acting as developers, owners, operators and funders, and there is significant complexity for financiers and operators in Hotel Management Agreements (HMAs). Sometimes there are also further stakeholders, such as third-party asset managers, involved.

This fragmentation results in sometimes competing aims and priorities, including operating costs, capital outlay, profits, and share price.

If the hotel industry is to meet much needed carbon targets, these stakeholders need to pull together to overcome the challenges faced, avoid stranded assets and the negative impact on brands from both guest and investor perspectives, and not simply because there is a moral imperative.

Although there is a cost premium for carrying out works over and above business as usual replacement cycles, this can be mitigated by looking across portfolios of assets, seeking economies of scale and different procurement strategies for carrying out the work. This asset review also provides an opportunity to plan works and prioritise to get the most impact for the best value.

Whilst in some ways there are more clear direct benefits for single private owner/operator arrangements, where there are less competing priorities, and the costs and bills are footed by the same organisation undertaking the work, the risk to brand perception and of potential future carbon taxes still exist, making the case for change stronger still.

Where our case study hotel is located - near London and the South East of England - high levels of performance prior to the COVID-19 pandemic meant hotel owners and operators had been deferring refurbishment of their buildings until absolutely necessary, or until things dropped off with the next economic downturn. Now that the sector has had to close and occupancy is predicted to be lower, and less reliable there is a great opportunity to carry out works to achieve net zero carbon in operation, ahead of targets, adding value to the property and staying ahead of the curve. This is likely to be the case in other geographies too.

Introduction

Operational impacts

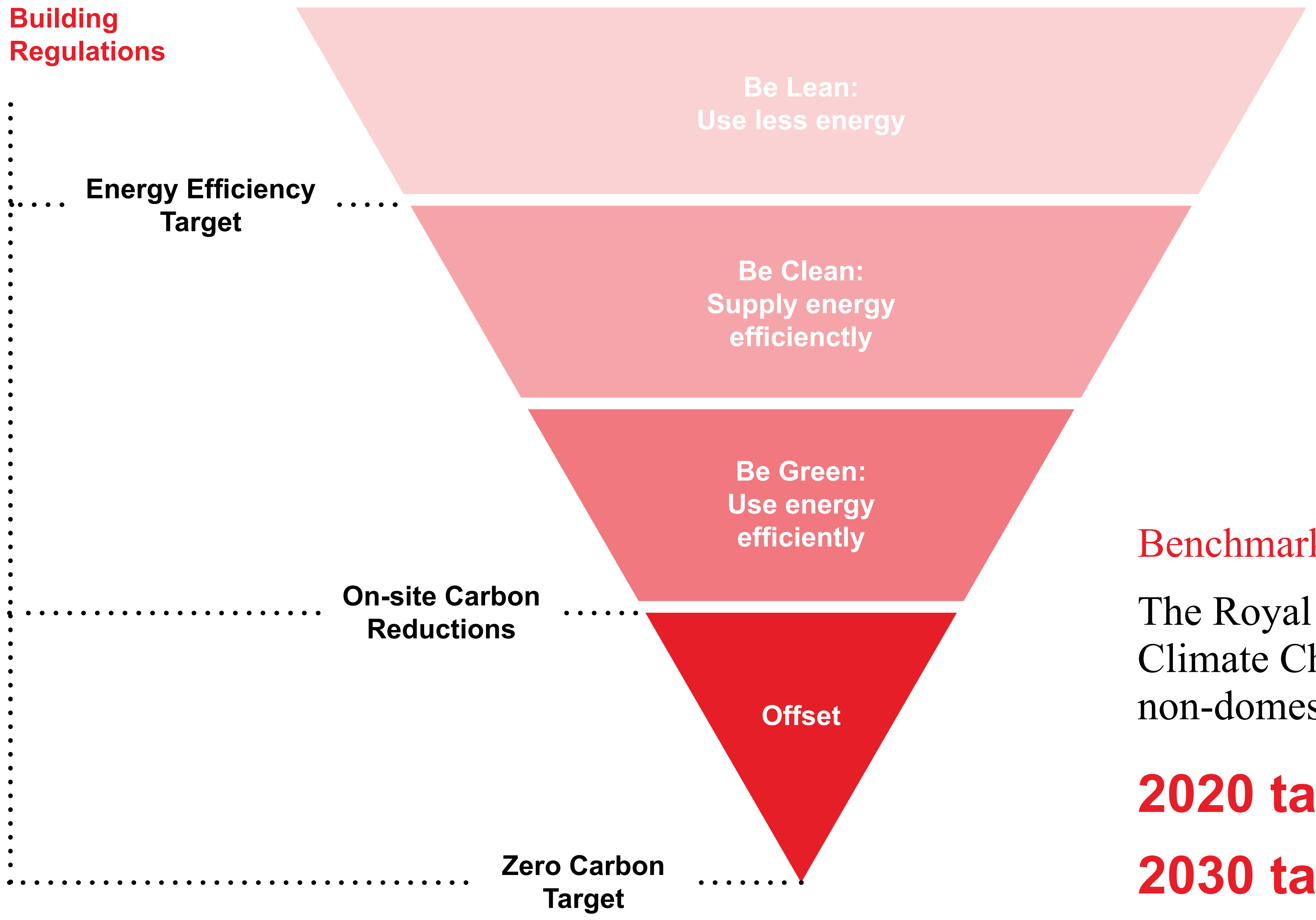
Energy consumption represents between 3% and 6% of hotel operating costs and is responsible for around 60% of its carbon emissions [10]. For our case study hotel, the annual energy cost was over £1,000 per room.

Many 2050 hotels have already been built. So, focusing on net zero carbon new buildings will not be enough to get us where we need to be for a sustainable future. We need to rapidly improve the performance of existing hotels.

The largest energy consumer in a hotel is typically space heating and/or cooling, followed by domestic hot water, fans and lighting. Reducing operational energy requires a holistic design approach.

There are other benefits to targeting Net Zero Carbon in operation. Reduced energy demand means smaller, cheaper heating and cooling equipment and puts less strain on systems, lengthening their design life. Better control not only saves energy but can improve guest comfort and reduce noise associated with services, improving guest experience and so have the potential to increase the Revenue Per Available Room (RevPAR).

The net zero design approach



Benchmarking

The Royal Institute of British Architects (RIBA) 2030 Climate Challenge provides metrics for benchmarking non-domestic buildings:

2020 targets <170 kWh/m²/y

2030 targets <110 kWh/m²/y

2050 targets 0–55 kWh/m²/y

However, given the daily use of hotels, these targets may be unrealistic. We therefore set out an alternative approach in the section Set a Target on page 22.

Introduction

Embodied impacts

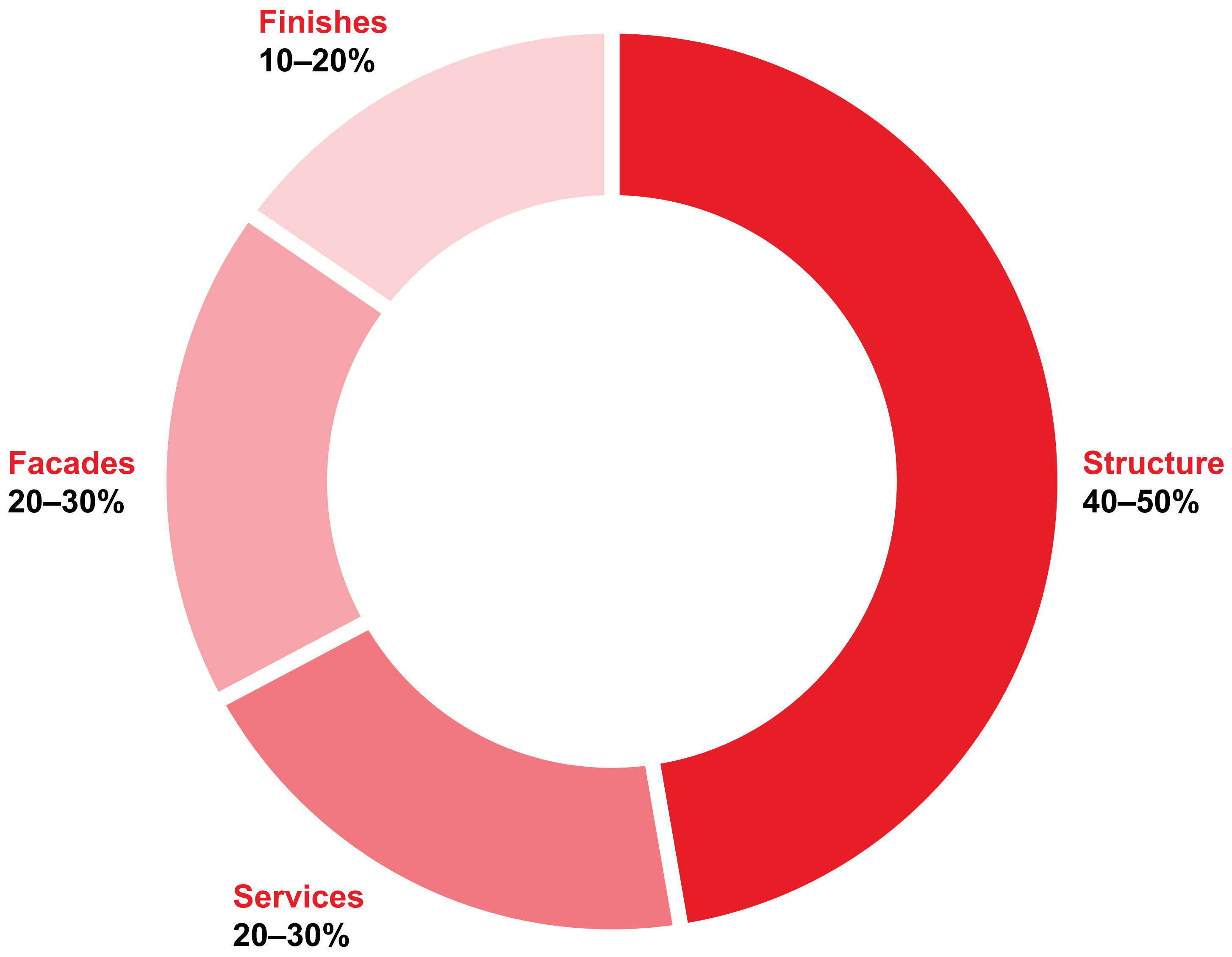
Embodied carbon makes up between 30% and 70% of a typical building's total lifecycle emissions.

Hotels are constructed of materials extracted from the ground or (in the case of timber) grown, transported to a facility to be processed, transported again (perhaps numerous times) to be fabricated, transported to site and craned into place. Every step of this activity produces carbon emissions.

This impact is repeated on a smaller scale during a hotel's lifecycle, through repair, maintenance, and refurbishment. Hotel bedrooms and public areas typically have hardgoods and softgoods refurbished on a six to seven-year cycle, with full Property Improvement Plans (PIPs), requiring significant construction, after 20 years.

At the end of the hotel's life, we once again expend energy and emit carbon, through demolition and disposal.

As the UK's National Grid electricity continues to decarbonise, as our reliance on fossil fuels reduces and the energy efficiency of buildings further improves, embodied carbon will become the predominant contributor to whole life carbon in hotels and other asset classes.



The split of embodied carbon on a hotel varies by project. Estimated splits of embodied carbon are shown above.

Benchmarking

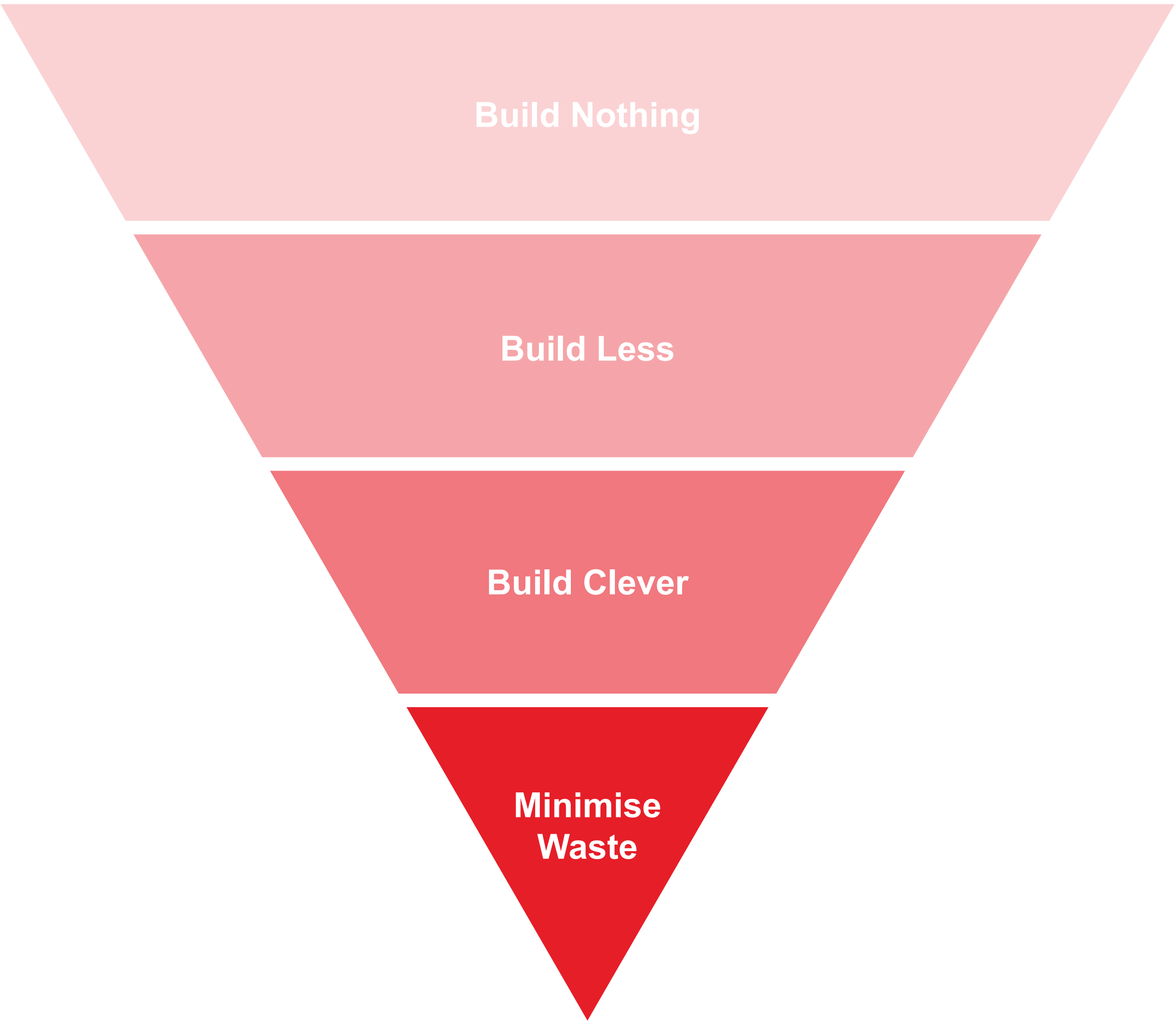
The RIBA 2030 Climate Challenge provides metrics for benchmarking non-domestic buildings:

2020 targets < 800 $kgCO_2e/m^2$

2025 targets < 650 $kgCO_2e/m^2$

2030 targets < 500 $kgCO_2e/m^2$

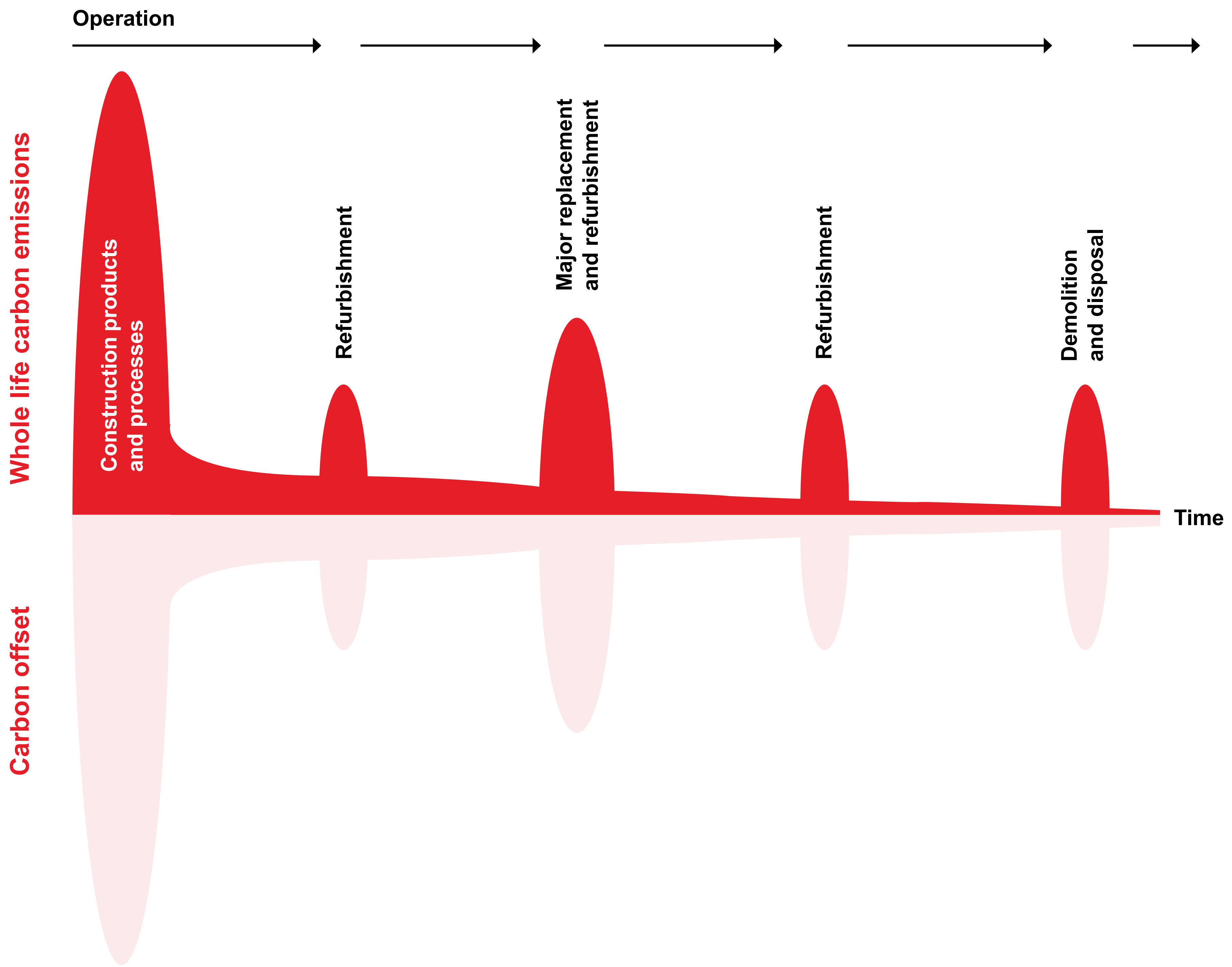
The Net Zero Design Approach

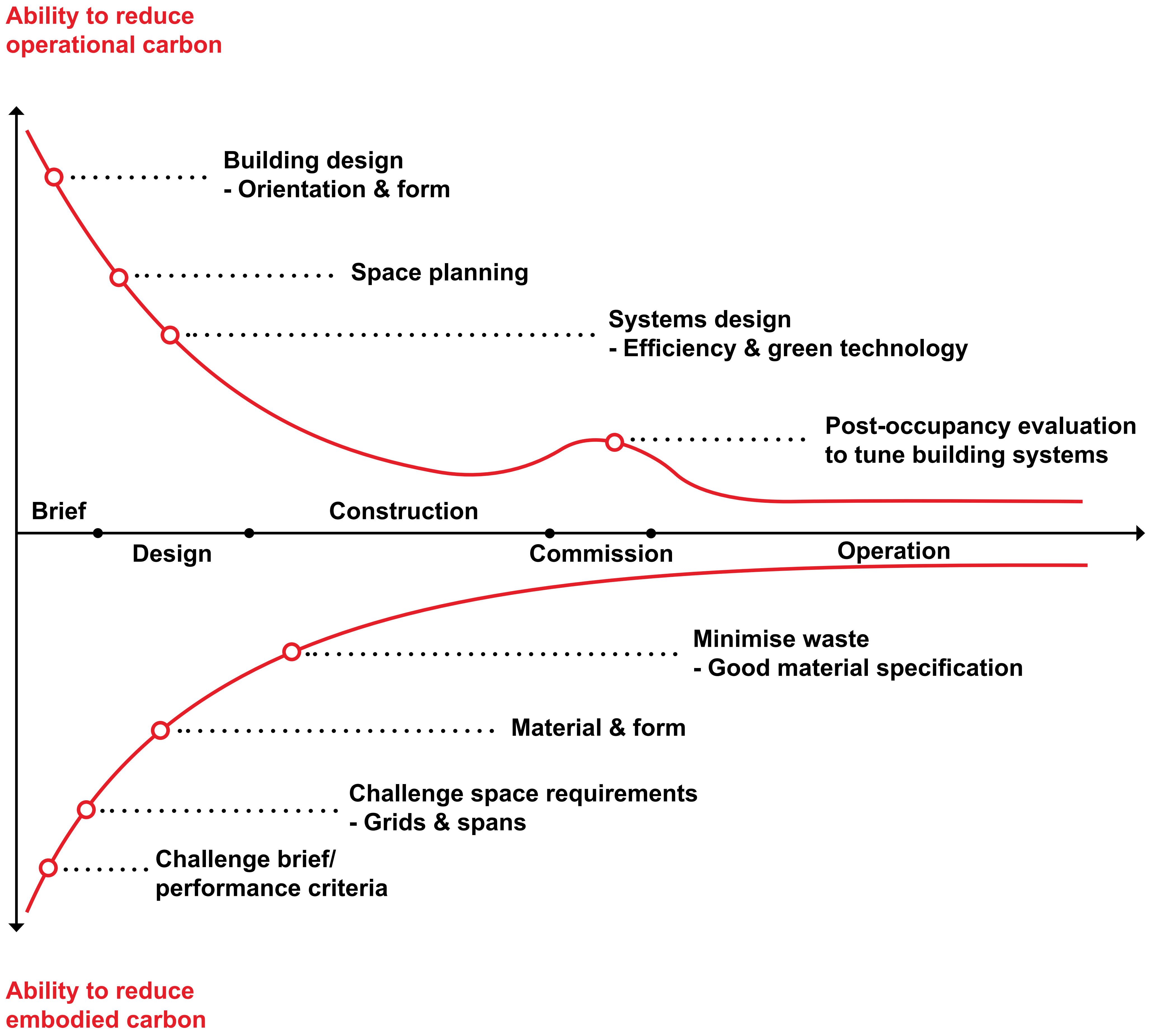


Introduction

Whole life carbon

To achieve net zero carbon hotels, we must take account of whole life emissions. There are many trade-offs between operational and embodied carbon emissions, starting with the decision about whether to demolish or repurpose. Newly constructed hotels are more energy efficient operationally, but their construction generates significant embodied emissions.





Real world case study

The hotel chosen for our case study is a typical midscale, full service business or leisure hotel, built in the UK in 1966. There are hundreds of similar hotels across the country. We selected it due to the potential for replication of the methodology and findings.

As will be clear throughout this paper, one size never fits all and all hotels are different. However, even though the interventions required may differ, the logic and methodology set out here provide a high-level framework for achieving net zero carbon in the operation of your hotel.

Energy use and sources

Reducing energy consumption is the best way to achieving net zero carbon in operation, alongside transitioning away from fossil fuels.

The case study hotel uses energy as follows:

- Atmospheric gas fired boilers heat domestic and pool hot water, as well as the pool hall.
- Electricity for small power, lighting and guestroom heating and cooling, (using a variable refrigerant flow system), as well as for fans and air handling units.
- Mixture of gas and electric for catering equipment.

Walls, windows, roofs and floors

A significant proportion of energy used to maintain comfort escapes through the building envelope.

Understanding current thermal performance is a key first step to assessing the potential benefits of improving walls, windows, roofs and floors.

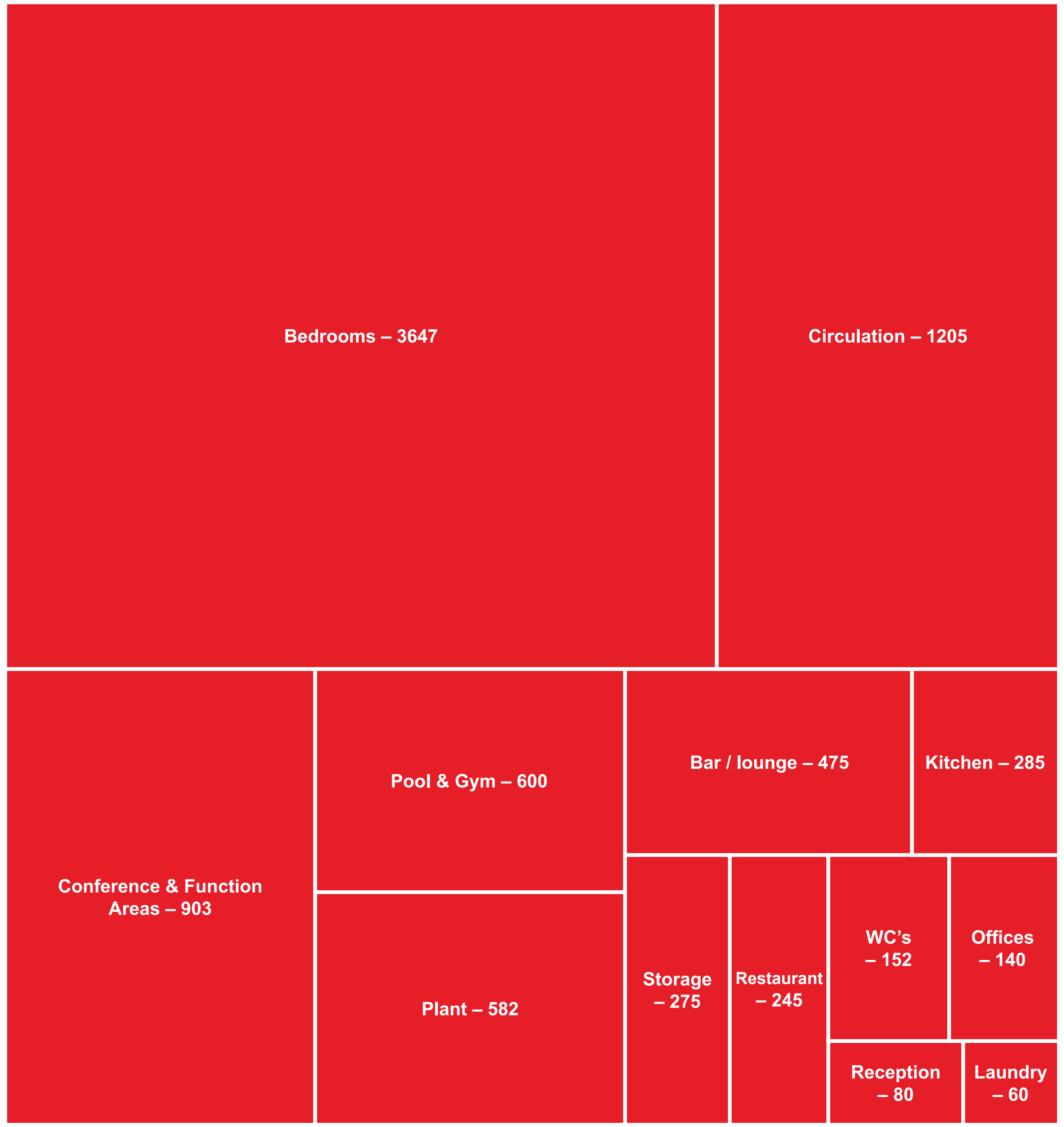
We surveyed the case study hotel and assessed the thermal properties of the building fabric, based on its age and construction. We used this information to develop a thermal model.

Catering, laundry, gyms and pools

Services offered by hotels influence where to focus interventions. While some are universal, such as heating, cooling, hot water and lighting, others are specific to individual buildings.

The case study hotel includes a gym, pool and a significant catering offer serving more than just guests. However, most laundry is carried out off site, so the associated emissions were not captured.

G.I.A OF THE HOTEL: 8,694m^2



Real world case study

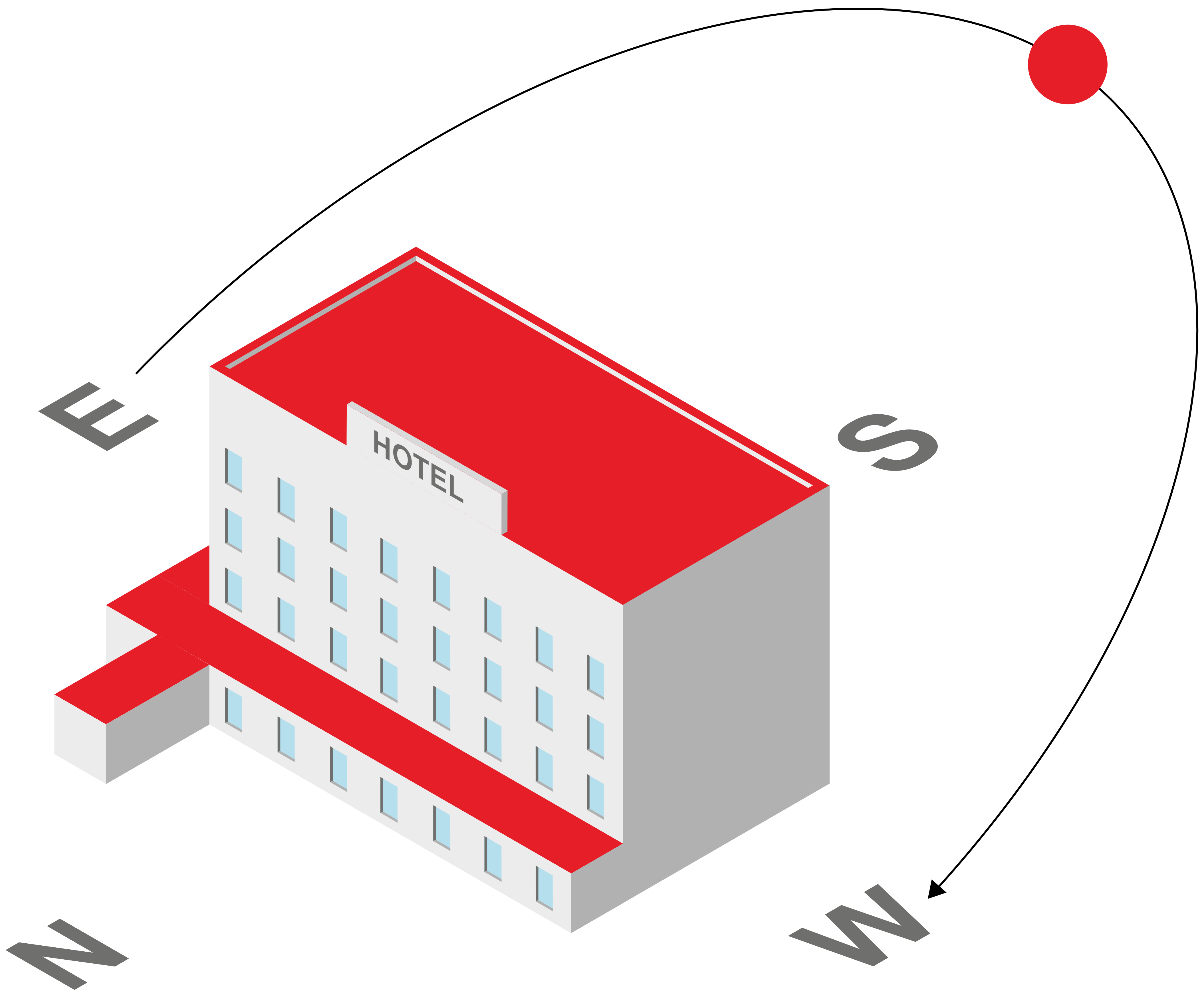
Location, location, orientation

A hotel's location and orientation impact its carbon footprint. Climate, weather and exposure all play their part, as does the carbon intensity of the energy network.

The case study hotel is located near London, in the south of England.

The main blocks housing the guestrooms are primarily arranged along a north west / south east axis. Guestrooms are suitably sized and configured for natural ventilation and daylight penetration. The depth to height ratios of between 2 and 2.5 metres promote single-sided ventilation.

The rest of the building is deep plan, with no particular orientation. The deep plan nature of the back of house and front of house areas makes it more difficult to introduce daylight and natural ventilation.



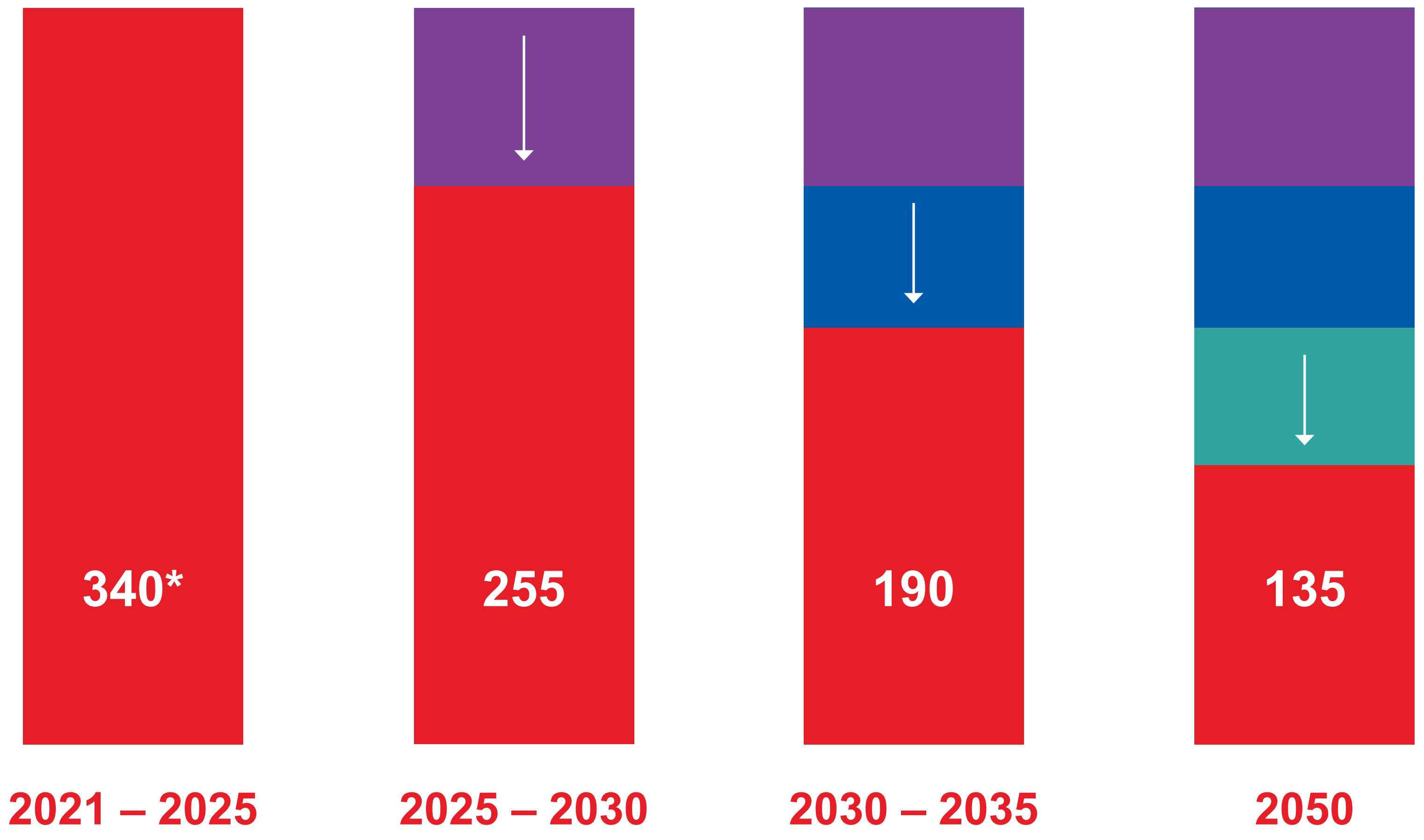
Set a target

Define the scope

We used the UK Green Building Council's (UKGBC) 'Net Zero Carbon Buildings: A Framework Definition to define the scope of net zero for the case study hotel.[11]

Net zero carbon – operational energy: "When the amount of carbon emissions associated with the building's operational energy on an annual basis is zero or negative. A net zero carbon building is highly energy efficient and powered from on-site and/or off-site renewable energy sources, with any remaining carbon balance offset."

Targets for typical UK hotels in kWh/m² per year:



* CIBSE Guide F, Good Practice Hotel 260 + 80 = 340 kWh/m²

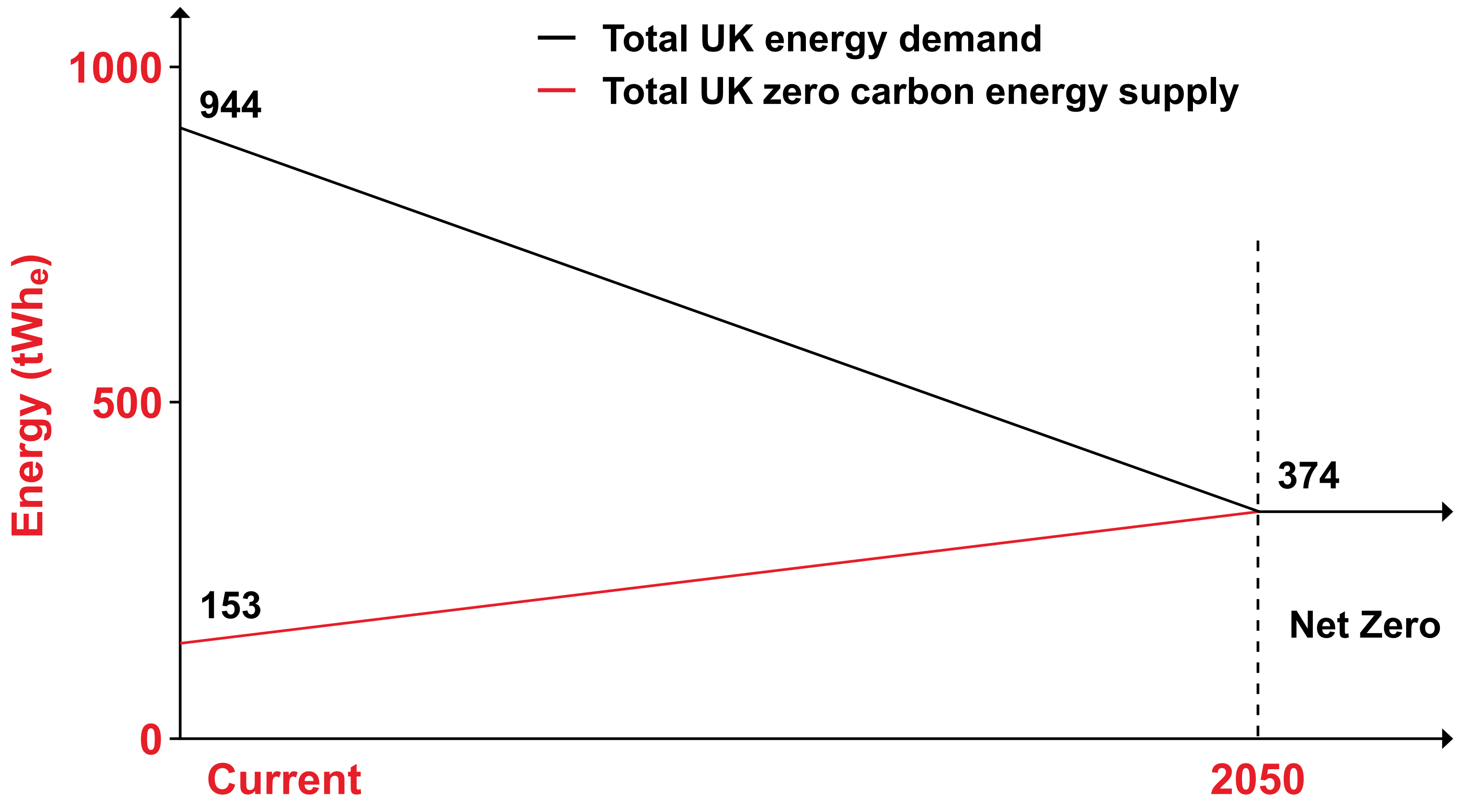


Figure 1: UKGBC June 2020

How far and how fast?

We drew on research by the UKGBC to establish Paris Proof carbon targets for existing hotels.

The UKGBC 'Energy performance targets for net zero carbon offices' report, published in 2020, identified that the office sector will need to reduce energy use by 60% by 2035-2050 to realise the aims of the Paris Agreement.

Adopting a similar Paris Proof target approach, we set out suggested targets for the case study hotel's energy consumption.

Suggested annual targets for the case study hotel

	Interim Targets			Paris Proof Target
Metric	2020-2025	2025-2030	2030-2035	2050
kWhe/m²	450	338	251	179

Gather the data

Lifecycle timeline

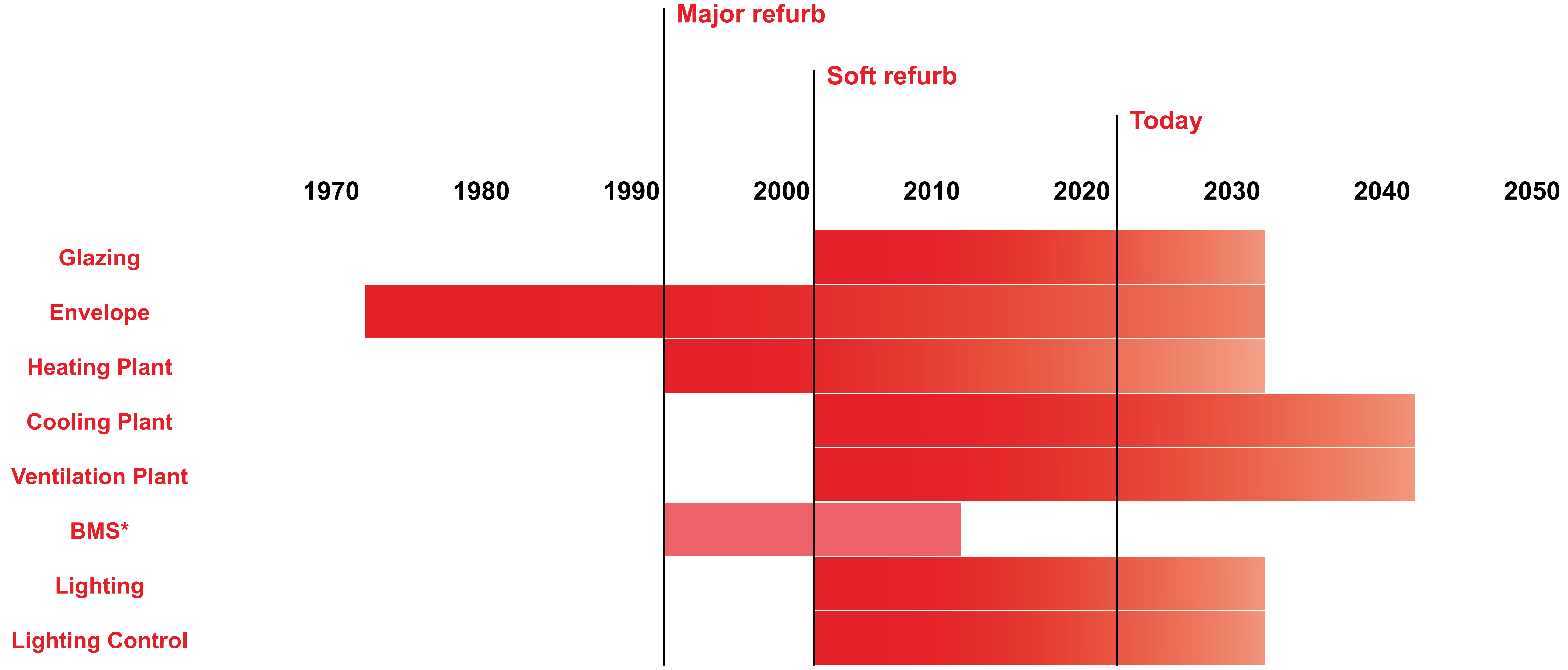
Developing a lifecycle timeline underpins the path to net zero, informing the timing of major interventions.

All main heating, ventilation and air conditioning (HVAC) equipment will reach life expiry and need to be replaced by 2050. When existing equipment approaches life expiry, replacement improves efficiency and performance but also causes disruption.

The issue is timing. Refurbishment of guestrooms, front of house spaces and plant must be coordinated with room bookings and ideally done during the off-season to minimise losses from reduced capacity. However, in the UK, this is often over winter, when heating plant disruption can be problematic.

The approach for refurbishments and replacements can range from one big project with vacant possession, through to a long series of projects within individual areas, either during off-season or working around guests.

A typical façade lifecycle is around 50 years, though the reality can vary substantially. The decision on whether, when and how to replace the façade is one of the main uncertainties in planning for operational net zero.



*Legacy BMS capability but no head-end, centralised control, network connectivity or IoT software provided

The case study hotel

The table above predicts the lifecycle of elements in the case study hotel, based on information provided by the hotel operators and managers and a non-intrusive survey of equipment on site.

When assessing potential interventions, we considered this lifecycle and looked at the uplift in costs and carbon over a baseline replacement strategy.

A full upgrade could be undertaken during a planned Property Improvement Plan, and the costs of doing this are summarised at the start of this report.

Gather the data

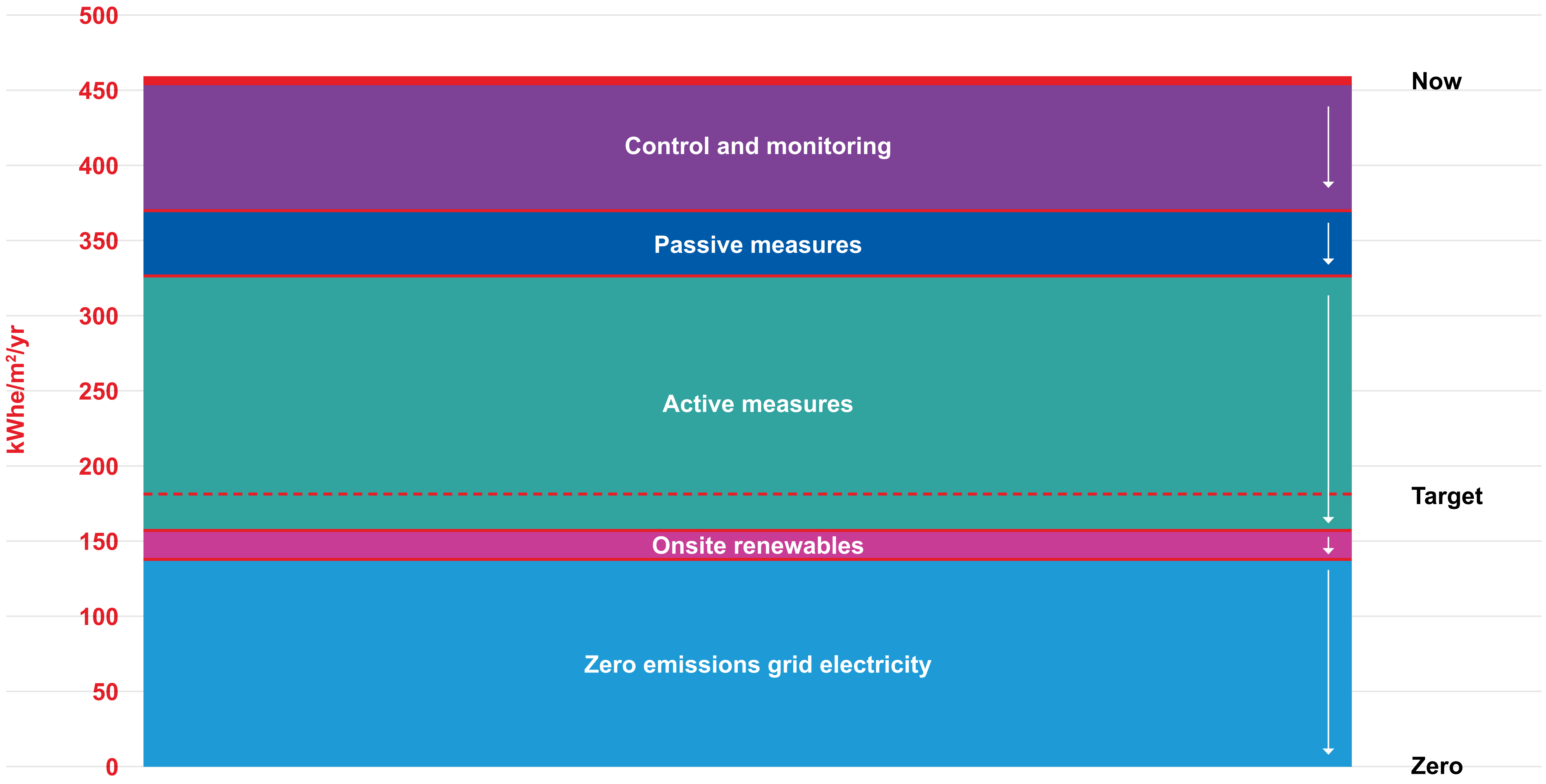
Plotting the path to the target

This chart outlines a suggested path for the case study hotel to achieve net zero in operation by 2050.

It illustrates the estimated carbon impact of each intervention package.

A timeline could be designed to align with the lifecycle replacement point for each system, as shown in the previous section. The building is estimated to achieve the previously defined energy use intensity target.

In a real scenario, this timeline should remain under regular review with the relevant stakeholders. The timings of each intervention would also consider other factors, such as the impact on hotel operations and further investigation into the anticipated lifespan of the hotel elements.



Establish the baseline

Understand current performance

To assess the extent of improvements required to achieve net zero in an existing hotel, we need to understand its current performance.

This baseline is established using primary energy meter data and knowledge of how this energy is used, ideally obtained from submetering of the main energy consuming areas and processes in the hotel.

This baseline data enables you to:

– Compare your hotel against similar hotels to benchmark relative carbon performance.

– See how far there is to go to reach net zero carbon.

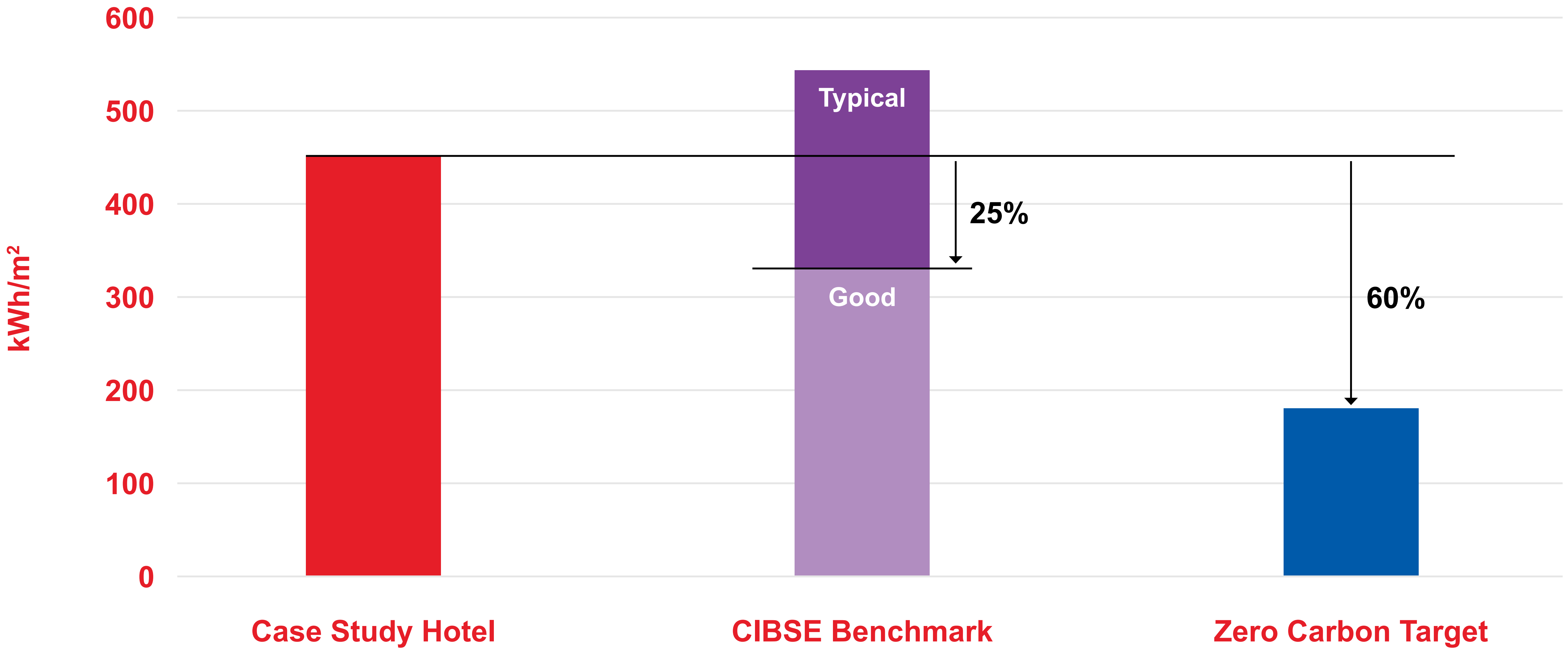
– Calibrate energy models of the building to assess the relative merit of various interventions.

See where you are in the race

For the case study hotel, we compared the overall carbon emissions with other hotels, using available benchmarks from Chartered Institution of Building Services Engineers (CIBSE) and with previous studies by Arup and others.

There is still a lack of good data in the UK. An Energy Performance Certificate provides a view on how a building's design suggests it could theoretically perform. However, it does not measure actual performance.

The graphs on these pages show where energy is currently used in the case study hotel and how that compares to available hotel benchmarks.



Establish the baseline

Effective metering of energy is key

We obtained historical primary energy meter data for the case study hotel. As is typical of buildings of this era, there was no submetering to split out end uses for the energy. Only monthly data had been captured, manually.

Submetering the main energy uses provides granular, in-depth data, allowing more informed decision making, such as targeting high energy demand equipment and gaining greater clarity on the potential impact of interventions.

To split the energy into end uses, we carried out a detailed survey of all the energy consuming equipment in the hotel. This included boilers, air conditioning, lights, ovens and minibars. We also assessed the building fabric. This helped us identify interventions to prioritise.

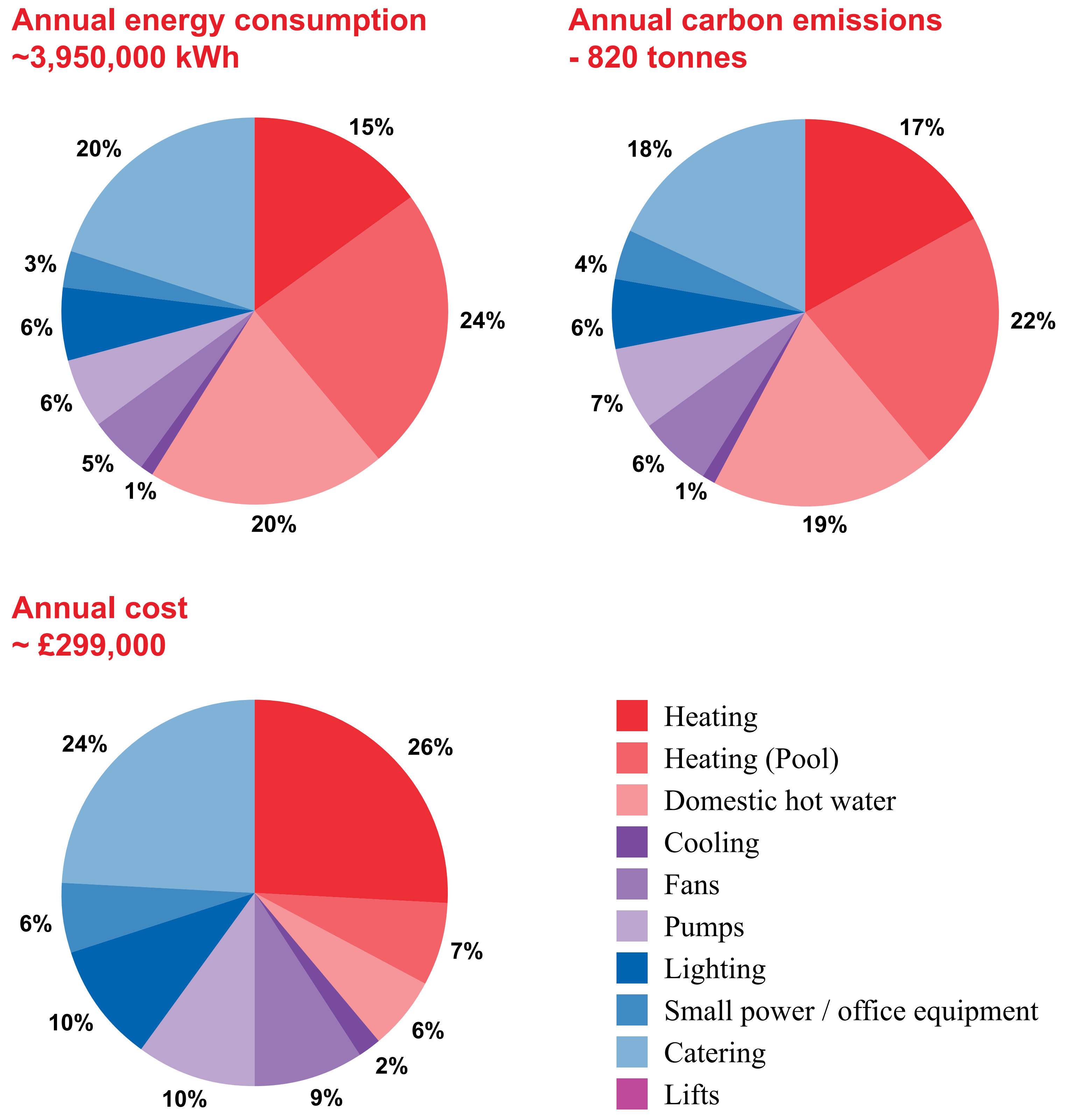
We interviewed the hotel and facilities managers to explore how the building was used. We were keen to understand issues raised by guests, to see if improvements could not only reduce carbon emissions but also improve the overall guest experience and comfort.

What are the key variables?

Outdoor temperatures impact energy consumption in all buildings, including hotels. Degree day analysis allows you to see whether your hotel's heating and cooling systems are being controlled efficiently.

The number of guests also impacts energy consumption. Unlike other building types, this data is regularly collected for hotels and is extremely useful to work out energy consumption associated with guests.

> The case study hotel produces the equivalent of the carbon sequestered by 27,000 trees planted in the UK.


Annual energy consumption ~3,950,000 kWh

Annual carbon emissions - 820 tonnes

Annual cost ~ £299,000

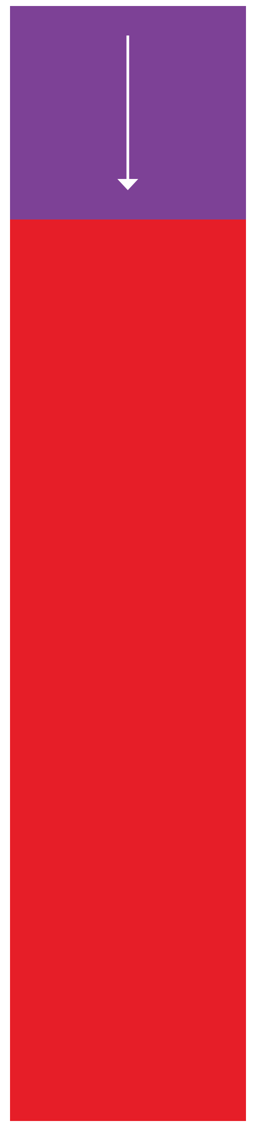
Control and monitor

On your journey, try to move more efficiently

The most cost effective and, arguably, easiest way to reduce the carbon emissions of the hotel is to improve how it is managed.

Significant savings can be made without altering the fabric of the hotel or its building services – from how rooms are booked, to when you cool and heat the spaces. In our case study hotel, operational changes alone are nearly enough to meet the target for 2026.

The impact of improvements



18% energy savings

£190k
CAPEX

£58k/yr
Energy bill savings

3.5yr
Simple financial payback

150tCO_2e/yr
Carbon savings

Control and monitor

Control and monitor what's happening

Building management system (BMS)

A centralised BMS allows hotel operators better control and monitoring of their building. Not only can it reduce energy consumption, it can also allow you to respond to faults with the heating and cooling systems before guests complain.

In our hotel, there was already the backbone of a BMS system, but no software to allow the building manager to view the systems and easily adjust HVAC systems centrally.

The following interventions are all possible without a BMS, but they can be more challenging to enact and maintain.

If the case study hotel had Internet of Things enabled control software, further optimisation could be applied to enhance active energy reduction and operational performance. Some examples that were not applied in our case study are weather adjusted set points, floating dead bands, demand based pumping and ventilation, time schedule rationalisation and night purge cooling.

Metering

As noted previously, the existing building did not have any submetering, making it more challenging to determine the end use of energy within the building.

Smart metering or networked sub-metering, combined with software, can also be an important tool to maximise and maintain energy performance, as well as to evaluate and assess the impact of any of the interventions outlined within this report.

Guestroom management

A modern guest room management system, integrated with building management, property management, and other systems provides a holistic view of each guest room in the hotel. These systems monitor and control energy consumption, allowing hotel operators to identify and proactively address maintenance needs, facilitate service requests, and enable troubleshooting problems remotely.

An effective guestroom management system detects and responds to the presence of guests, allowing heating or cooling to be reduced when rooms are unoccupied. This makes the following approaches much simpler to enact and manage.

For our study, we looked at the potential impact of installing Schneider Electric SE8300 Room Controllers. These employ guest detection via a combination of a door contact and an inbuilt occupancy sensor within the room controller.

Don't waste energy on empty rooms

When we visited the case study hotel, we found that guestrooms were heated or cooled to the same set-points, regardless of whether they were occupied, for set periods every day.

The heating and cooling set-points were also higher and lower than required for comfort (22°C and 20°C respectively), resulting in significant energy consumption. In winter, guests sometimes complained about rooms being too hot. As the HVAC system was not able to simultaneously heat and cool different rooms, the only remedy to overheating was for guests to open their windows, wasting heat and increasing carbon emissions.

Setting the target temperature for occupied rooms to 21°C for both summer and winter and allowing rooms that are not booked to set back to 18°C in winter and 24°C in summer, saved around 30% of the heating and cooling energy associated with bedrooms. It is also likely to improve overall guest comfort.

Control and monitor

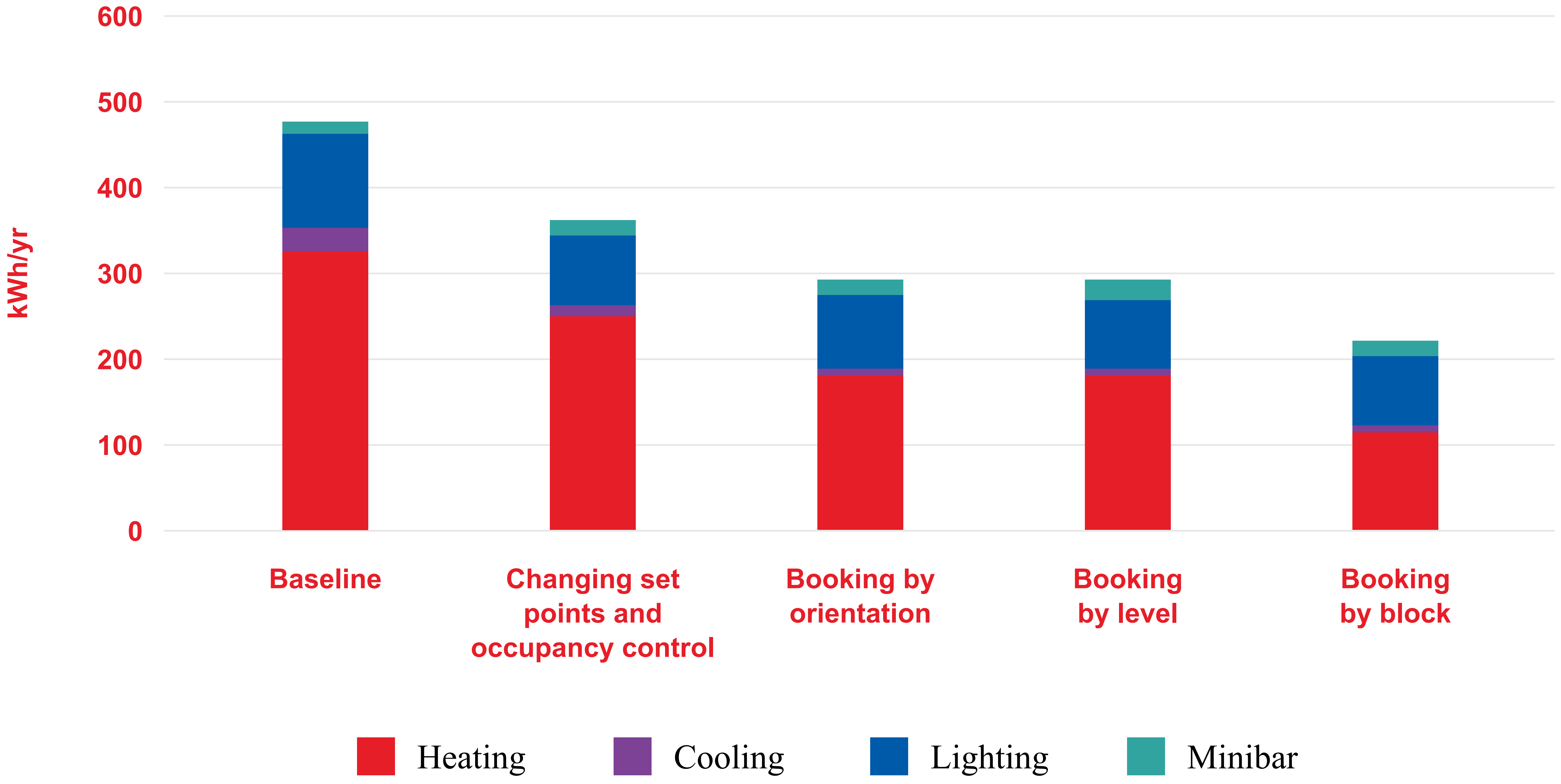
Try to allocate rooms close together

In the case study hotel, room allocation was based on guest preference and availability, without taking energy optimisation into consideration. As a result, lighting in circulation spaces, minibars, heating and cooling were running throughout guestroom blocks unnecessarily. Occupancy varies through the year, ranging from around 65% in low season to over 90% in peak season. The hotel was busy on weekdays during the low season with business guests, and busy on weekends during the peak season.

We assessed the impact of different approaches to allocating rooms: by block, by orientation and by level. This was done over a typical year, using occupancy data from the previous five years, as well as discussion with the hotel managers about the typical daily and weekly profiles.

Allocating rooms together has other operational benefits. For example, cleaning and service staff have less distance to travel and areas can be closed off for maintenance.

Impact on bedrooms



Control and monitor

Pool temperature

To reduce evaporation and condensation, pool halls are kept above the water temperature of the pool. This means they are typically a big energy consumer, as shown in our baseline data.

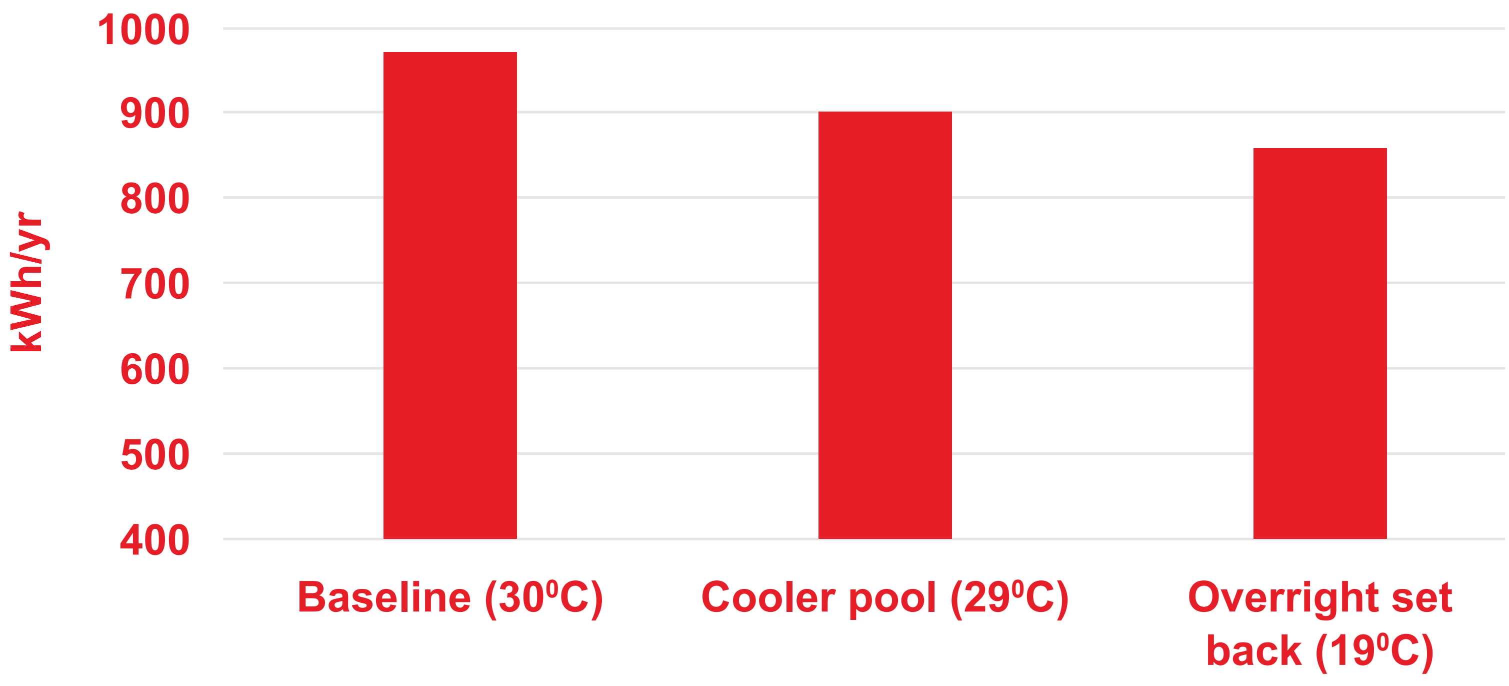
The Pool Water Treatment Advisory Group recommends that pool hall air temperature should normally be maintained at the water temperature or within 1°C. However, air temperatures over 30°C should generally be avoided.

In our study, the pool hall air temperature was set 2°C above the pool water temperature. Like many hotels, the pool water was set at 30°C. Although many guests use the pool casually, enjoying the warm temperature, it is also used for aqua aerobics and by travellers exercising in the morning.

We would not suggest reducing the temperature to 25.5°C, like a pool for competitive swimming, but there would be little impact on the guest experience by reducing the pool to 29°C, saving about 6% of the associated energy demand.

In addition, pool and pool hall temperatures were maintained 24 hrs a day, perhaps because of concerns about the time required to heat it up or to deal with condensation risk. However, using pool covers and allowing the pool hall temperature to drop overnight to around 19°C generated a further 4% energy saving.

Impact on pool – (pool and pool hall air)



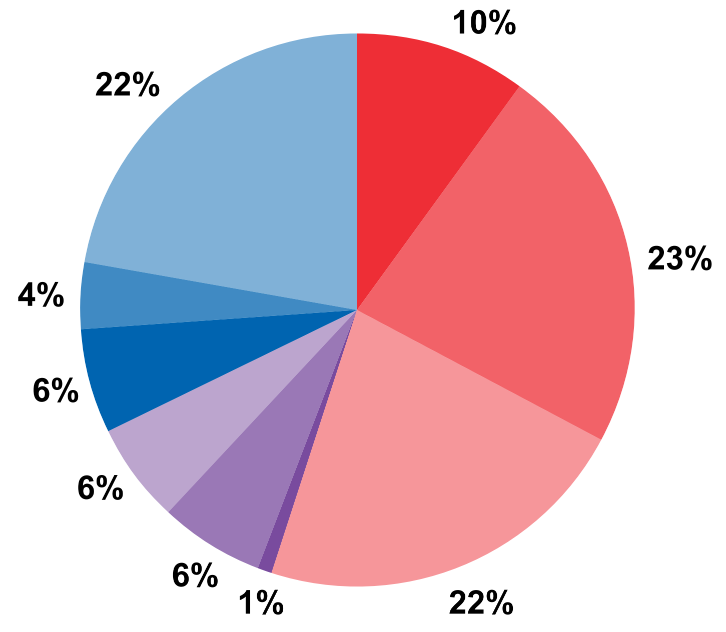
Catering

The kitchen is another key focus area for changes to ways of working. Catering accounts for about a fifth of the energy consumption and carbon emissions in our hotel.

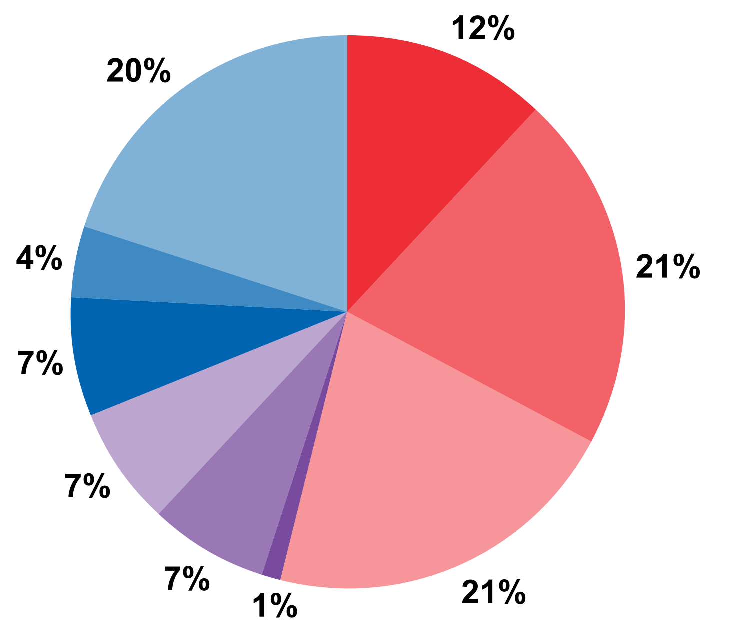
Further energy reduction measures are discussed in a subsequent section of this paper on page 45.

The remaining energy consumption is 372 kWh/m^2 of energy a year, producing the equivalent of the carbon sequestered by 22,300 trees in the UK.

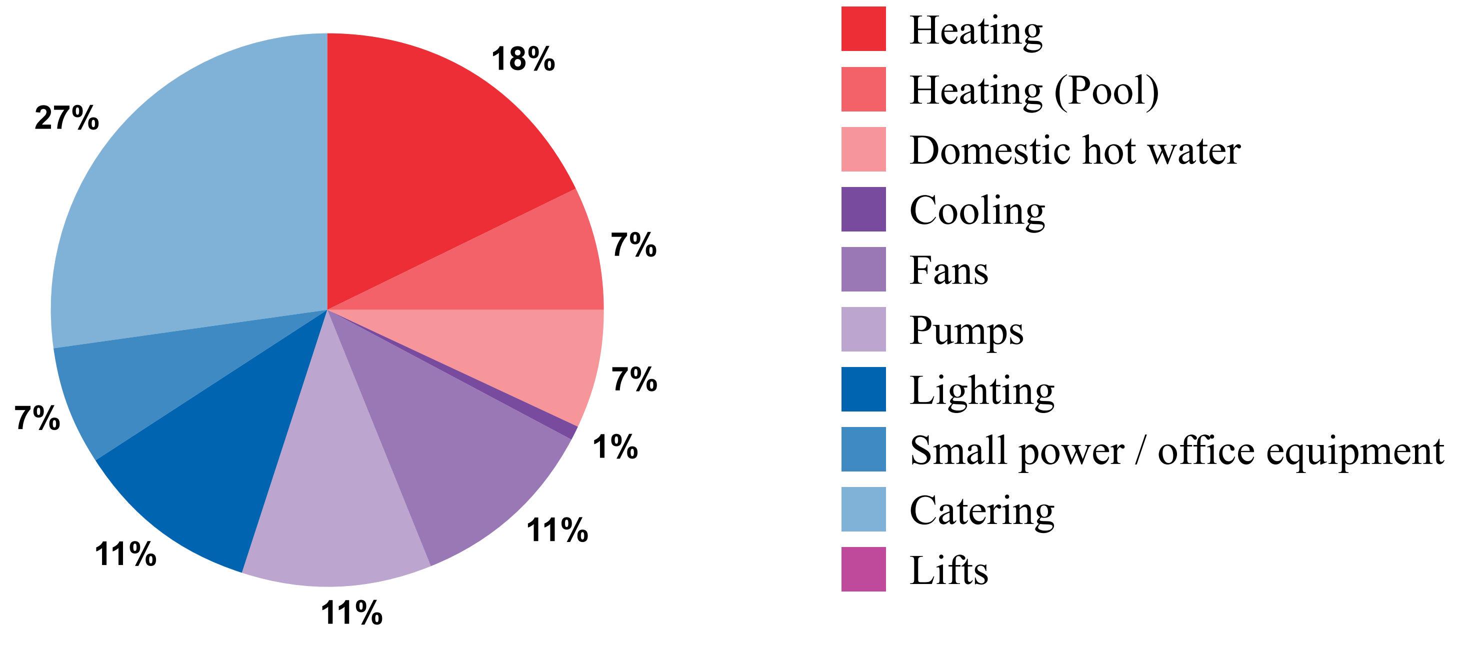
Annual energy consumption ~3,236,000 kWh



Annual carbon emissions - 669 tonnes



Annual cost ~ £241,000



Passive measures

Methodology

In investigating passive design measures, we used various calculation methods, including dynamic thermal simulation and parametric modelling.

We applied parametric modelling to consider incremental improvements to guestrooms, including:

- Thermal performance of walls and windows.
- Air tightness.
- Wall to window ratios in various orientations.
- Lighting efficiency and daylight control.
- Internal and external solar shading.

We applied dynamic thermal simulation to explore thermal performance improvements to the pool hall fabric.

Improving the building fabric

After optimising the operation of the hotel, we investigated improvements to the thermal performance of the building fabric.

The savings outlined here are based on natural ventilation for the guestrooms and changes to the façade to optimise glazing and daylight, insulation values and infiltration rates.

The impact of passive measures

11% energy savings

£463k
CAPEX

£26k/yr
Energy bill savings

18yr
Simple financial payback

262tCO$_2$e
Embodied carbon

86tCO$_2$e/yr
Carbon savings

3yr
Simple carbon payback

Passive measures

Insulation

In the UK, much of the focus on reducing heating demand for buildings has been on improving insulation and air tightness. While important, there is a potential risk of overheating and increased cooling need, particularly with increasingly hot summers.

This is a particular issue for hotels, with UK guests already more likely to complain about rooms being too hot rather than too cold - a fact raised by hotel managers in our study. This is partly because comfort temperatures for sleeping underneath a duvet are lower than those when awake, making the comfort balance difficult to achieve across the hotel building.

In our hotel, little could be done about overheating during the ‘heating’ season as no active cooling was available during winter. As well as the potential to reduce energy, there was also potential to improve guest comfort.

Air tightness

In any building, low levels of air leakage reduce heat lost to or gained from outside. In turn, this cuts energy use and carbon emissions associated with heating and cooling. Improving air leakage significantly beyond legislative guidance can similarly reduce energy consumption. We tested the impact of this in our case study hotel.

Glazing and daylight

Consider the balance between daylighting, solar gains and artificial lighting before developing the façade treatment.

The ratio of window to wall on the hotel façade changes the heat loss, solar gain and artificial lighting requirements.

Solar shading, such as brise soleil or internal blinds, can reduce unwanted summer solar gain, but needs to be balanced with useful winter solar gain.

We also looked at the impact of different options for daylight dimming controls within guestrooms.

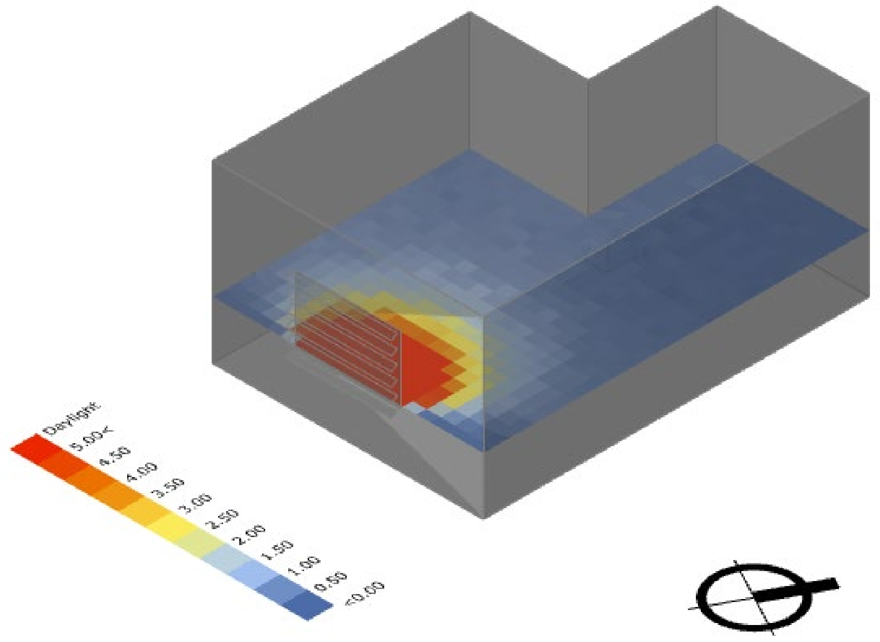
Modelling multiple criteria

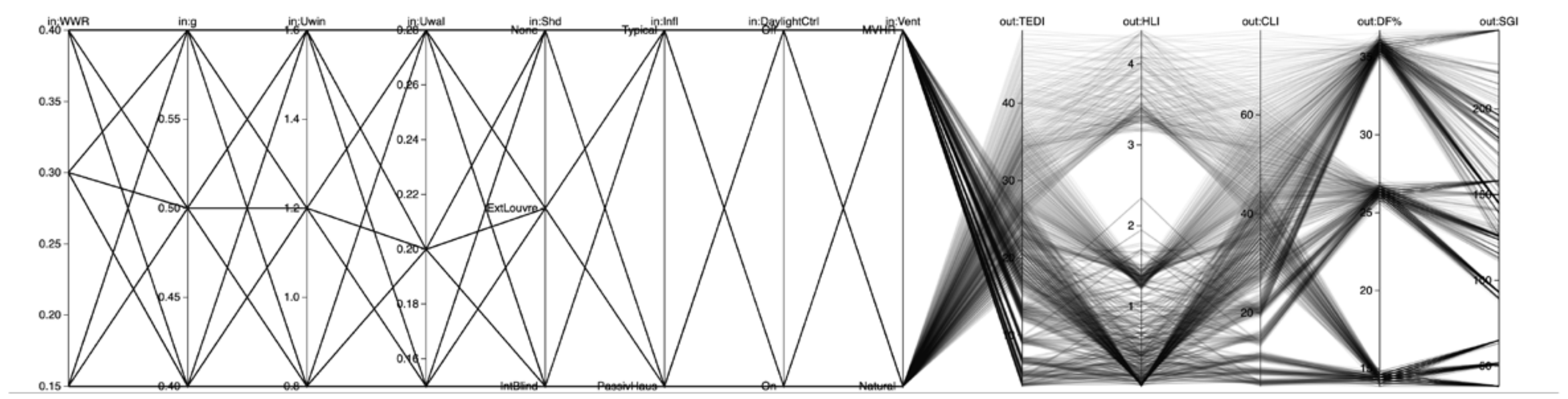
Multi-objective optimisation analysis is a decision-making process that considers multiple criteria simultaneously to achieve an objective or objectives using algorithms. We built a tool within Grasshopper software, using Ladybug and Honeybee.

When applying this powerful approach to address complex problems, it is essential to simplify the number of variables being modelled. For a new building, these could include the massing and orientation of your hotel, to help define the most energy efficient building form factor in the early stage of design.

The thousands of potential outcomes from different parameters can be hard to understand and filter. Arup has developed a graphic interface ‘Parameterspace’ to flip though design options and evaluate and discuss their merit with clients.

We used this tool to select the acceptable range of passive design outputs from the model and explore different possible inputs. For example, we looked at what was achievable using natural ventilation compared with mechanical.





Passive measures

Existing guestroom façade

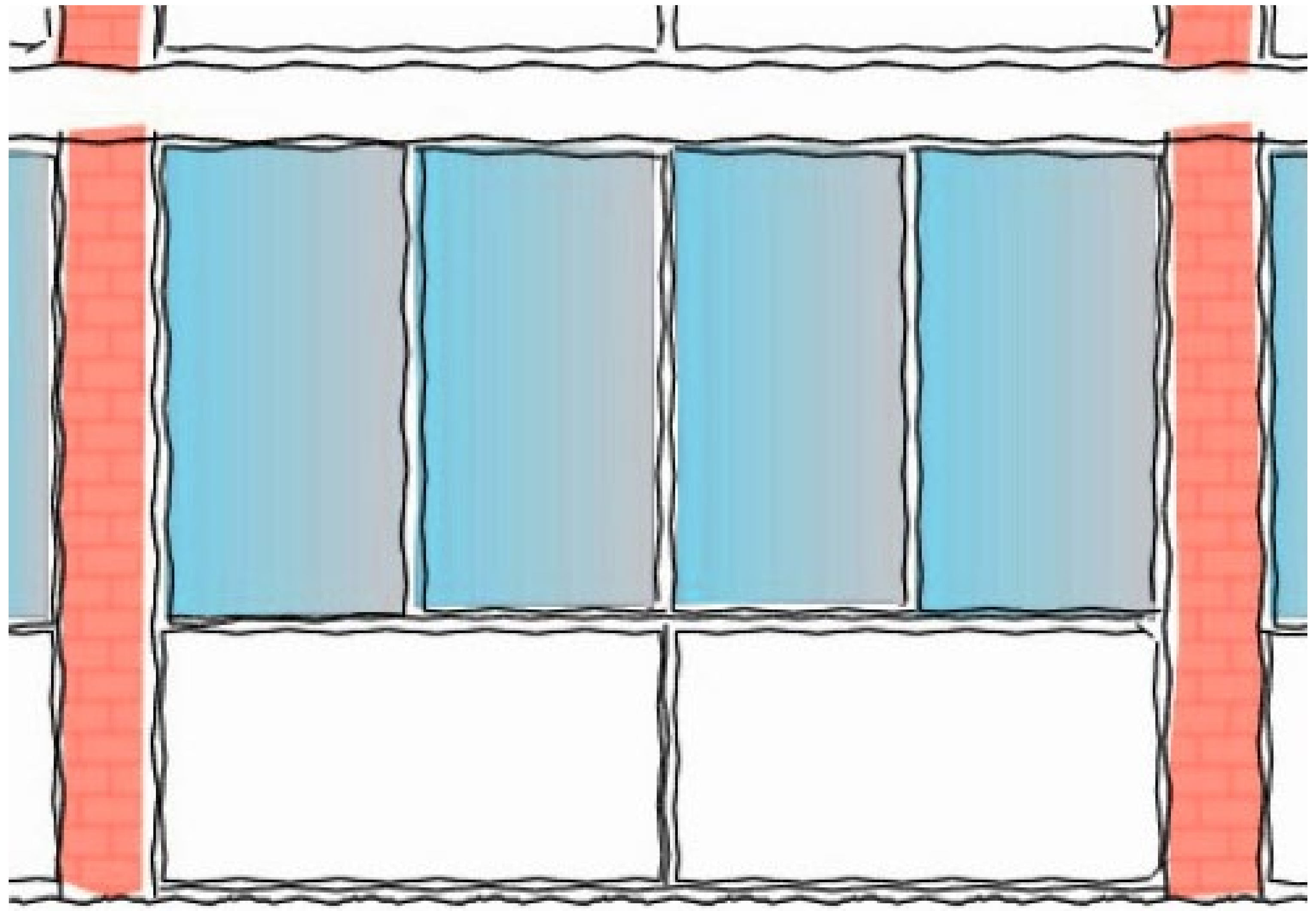
The existing façade of the envelope in the case study hotel is typical for a 1960s building.

The windows were upgraded to aluminium framed air-gap double glazed units around 20 years ago. Many of these are now blown, resulting in condensation build up within the gap and adversely impacting the guest experience.

As such, the windows are at the end of life and need replacing. We compared the financial and carbon costs of a base case, replacing the windows with new units, versus a full façade replacement.

A thin façade panel provided little insulation relative to modern standards, and the arrangement of the panel within the overall structure results in 'thermal bridging' where heat can escape.

Base case: replacing the double glazing



Figures right detail the costs of the base case of replacing the windows.

£730k

Base case CAPEX

$54tCO_2e$

Embodied carbon

Improving guestroom façades

In our hotel, the external façade to the guestrooms needs replacement within five to ten years. We therefore focused our algorithm on the external envelope of the guestrooms, looking at 12 rooms based on their position in the building, such as floor level and orientation.

The guestrooms lent themselves to the parametric modelling approach. Taking up a significant amount of floor area, they are repetitive in layout. So, it is reasonable to extrapolate findings from one room to other rooms.

We modelled the guestrooms in Grasshopper software to assess tens of thousands of combinations of thermal properties and window options.

We targeted getting the Thermal Load Intensity (TLI) as low as possible. This metric considers the energy used for both heating and cooling over a typical year.

We analysed the results using Arup's Parameterspace tool to suggest improvements to the fabric of the building.

Passive measures

Detailing is key

Careful detailing in design and construction is important to eliminate thermal bridging, maximising the thermal performance of the building envelope.

A thermal bridge, sometimes called a cold or heat bridge, is part of the façade or structure with higher thermal conductivity than the surrounding materials, creating a path of least resistance for heat to move between inside and outside.

In our proposals for façade changes, we referred to Passivhaus type detailing to avoid thermal bridging.

Partial pre-fabrication of the façade speeds up construction, reduces time required to work at height, cuts waste on site and improves the quality of the installation. The improved quality could lead to substantial carbon reductions over the lifecycle of the hotel.

Changes tested

Energy efficiency measures	Proposed options		
Thermal insulation walls	Part L2B min U-value	0.28	W/m^2.K
	Improved U-value 1	0.2	W/m^2.K
	Improved U-value 2	0.15	W/m^2.K
Thermal insulation windows	Part L2B min U-value	1.6	W/m^2.K
	Improved U-value 1	1.2	W/m^2.K
	Improved U-value 2	0.8	W/m^2.K
Air tightness (@50Pa)	Part L2B 'reasonable'	5	m^3/h/m^2
	PassivHaus	3	m^3/h/m^2
Window to wall ratio	40%		
	30%		
	15%		
Window g value	Part L	0.60	
	Improved 1	0.50	
	Improved 2	0.40	
Lighting	All LED		
	Full daylight dimming		
Solar shadings	None		
	Blinds		
	External brise soleil		

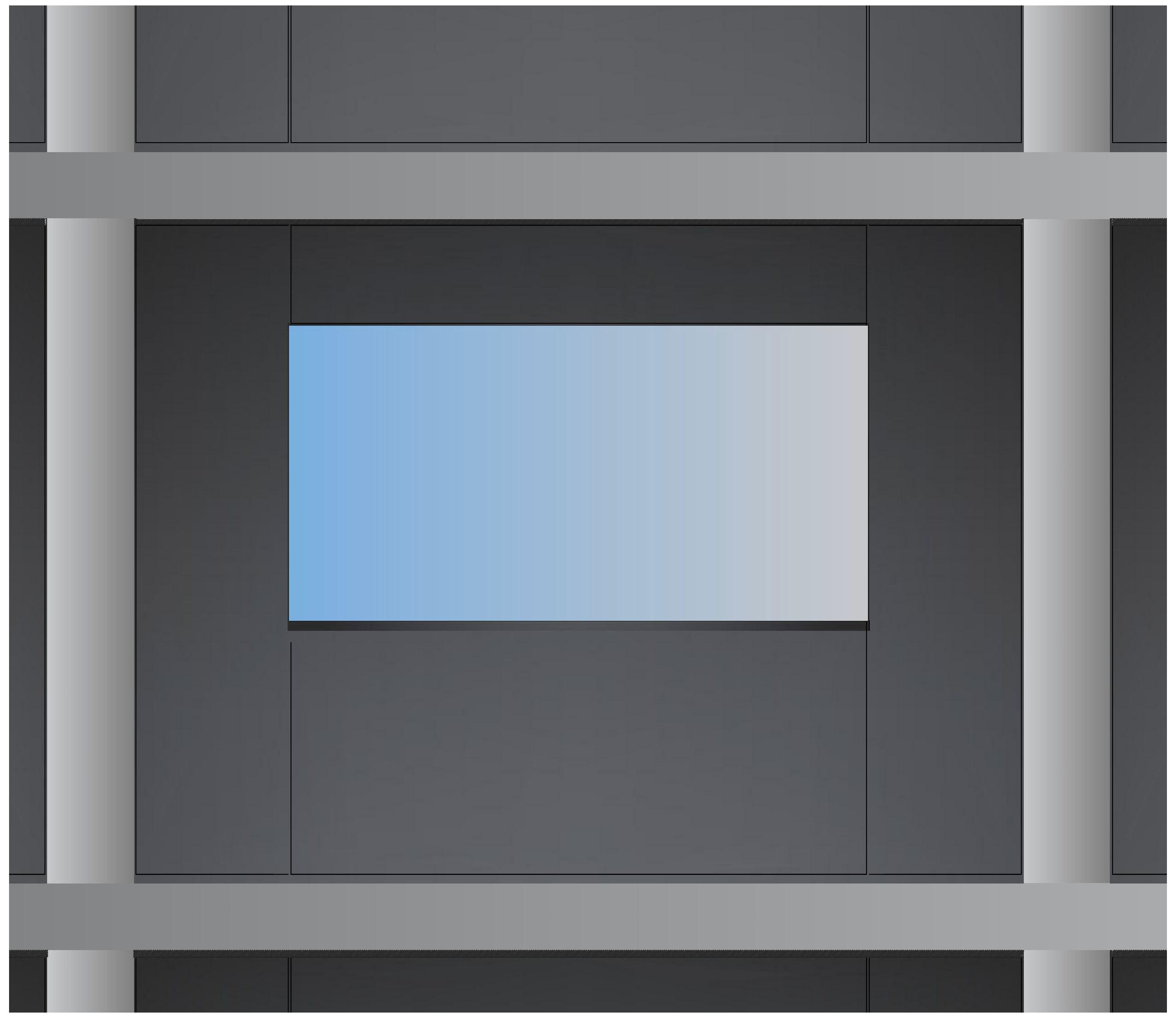
Passive measures

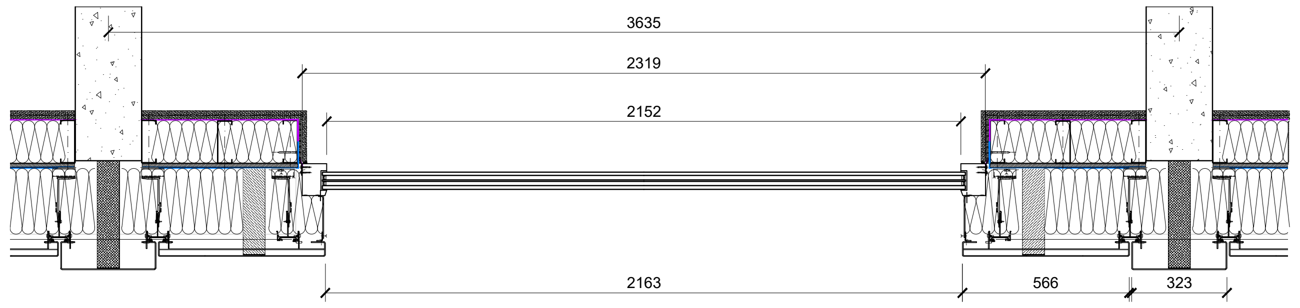
Façade with mechanical ventilation

Parametric modelling indicated that the lowest TLI was achievable by removing natural ventilation and using mechanical ventilation with heat recovery (MVHR).

MVHR allowed for insulation to be increased significantly, without the need to increase cooling capacity to cope with potential overheating. However, removing the option for guests to open windows could negatively impact their experience.

CAPEX was significant, due to higher insulation levels, triple glazing and installation of the MVHR units. The MVHR units would require additional energy use to power them and increase maintenance costs. It would also be difficult to implement in the case study hotel, due to space constraints.





Costs and savings of installing MVHR compared with simply replacing the windows:

£681k
Extra CAPEX above base case

£27k/yr
Energy bill savings

25yr
Simple financial payback

252tCO_2e
Embodied carbon cost

48tCO_2e/yr
Carbon savings

5yr
Simple carbon payback

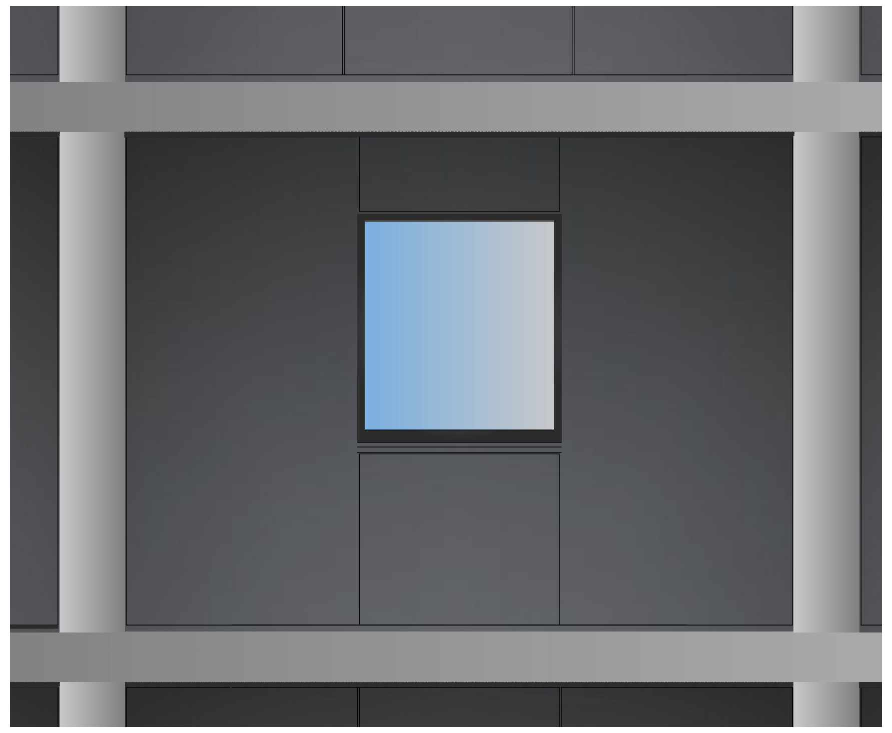
Passive measures

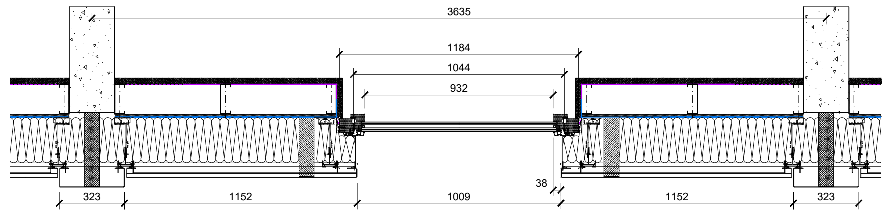
Façade with natural ventilation

This is the recommended route. Reducing the glazing to 15% of the overall façade and providing natural ventilation through openable windows achieved a significant reduction, although with a slightly higher TLI than MVHR.

Unexpectedly, the TLI for this approach was higher when using more insulation, due to additional cooling requirements in summer. This meant that double glazing and insulation levels up to those required by UK building regulations were optimal, keeping the capital costs lower than in the first approach.

In addition, giving guests control over the ventilation improves their experience.





What about noise?

Relying on natural ventilation means opening the window, which can let in unwanted noise. To avoid this, we modelled the opening windows based on Arup's SoftTone window product, which is designed to let fresh air in but keep noise out.

This parallel-opening window system uses an intelligent combination of materials and geometry to minimise noise levels while enhancing natural ventilation to create quieter, healthier and more sustainable spaces.

More and more urban centres are reducing speed limits. Engine noise becomes predominant at lower vehicle speeds. However, with the move towards electric vehicles and the near elimination of engine noise, we envisage an increase in uptake in natural ventilation.

The following outlines the costs and savings in comparison with simply replacing the windows. The costs shown below are:

£230k
Extra CAPEX above base case

£20k/yr
Energy bill savings

12yr
Simple financial payback

230tCO$_2$e
Embodied carbon

35tCO$_2$e/yr
Carbon savings

7yr
Simple carbon payback

What about light?

The reduced window size means less daylight. In other buildings this may have a big impact on the energy required for lighting, but in a hotel building guest rooms are usually unoccupied in the daytime. However, we ensured there was ample daylight at the table by the window.

Passive measures

Swimming pool hall façade

To prevent condensation problems and keep swimming pools at a comfortable temperature for guests, the temperature of the water and the room need to be higher than other areas in the hotel.

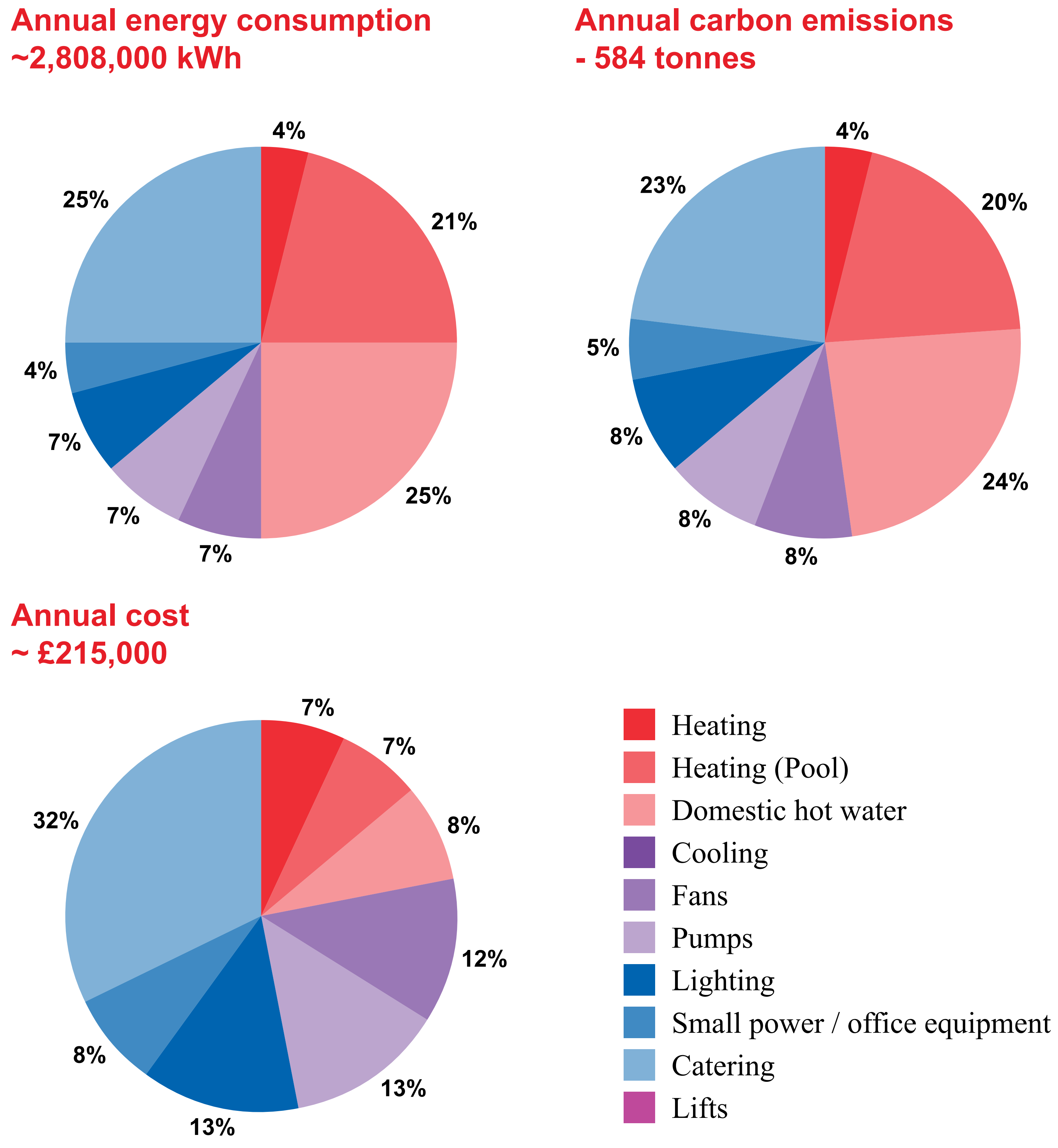
In our case study hotel, heating the pool and pool hall used nearly a quarter of all energy. The systems within the pool were quite modern; however, the building fabric had not been improved when these were updated, resulting in significant heat loss.

Whilst this aspect of the building fabric was not highlighted as requiring immediate remedial work, we looked at two options to improve the glazing and the impact of improving the roof insulation. When comparing, cost, energy saving and complexity of implementation, of single or combinations of options, triple glazing provided the best balance, particularly given the uncertainties around the unusual roof construction.

	Roof insulation	Double glazing	Triple glazing
CAPEX	£138k	£174k	£233k
Energy bill savings	£1.5k/yr	£5.5k/yr	£6.5k/yr
Simple financial payback	92yr	32yr	36yr
Embodied carbon	18tCO_2e	24tCO_2e	32tCO_2e
Carbon savings	12tCO_2e/yr	43tCO_2e/yr	51tCO_2e/yr
Simple carbon payback	1.5yr	<1yr	<1yr

Passive measures

The remaining energy consumption is 322 kWh/m^2 of energy a year, producing the equivalent of the carbon sequestered by 19,400 trees in the UK.


Annual energy consumption ~2,808,000 kWh

Annual carbon emissions - 584 tonnes

Annual cost ~ £215,000

ARUP

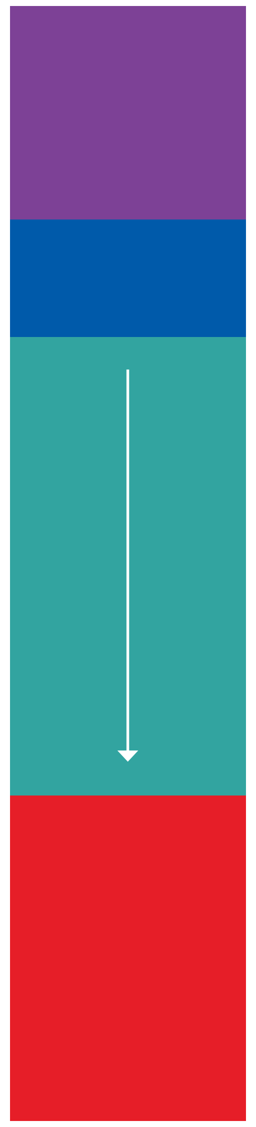
Active measures

Methodology

With the passive measures optimised, we explored upgrading or replacing key items of building services plant and equipment in the hotel, such as HVAC and lighting. We also considered changes to catering equipment.

The savings outlined here are based on upgrading the variable refrigerant flow (VRF) system, replacing the boilers with a ground source heat pump, replacing lamps with LEDs and refurbishing the kitchen equipment to a high specification.

The impact of active measures



37% energy savings

£899k

CAPEX

£36k/yr

Energy bill savings

25yr

Simple financial payback

540t/CO$_2$e

Embodied carbon

271tCO$_2$e/yr

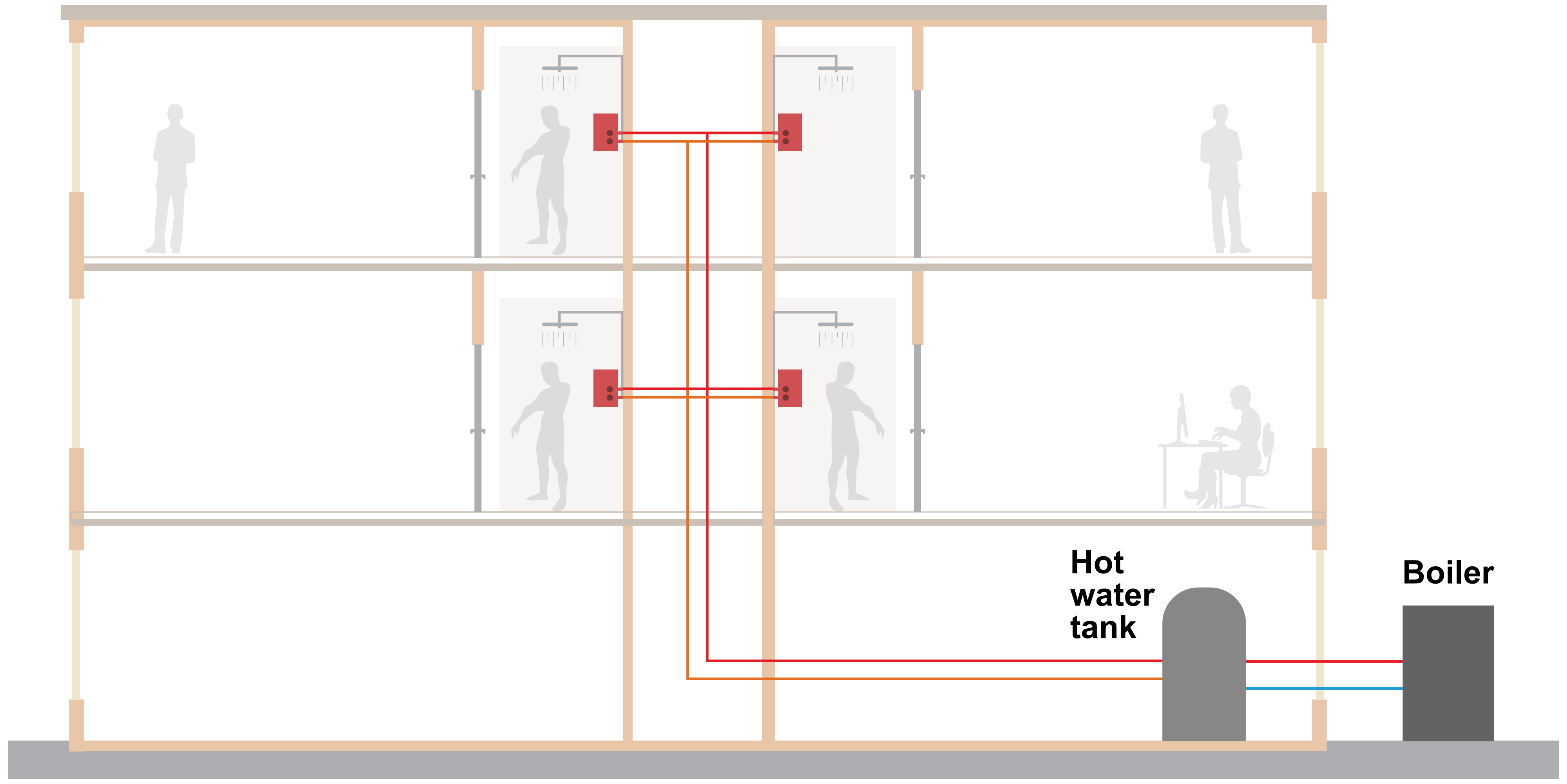
Carbon savings

2yr

Simple carbon payback

Active measures

Hot water and heating for swimming pool



Boilers

Two 650kW boilers are located in the building housing the swimming pool. These generate hot water for the whole hotel and heating for the swimming pool. The boilers generate about 40% of the hotel's carbon (c.325 tonnes) per year.

While achieving net zero carbon ultimately means switching away from gas, upgrading these old boilers to a newer condensing model would reduce annual energy consumption and associated carbon emissions and costs.

As well as being inefficient due to age and type, the boilers are significantly oversized for current requirements due to changes in the building, so replacements could be smaller too.

There are three options – carry on fixing the existing atmospheric gas boiler, install a modern condensing boiler or install a Ground Source Heat Pump.

New condensing gas boiler

£90k
CAPEX

£8k/yr
Energy bill savings

11yr
Simple financial payback

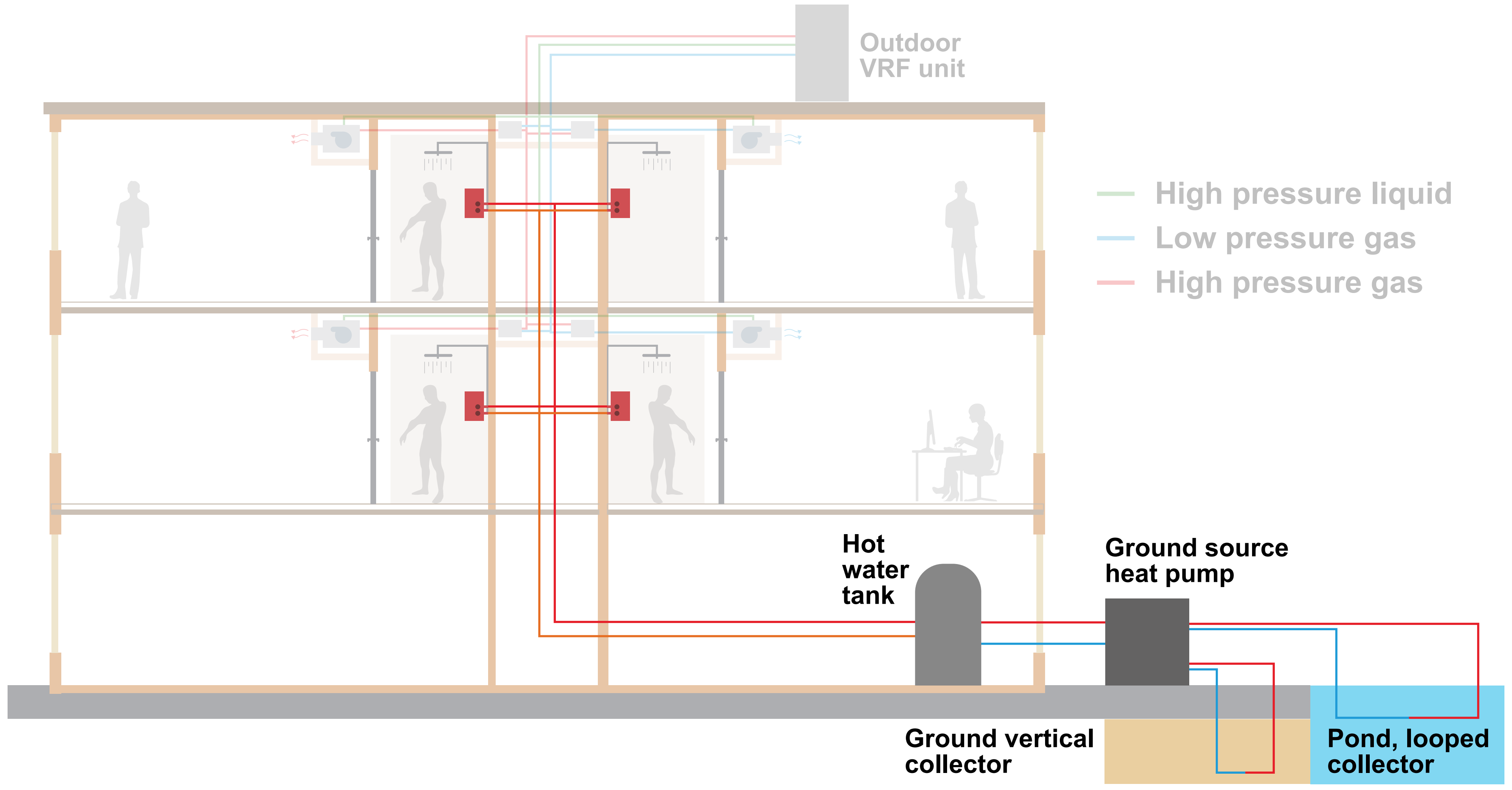
42tCO$_2$e
Embodied carbon

62tCO$_2$e/yr
Carbon savings

<1yr
Simple carbon payback

Active measures

Hot water and heating for swimming pool



Ground and water source heat pumps

Ground and water source heat pumps take advantage of the fact that the temperature of these sources does not fluctuate as much as that of the air with seasonal change. This enables them to be significantly more efficient that an air source heat pump, although they come with a cost, both financially and in the embodied carbon impacts of installation.

In the case study hotel, there was sufficient space to install vertical collectors and a large pond near the existing boiler house.

A thorough investigation of the viability of such an approach was outside the scope of this study. However, we have assumed that such a heat pump would be used in place of the current gas fired boilers, to heat the pool and generate hot water, and would require minimal changes to distribution.

Although the financial payback is very long, the model assumes that gas and electricity prices are 2019 prices throughout. If gas prices rise faster than retail electricity prices the payback will improve.

£400k
CAPEX

£4k/yr
Energy bill savings

100yr
Simple financial payback

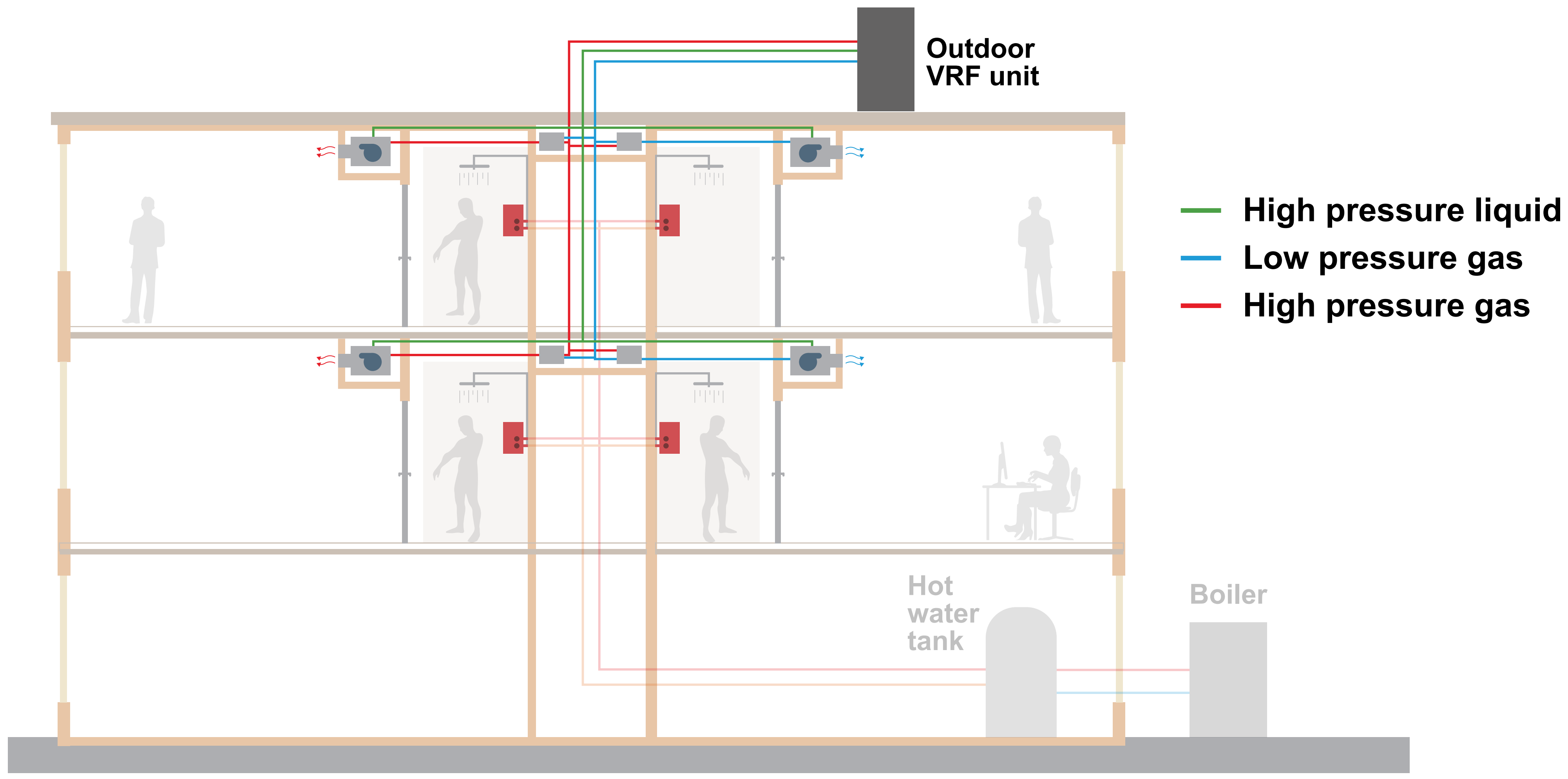
530tCO$_2$e
Embodied carbon

152tCO$_2$e/yr
Carbon savings

3yr
Simple carbon payback

Active measures

Heading and cooling



VRF system

The current system supplying heating and cooling throughout the hotel (with the exception of the pool hall) is not able to heat and cool at the same time. It could be upgraded to one that can reclaim heat from one part of the building for use elsewhere, for example when one guest asks for heating and another asks for cooling.

We have assumed that the terminal units and some of the distribution can be retained rather than a wholesale replacement.

Much of the embodied carbon impact of upgrading this system is associated with refrigerant leakage.

The figures to the side are compared with the £105k base case cost of replacing the outdoor condensing units of the system.

£240k

CAPEX above base case

£10k/yr

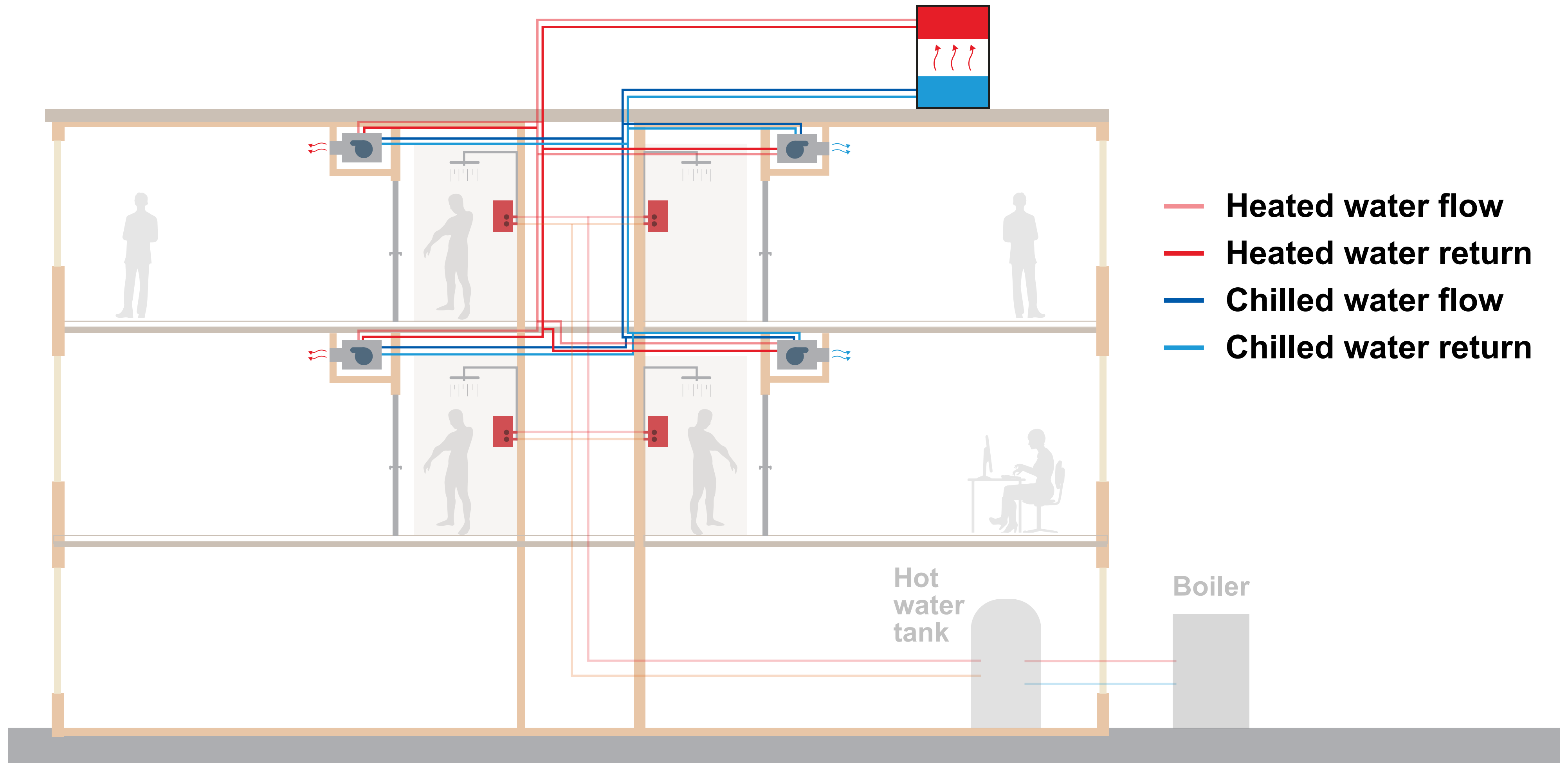
Energy bill savings

24yr

Simple financial payback

Active measures

Heating and cooling



Air source heat pumps

Rather than a VRF system, it may be suitable to use a polyvalent heat pump. During the summer, heat extracted from rooms could then be put into the hot water tanks and swimming pool, increasing heat pump efficiency.

Retrofitting this to the existing system would require wholesale replacement of all fan coil units (FCUs), causing major disruption within hotel rooms, although it could be phased over time.

This system also has the advantage of significantly reducing refrigerant use. These are potent greenhouse gases, so the lifecycle carbon impact of such systems is significantly lower than for VRF, when starting from new.

However, in our case study hotel, the financial and embodied carbon cost of replacing all the FCUs and pipework mean we would not recommend it for this building.

£770k
CAPEX above base cases

£15k/yr
Energy bill savings

51yr
Simple financial payback

252tCO$_2$e
Embodied carbon

69tCO$_2$e/yr
Carbon savings

4yr
Simple carbon payback

Active measures

‹ ›

Showers

Hot water can be efficiently produced using ground or water source heat pumps. In summer, heat recovery mode is particularly efficient. For our case study we modelled using the proposed heat pump to generate the hot water.

Low flow fittings can reduce the volume of water supplied at the outlet. For our case study, we investigated the impact of introducing low-flow shower heads, which reduce associated hot water consumption by approximately 40%.

Shower wastewater heat recovery provides an opportunity to considerably reduce the amount of hot water heating required. This system recovers and uses wastewater heat from showers to preheat cold water and can reduce energy required by 30 to 40%.

It is difficult to retrofit, so we have not modelled it here, but strongly recommend it for new hotels or major refurbishments. In recent high-rise residential projects we have undertaken, the return on investment of this technology was better than improving the thermal performance of the building fabric above normal practice. However, this needs to be assessed on a case by case basis. Replacing shower heads on a like-for-like basis will cost £6k, or £8k for low-flow shower heads, an extra £2k.

£2k
CAPEX above base value

£4k/yr
Energy bill savings

<1yr
Payback

Lighting

LED lamps

We looked at the impact of replacing all the lamps to LED in one go, rather than waiting over a long period of time as currently.

Replacing luminaires and controls

We modelled the impact of introducing occupancy and daylight control and replacing luminaires throughout the building, except in the bedrooms. The cost of this was prohibitive and didn't make sense against the savings, although if all were being stripped out anyway as part of a major refurbishment, there may be an argument for doing this. For a new build the use case becomes less cost prohibitive, and sustainability-minded hotel chains may consider installing intelligent panel boards for automated lighting control, along with room sensors, to improve the efficiency and sustainability of their hotel properties.

The payback for LED lamps at 12 years appears very high, but this is because the calculation has not taken account of the fact that compact fluorescents and halogen lightbulbs have much shorter lifespans at about 15,000 hours and 2,000 hours respectively compared to 50,000 with LEDs.

LED lamps

£161k
CAPEX

£13k/yr
Energy bill savings

12.5yr
Simple financial payback

10tCO$_2$e
Embodied carbon

23tCO$_2$e/yr
Carbon savings

<1yr
Simple carbon payback

Replacing luminaires and controls

£598k
CAPEX

£15k/yr
Energy bill savings

40yr
Simple financial payback

11tCO$_2$e
Embodied carbon

26tCO$_2$e/yr
Carbon savings

<1yr
Simple carbon payback

Active measures

Catering

Busy hotel kitchens often yield a very short payback for replacing old equipment with more energy efficient, newer equipment. We recommend this is done as part of the typical refurbishment cycle to maximise the benefits of the new kit and avoid unnecessary capital expenditure, and the costs to the right are those over and above a typical kitchen refit.

During this refurbishment, it is worth installing local water, electric and gas meters to allow the kitchen's energy use to be monitored and understood separately from the rest of the hotel building.

Transitioning away from fossil fuels, catering equipment will become primarily electric.

Due to our inability to easily break out all the end energy uses within the kitchen, and because the kitchen was not in operation, we have made high level assumptions in modelling the following interventions including a base case refit on a like-for-like basis of £260k or £350k for a higher specification kitchen.

£90k
CAPEX above base case

£5k/yr
Energy bill savings

18yr
Simple financial payback

45tCO$_2$e/yr
Carbon savings

1. Demand based ventilation

   Demand based ventilation is one of the most effective means of saving energy in a kitchen ventilation system. For hotels with an intelligent BMS system, optimising controls strategy for demand-based ventilation is one of the most effective means of saving energy in a kitchen and can be highly effective in reducing energy consumption for a low cost.

   Kitchen hood and extract systems provide extraction according to the maximum load of all equipment running simultaneously. This scenario is highly unlikely in normal use, meaning a lot of energy is wasted.

   We modelled the installation of an automated control as reducing fan energy consumption by 30%.

   A similar approach could be undertaken for hotels with central ventilation systems outside the kitchen too, however in the case study there was less scope for energy savings as the guest rooms were natural ventilated.

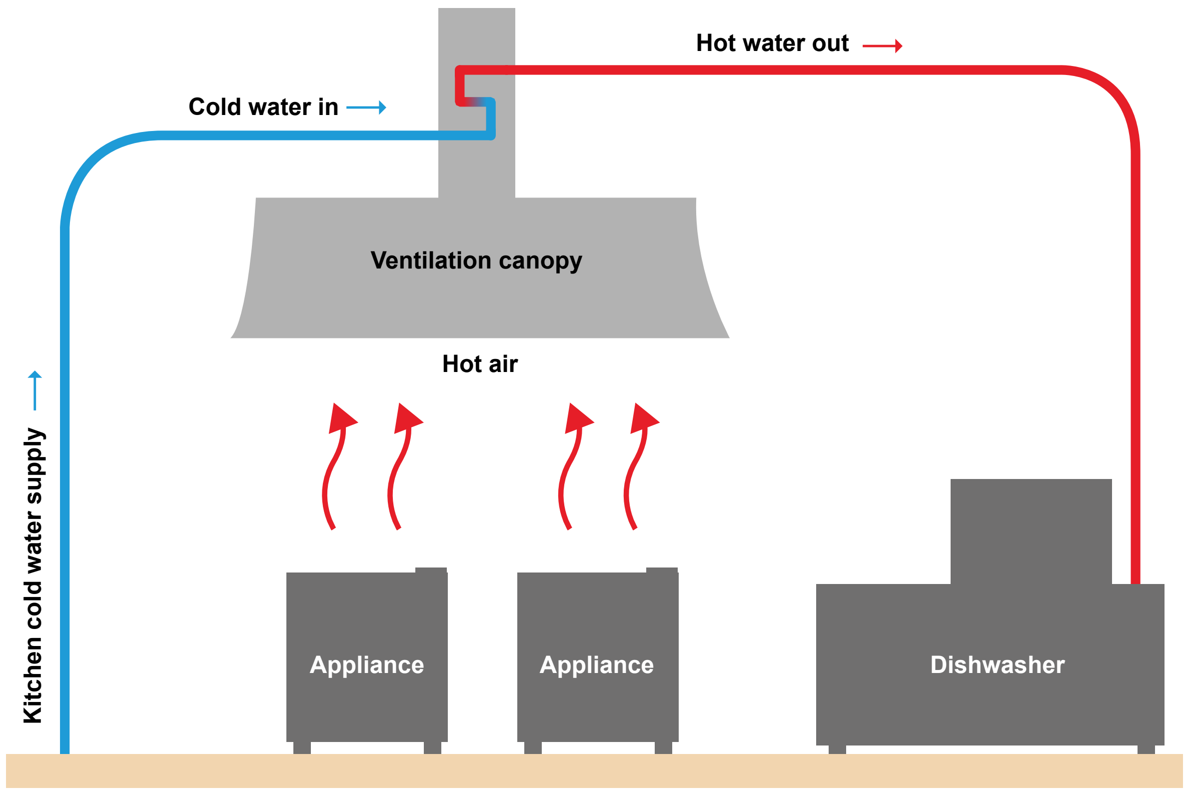
Active measures

2. Ventilation heat recovery

As part of a major kitchen refurbishment, where the ventilation system requires replacing or significant modification, ventilation heat recovery can be installed.

In the UK, it is not generally advantageous to reclaim escaping heat to warm incoming air. Typically, this is only needed for, at most, eight months of the year, and high heat gains in kitchens mean they are more prone to overheating than underheating. Instead, ventilation heat recovery is most efficient when used to preheat hot water supply to the kitchen.

For our study, we modelled a run-around coil system, reclaiming 55% of the heat extracted from the kitchen, based on the ventilation rate during use, and using it to preheat water for washing up.

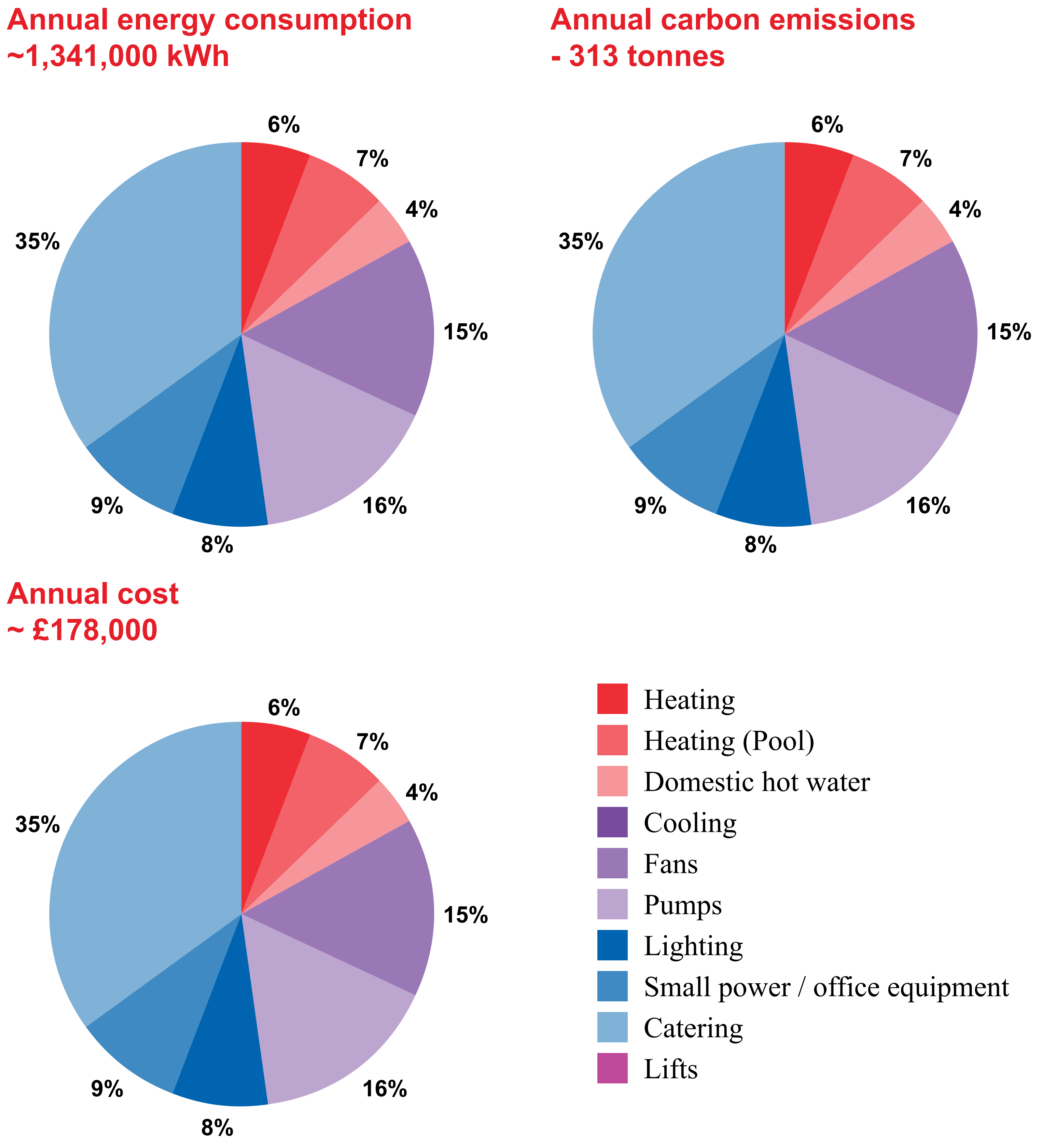


3. Induction cooking

Induction units generate very little wasted heat, as energy is directly applied to pots and pans, although these must be specifically for induction, which can make them more expensive. However, the reduction in wasted heat means cooler kitchens, more comfortable staff and less additional cooling need.

We modelled this intervention as a switch from gas to electric, and as allowing us to achieve good benchmark targets as laid out in CIBSE TM50.

The remaining energy consumption is 154 kWh/m^2 of energy a year, producing the equivalent of the carbon sequestered by 10,400 trees in the UK.



Annual energy consumption ~1,341,000 kWh

Annual carbon emissions - 313 tonnes

Annual cost ~ £178,000

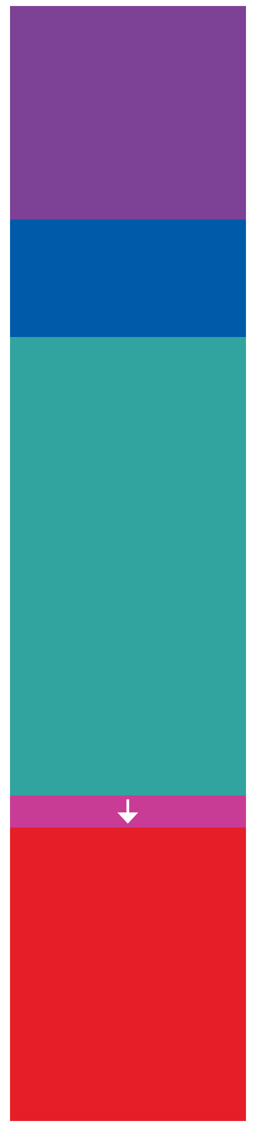
Transition to low carbon energy

On-site energy generation

Generating renewable energy on site can form an integral part of meeting the residual building load without generating carbon emissions. We aimed to produce enough energy on site to reach the Paris Proof Target.

In the UK, the Renewable Heat Incentive pays a tariff based on the size of installation and the amount of heat likely to be generated. This is not accounted for in the cost analysis in this paper. Therefore, the numbers on this page and those for heat pumps in the previous section only include the anticipated savings to energy bills, not the potential additional income.

The impact of on-site renewables



3% energy savings

£109k
Extra CAPEX

£13k/yr
Energy bill saving

8yr
Simple financial payback

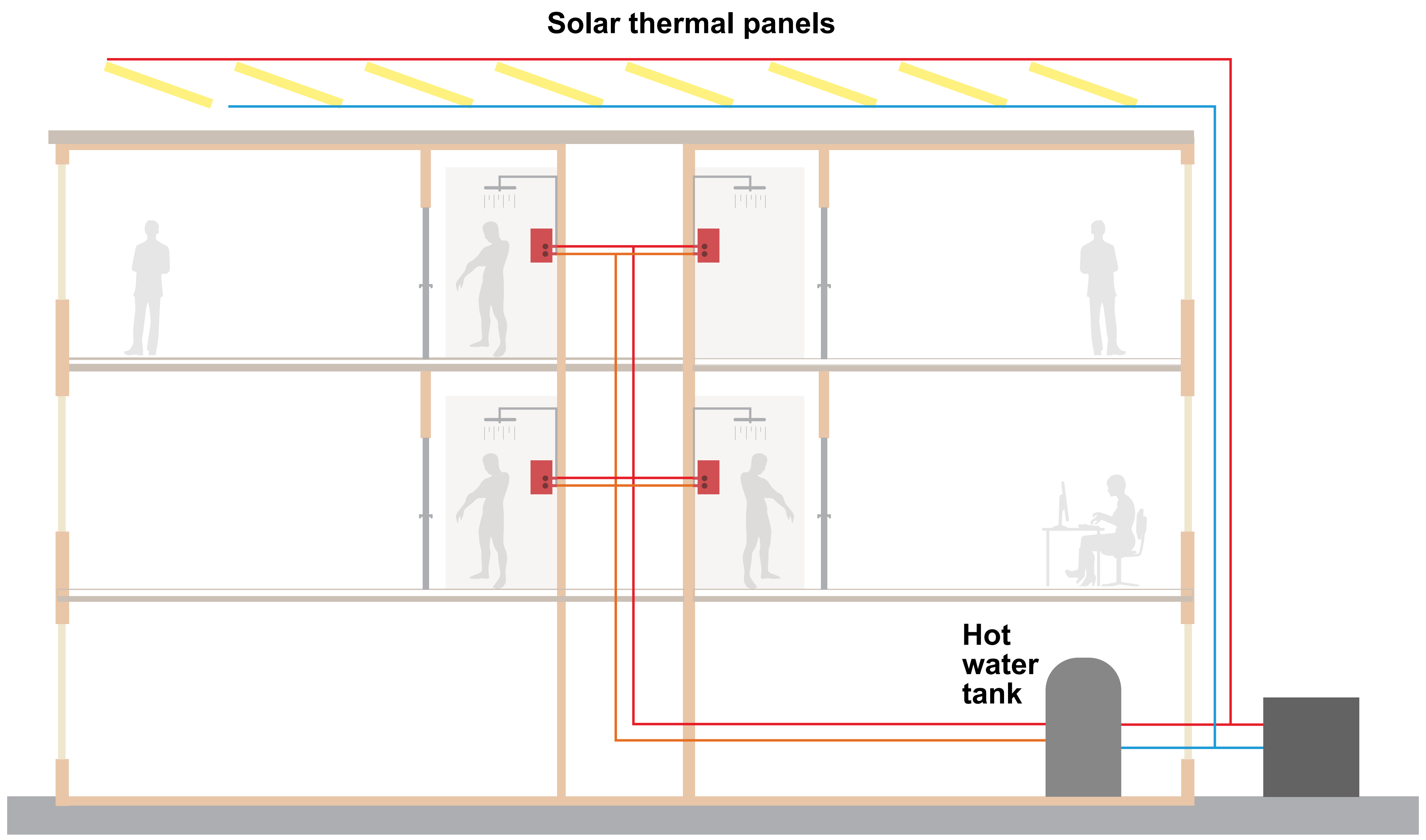
194t
Embodied CO_2e

23t
CO_2e saved

8yr
Simple carbon payback

ARUP

Transition to low carbon energy



Solar hot water

The largest chunk of energy still to be generated, following all the previous interventions, is for hot water production. Our hotel has large areas of flat roof and is not shaded by nearby buildings or vegetation, so is well suited to solar thermal generation. This solar thermal energy could also be used to meet some of the heat demand for the pool.

There is sufficient roof space on the building housing the boiler plant room and pool to install enough solar thermal panels to provide about a quarter of the hotel's annual hot water demand, or 140 MWh of energy. This would require 250m^2 of roof area or 100 solar thermal panels of 2.5m^2 (gross area).

£92k
CAPEX

£3k/yr
Energy bill savings

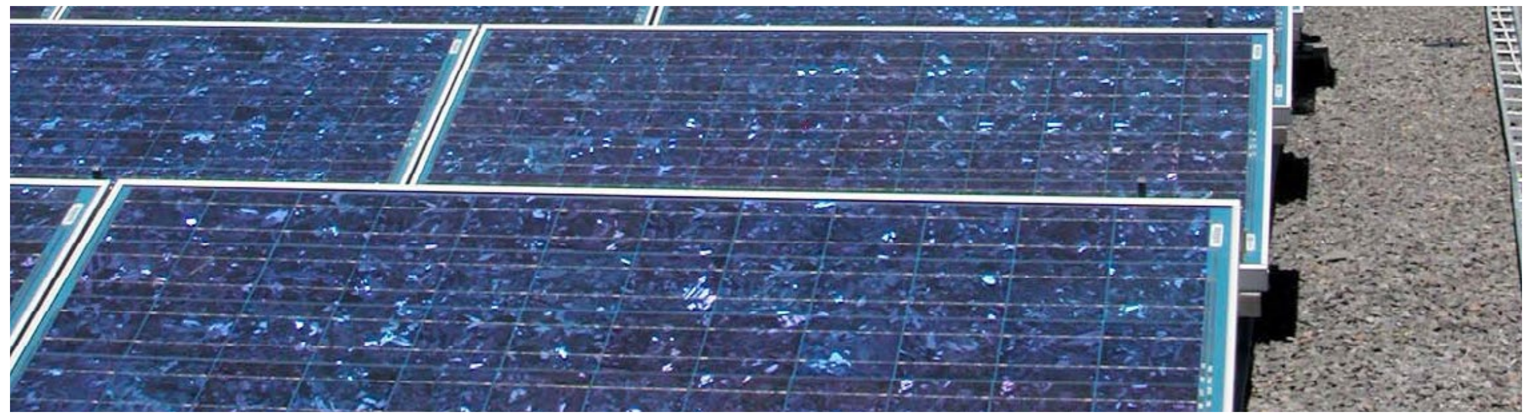
31yr
Simple financial payback

5tCO$_2$e
Embodied carbon

5tCO$_2$e/yr
Carbon savings

1yr
Simple carbon payback

Transition to low carbon energy



Photovoltaic panels

There is a total roof space of c.700m^2 (250m^2 for the building housing the pool and 450m^2 for the remainder of the hotel). If the main hotel had solar PV on it would generate c.5% of the remaining energy demand (64,000 kWh) from 70kWp of panels.

Given the respective paybacks on the solar thermal and solar PV options it would therefore make commercial sense installing solar PV panels on the building housing the swimming pool as well as the main building, i.e. covering the full 700m^2 of usable roof space. This will proportionately increase the total Capex to c.£109k.

Combined heat and power

Our hotel had a decommissioned, gas fired, combined heat and power engine on site. This used a fossil fuel and is not advised, to enable the hotel to achieve net zero. Further, when we reviewed the energy data from the time of operation, it seemed to increase overall energy consumption, likely due to incorrect operation. This is an issue we have seen in other locations due to the high maintenance and operational demands the engines place on building operators.

Photovoltaic panels covering 450m2 of roof space

£70k
CAPEX

£8k/yr
Energy bill savings

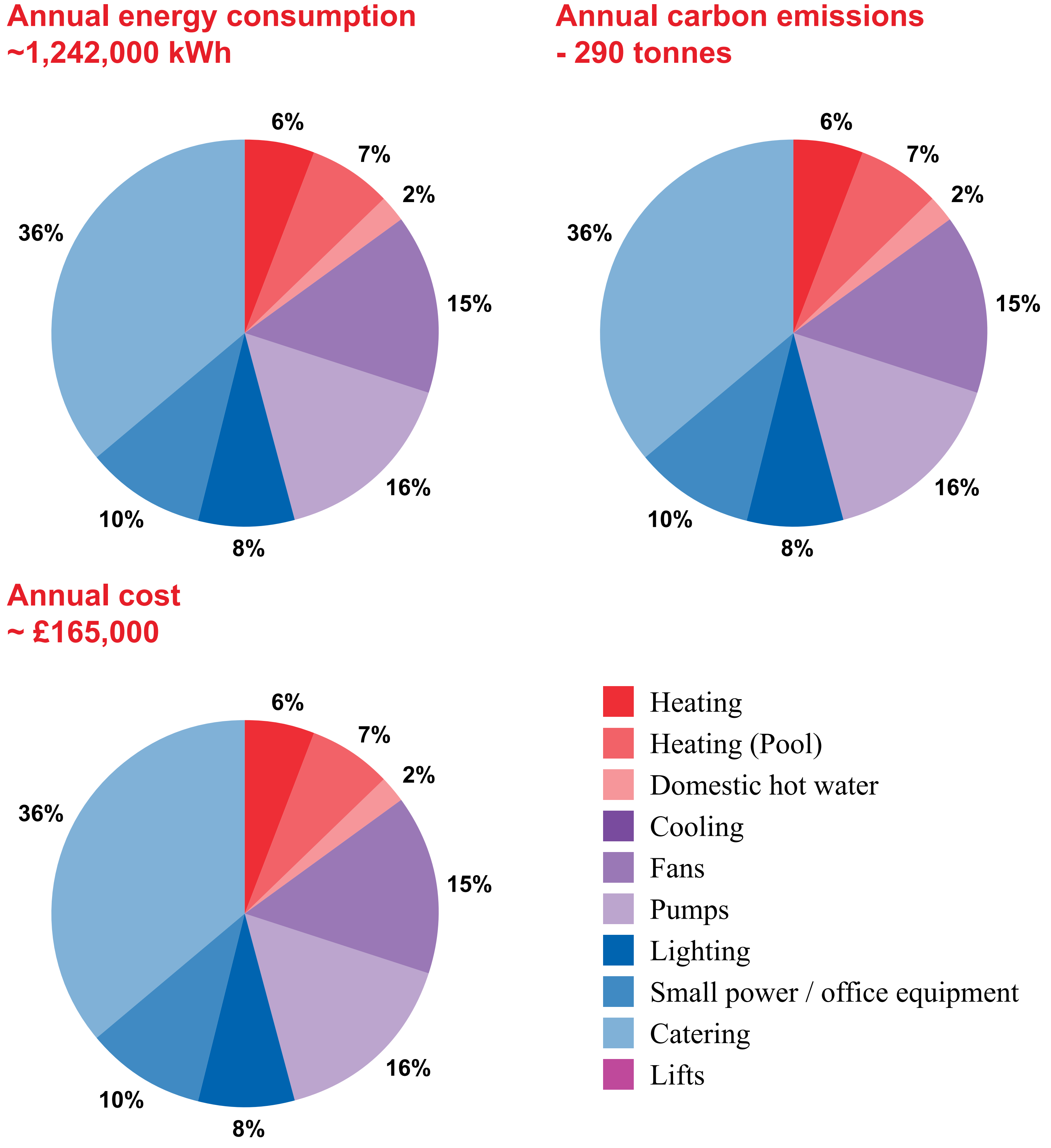
9yr
Simple financial payback

125tCO_2e
Embodied carbon

15tCO_2e/yr
Carbon savings

8yr
Simple carbon payback

The remaining energy consumption is 143 kWh/m^2 of energy a year, producing the equivalent of the carbon sequestered by 9,700 trees in the UK at current Grid carbon factors.



Annual energy consumption ~1,242,000 kWh

Annual carbon emissions - 290 tonnes

Annual cost ~ £165,000

Transition to low carbon energy

Helping decarbonise the grid

Treating operational energy as synonymous with operational carbon is an oversimplification.

Where and when energy from the Grid is used impacts its carbon impact. The figure on this page shows a typical daily carbon profile for the UK National Grid in 2019.

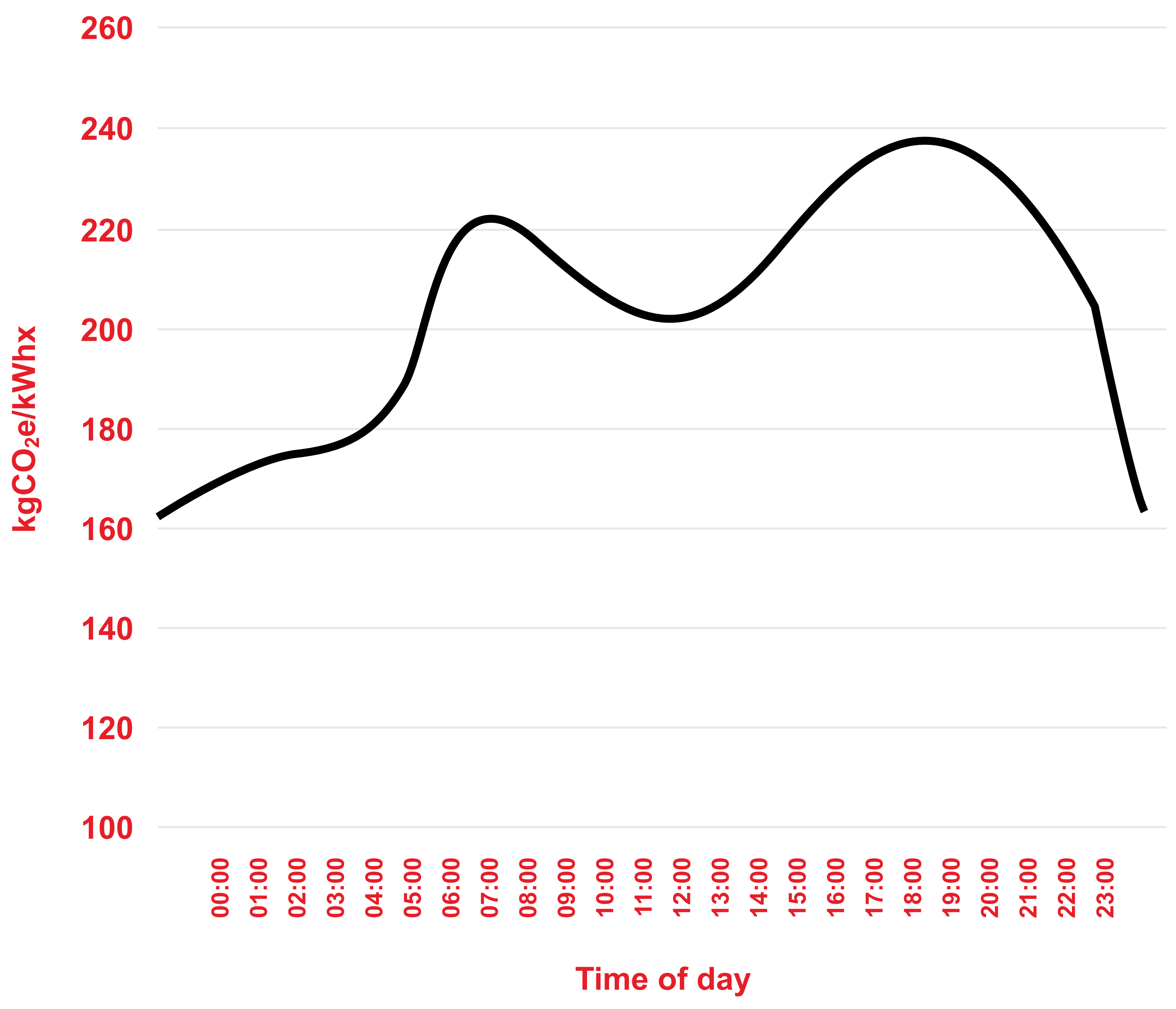
Shifting demand to low usage periods can help decarbonise the system by eliminating the need to run expensive gas fired peaking power plants. At the same time, it can reduce the overall cost of electricity, as peaking plants are expensive to run.

Carbon intensity and price strongly correlate as, after capital expenditure, renewable energy is almost free to generate. For larger hotels on half-hourly settlement electricity meters, shifting demand away from peak wholesale prices can further reduce bills. For example, Ground Source Heat Pumps do not need to be operated continuously and can avoid evening price surges.

Integrating demand response and energy storage into the hotel would give it more flexibility in when and how much energy it needed.

In the UK, there are innovative energy tariffs for domestic uses that vary price according to the wholesale energy market price. Carbon intensity and price strongly correlate as, after capital expenditure, renewable energy is almost free to generate. When these tariffs come to the commercial sector, applying strategies to minimise peak energy demand may also mean lower bills.

As the use of electric vehicles (EVs) increases, hotels are well placed to provide charging infrastructure to help shift demand on the electricity grid. In the UK, National Grid modelling that suggests electric vehicles charged with smart technology, or able to give up energy to the grid, could reduce additional peak demand from EVs more than 90% by 2050, also storing about 20% of Britain's solar generation until the energy is needed. In 2030, smart charging to shift demand to times when there is an excess of supply of renewable electricity could allow additional renewable generation to be installed on the grid.[12]



Certified offsets

Carbon offsetting is the act of compensating for CO_2e emissions resulting from the release of fossil-derived carbon, by participating in CO_2e reduction schemes designed to reduce the overall emissions of CO_2e in the atmosphere.

Carbon offsetting is a solution to be considered for managing the CO_2e emissions which cannot be otherwise eliminated.

Whilst the targets laid out for our case study hotel aimed at achieving net zero carbon by 2050, if they were undertaken right now, the energy use would still have associated carbon emissions. These emissions could be offset to achieve net zero currently, however it is important to note that by 2050, offsets are likely to be considerably more expensive, and are unlikely to be a cost-effective way of achieving net zero carbon.[13]

Carbon offsets can be divided into three main classifications:

- Avoided natural depletion (e.g. avoided deforestation);
- Avoided emissions (e.g. renewable energy projects, replacing kerosene cookstoves with solar-powered); and
- Greenhouse gas removal (GGR/sequestration), including:
  - Natural (e.g. mineral carbonation, ocean alkalinity, enhanced terrestrial weathering);
  - Engineered (e.g. direct air capture, low carbon concrete); and
  - Increasing biological update (e.g. forestation, peatland; bioenergy with carbon capture and storage).

If looking to carbon offsets as part of a net zero strategy, they should be undertaken according to environmental integrity and transparency principles, with a strategy for identifying and managing accredited offsetting measures.

To be a meaningful strategy, offsets must be:

- Additional – the project must not have occurred without finance from offsets.
- Permanent – emissions reduction must be permanent or for a minimum time (e.g. 100 years).
- Measurable – they must be able to quantify the carbon saving accurately.
- Independently audited and verified – for transparency, and to ensure the offset is traceable and cannot be double counted.

Whilst the targets laid out for our case study hotel aimed at achieving net zero carbon by 2050, if they were undertaken right now, the energy use would still have associated carbon emissions.

Embodied carbon

In the previous sections, we have examined how to achieve operational net zero carbon by changing hotel operations and refurbishment upgrades.

Here, we consider how refurbishment compares with replacement in terms of embodied carbon, taking account of the following issues alongside embodied carbon and cost:

- Condition of the existing structure and foundations.
- How internal layout accommodates or restricts use. This includes column grids, floor to floor heights, downstand beams and stair / lift locations.
- Whether the original design loadings are still appropriate or building use exceeds them.

What is embodied carbon?

Embodied carbon is a measure of emissions associated with the extraction, processing, manufacturing, transportation, construction, installation and, finally, disposal of materials and products. In this study, we report the embodied carbon from initial designs to practical completion (stages A1-A5) of a building's lifecycle.

Sequestration

When quoting embodied carbon values for stages A1-A5, the benefit of carbon sequestration, such as in timber products, cannot be included and needs to be accounted for elsewhere.

Inclusion of sequestration reduces the embodied value thanks to the carbon that is locked into timber during photosynthesis. This can only be accounted for if the timber is to be repurposed when the building is dismantled. This accords with Royal Institution of Chartered Surveyors (RICS) and Institution of Structural Engineers (IStructE) guidance on assessment and reporting of embodied carbon.

Mechanical, electrical and plumbing (mep)

Information on embodied carbon benchmarks for building services is currently limited, so they are difficult to calculate. This is partly due to supply chain complexity and lack of data on the impact of products and components in the form of Environmental Product Declarations (EPD). These are objective reports that detail what a product is made from and its lifecycle environmental impact.

CIBSE has released guidance, TM65, suggesting an approach to calculating an EPD when it is not provided by a manufacturer. This approach has been tested for some MEP interventions suggested for our study, but any final decision would require a detailed review.

Embodied carbon of refurbishing guestrooms

Below we show the embodied carbon impact of the two refurbishment options presented earlier to reduce operational emissions.

Option 1 – Mechanical ventilation with heat recovery	208 t	75 kgCO_2e/m^2 on elevation
Option 2 – Natural ventilation	228 t	82 kgCO_2e/m^2 on elevation

Table 1 – Embodied carbon of refurbishment options from stages A1-A5

Embodied carbon

Embodied carbon of a replacement building

When considering the replacement building option, the following should be considered in conjunction with comparing embodied carbon and cost:

- Floor to ceiling heights: To allow appropriate space for the building use and required services.
- Internal layout: To suit the intended use and allow flexibility for change in use. This includes column grids, downstand beams and stair / lift locations.
- Specific requirements, such as fire, acoustics and vibration to suit the building use.
- Construction: Speed and type.
- Building form and orientation: To minimise operational emissions.

We made the following assumptions in considering a replacement building for guestrooms.

- No change in structural layout or building use, so the same loading and grid size as the existing structure.
- Existing foundations are in good condition and can be reused.
- Internal finishes, including partitions and fixtures, are lightweight.

To minimise embodied carbon, it is helpful to refer to industry targets such as the RIBA 2030 Climate Challenge. This provides benchmark figures for the total embodied carbon in non-domestic buildings. RICS and LETI guides split out this value for different project stages and building elements.

The RIBA 2030 embodied carbon target is 500 $kgCO_2e/m^2$, of which 51% is attributed to stages A1-A5 as per the RICS guide. We have assumed the substructure can be reused, which reduces the embodied carbon target for a replacement building to 201 $kgCO_2e/m^2$.

Figure 2 shows the proportion of embodied carbon attributed to various building elements, as per the LETI guide.

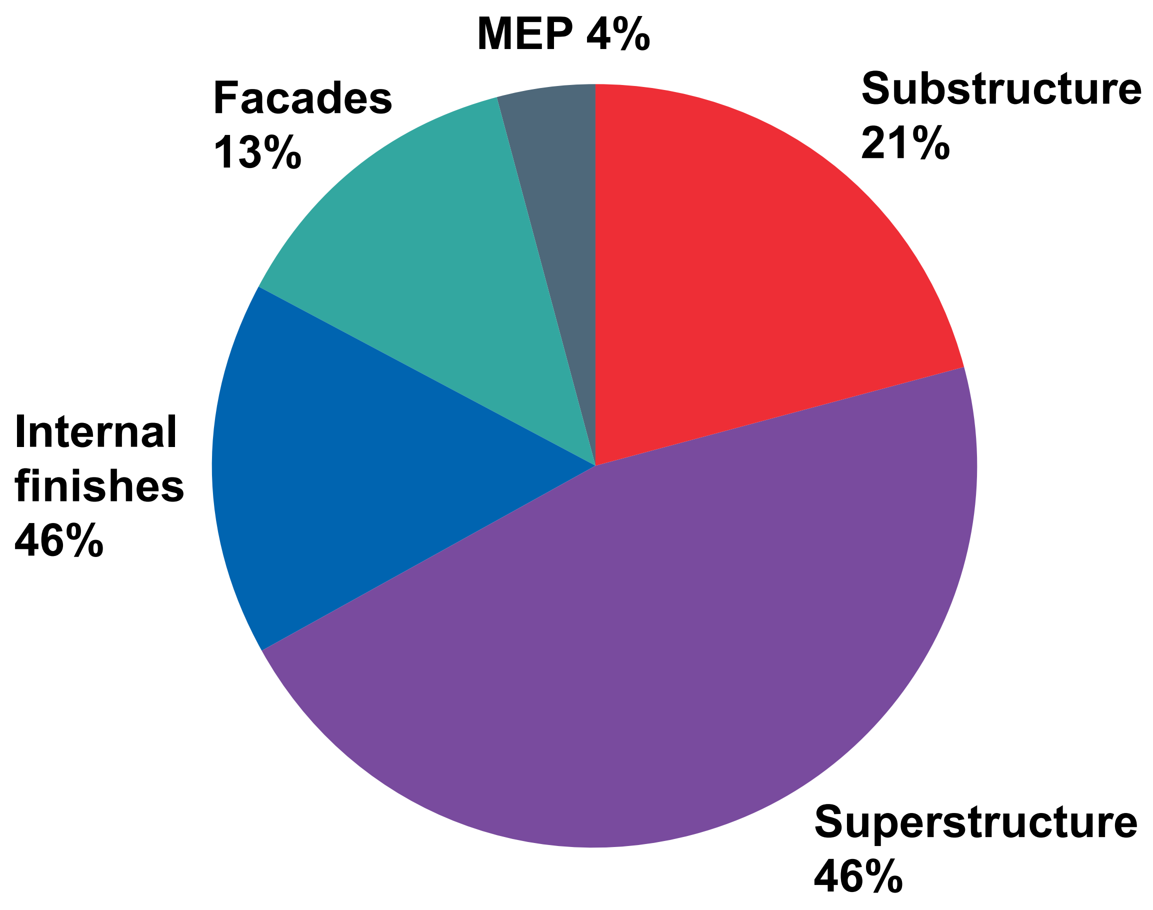


Figure 2 – Approximate proportions of building elements with respect to embodied carbon as defined in the LETI guide for stages A1-A3

To meet the 2030 target, the design team should reassess the attributes in Figure 3 at each design stage.

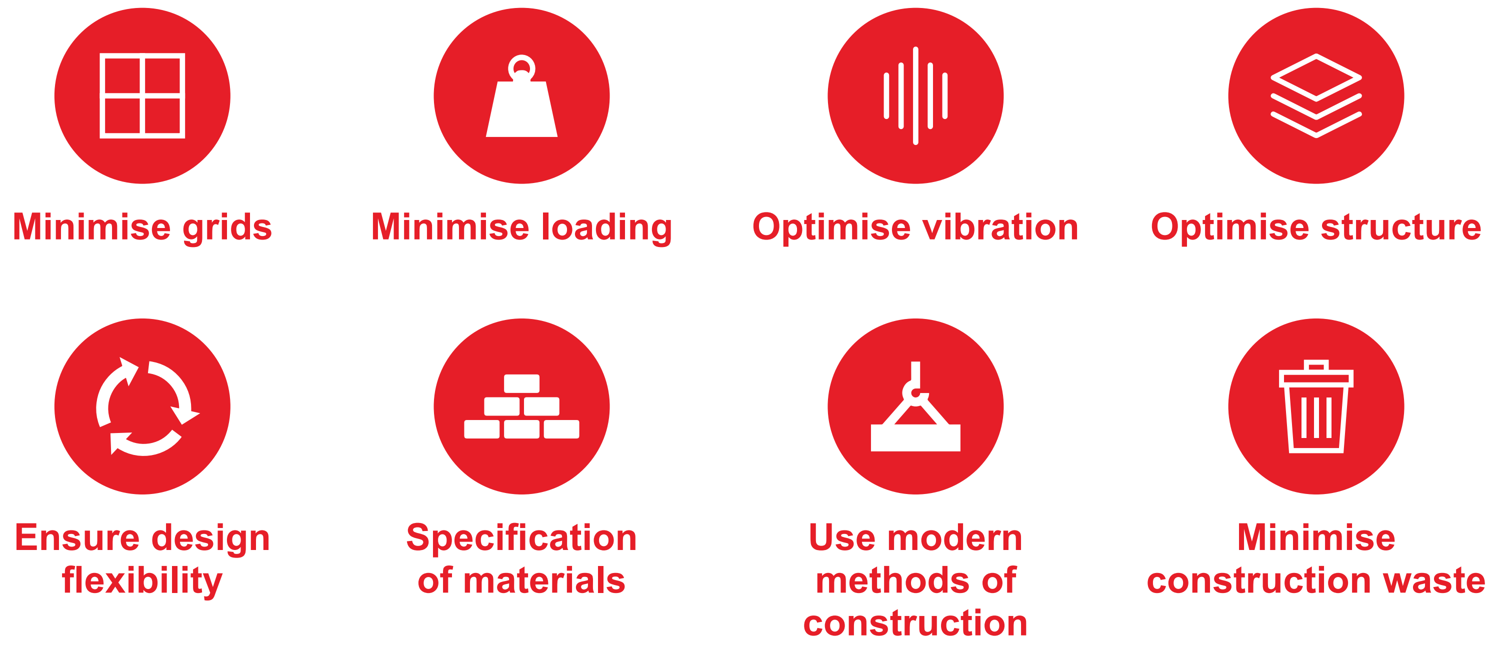


Figure 3 – Design considerations to reduce embodied carbon in new / replacement structures.

Embodied carbon

Embodied carbon of a fabric upgrade versus a replacement building

Figure 4 looks at the embodied carbon per unit area for the existing guestroom building, comparing a fabric upgrade with a replacement building. It includes embodied carbon for the substructure, superstructure, MEP fit-out, façades and internal finishes. It includes values for carbon sequestration when using timber; this should be included as part of the total structural carbon, unless the timber is to be repurposed when the building is dismantled.

Frame options – Total embodied carbon for guestrooms building

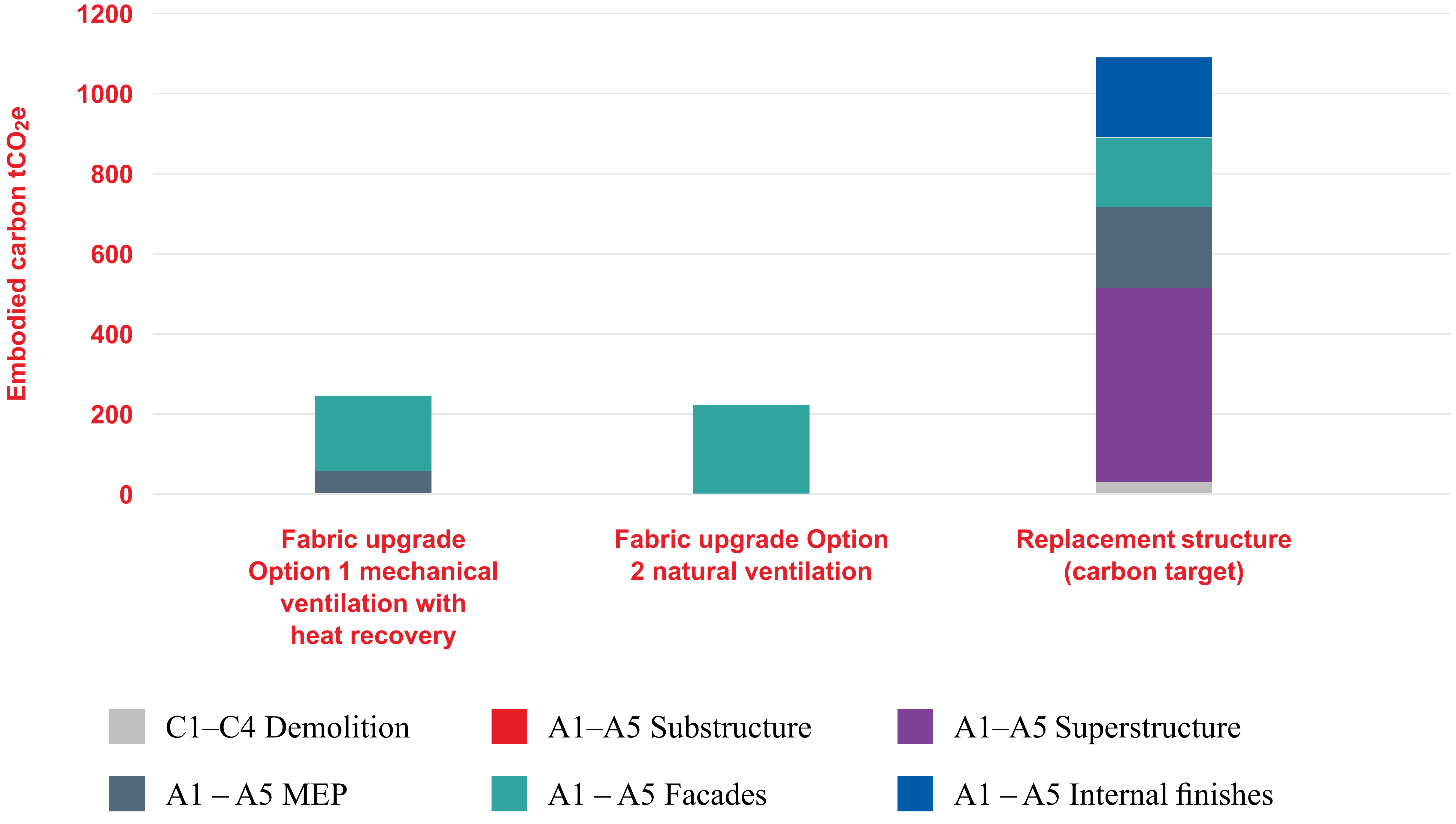


Figure 4 – Embodied carbon for the guestroom building with refurbishment and new-build options.

Summary

Call for action

It is clear that there needs to be a paradigm shift in the way we operate hotels to reduce our reliance on fossil fuels. The world needs technology, strong policy and government backed incentivisation to compel this change.

COP26 concluded with nearly 200 countries agreeing the Glasgow Climate Pact to keep 1.5C alive. This global agreement will accelerate action on climate this decade, and finally completes the Paris Rulebook. Over 450 institutions, responsible for over $130 trillion of private finance assets, are committed to net zero targets through the Glasgow Financial Alliance for Net Zero (GFANZ), within the UN's Race to Zero. A new International Sustainability Standards Board (ISSB) was established to develop a global baseline for disclosure standards on climate and other environmental, social and governance (ESG) matters. This compliments the UK government's announcement, just prior to COP26, to introduce new legislation that will require firms to disclose climate-related financial information, with rules set to come into force from April 2022. New requirements were announced for all listed companies in the UK to produce net-zero transition plans by 2023. The strategies will need to include targets to reduce greenhouse gas emissions, and steps which firms intend to take to get there. UN secretary-general, António Guterres, also announced that the UN will establish a group to propose clear standards for measuring and analysing net-zero commitments from non-state actors. This will create international standards on net zero for all businesses. It is intended to expose greenwashing and reward those who have adopted robust and legitimate net-zero strategies.

It is inevitable that over the coming months and years we will see fuel costs rise, and potentially the introduction of carbon taxes and penalties for not meeting targets.

Doing nothing or too little presents a commercial and reputational risk for brands, operators and owners.

By developing and implementing zero carbon investment strategies, owners and operators have an opportunity to raise profit margins through energy savings, increase revenue by fulfilling customer preferences, safeguard asset value, improve operational resilience and reduce reputational and regulatory risk, whilst capitalising on government incentives.

Are you ready? Do you have a robust, transparent strategy that sets out how you will reduce your carbon emissions and operating costs? One that informs how you will prioritise capital expenditure over the coming years, de-risking your carbon intensive assets from premature depreciation and stranding?

Do these three things!

Whilst you are developing your zero carbon investment strategies, there is little excuse for not targeting the following measures that offer a combination of low or moderate levels of investment and significant carbon savings, whilst creating minimal disruption for guests and on hotel operations during implementation:

- Controls & monitoring
- LED lighting replacement
- Shower head replacement

Further considerations

The reader is reminded that this paper focuses on operational carbon emissions, which is only a portion of the totality of an existing hotel's whole life carbon emissions. The following list is not exhaustive, but each area warrants its own consideration:

- Lifecycle soft refurbishment (FF&E + OS&E) and circular economy principles
- End of life demolition
- Transportation of:
  - Guests to and from the hotel
  - Staff between home and place of employment
  - Staff travelling for business
- Water usage
- Laundry
- Transportation and disposal of waste
- Food production, transportation and the disposal of food waste
- Production and transportation of hotel materials and consumables

There are a number of financiers providing Green Loans and Sustainability-Linked Loans. Low and zero carbon projects appeal to an expanding pool of investors who are interested in making measurable, beneficial social and environmental impact, while earning commercially attractive returns. Banks and financial institutions keep track of the green credentials of their lending portfolio, which supports their own sustainability KPIs. In some instances, lenders will lower the cost of borrowing based on the company's environmental, social and corporate governance (ESG) performance. As an example, Edwardian Hotels' "The Londoner Hotel" was the first hotel to receive a Green Loan in the UK hotels sector. The subject of green finance merits exploration in a further publication.

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About the collaborators

Arup

Arup is a global firm of designers, planners, engineers, architects, consultants and technical specialists. Working at the heart of many of the world's most prominent projects, we share a common desire to create world-leading sustainable solutions. As an employee-owned firm, we attract a diverse mix of independently-minded, forward thinking people

Arup is committed to sustainable design, to its increasing incorporation in our projects and to industry-wide sustainability initiatives. We have a responsibility to build back better by developing more resilient, regenerative and responsible solutions for our clients. Our approach has to be as multifaceted as the challenges we face; it is our responsibility to create low energy, net zero carbon, high-functioning, smart buildings that promote wellness and have a low environmental impact.

We share a focus on ambition, excellence, quality and sustainability. With 15,000 people in 89 offices across 33 countries, we are a humane organisation and pride ourselves in the quality and nature of the relationships we have with each other and with our clients and wider communities.

Recent publications on related topics include: 'Net Zero Carbon Buildings: Three Steps to Take Now', 'FM 2.0 – Re-imagining Facility management for the Digital Age', 'Net Zero Carbon Healthcare' and 'Digital Twin: Towards a Meaningful Framework'.

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Gleeds

Gleeds is an international property and construction consultancy with over 130 years' experience in the property and construction industry. With 1,900 dedicated staff across six continents and 73 offices, Gleeds prides itself on being a global business that is structured to act and think locally. Working with clients in almost every sector, Gleeds services the entire project lifecycle and categorises its offering into the following core areas: programme and project management, commercial and contract management, property and asset management and advisory. Sustainability is a core part of our offer, and our in-house sustainability team regularly delivers to BREEAM/LEED/WELL Standards. We have an in depth understanding of the UKGBC and LETI Steps to Achieving a Net Zero Carbon Building.

Find out more on our website www.gleeds.com and follow us on our social handles LinkedIn: @Gleeds | Twitter & Instagram: @GleedsGlobal

About the collaborators

IHG Hotels and Resorts

IHG Hotels & Resorts is a global hospitality company, with a purpose to provide True Hospitality for Good.

With a family of 17 hotel brands and IHG One Rewards, one of the world's largest hotel loyalty programmes, IHG has nearly 6,000 open hotels in more than 100 countries, and a further 1,800 in the development pipeline.

- Luxury and lifestyle: Six Senses Hotels Resorts Spas, Regent Hotels & Resorts, InterContinental Hotels & Resorts, Vignette Collection, Kimpton Hotels & Restaurants, Hotel Indigo
- Premium: voco Hotels, HUALUXE Hotels & Resorts, Crowne Plaza Hotels & Resorts, EVEN Hotels
- Essentials: Holiday Inn Hotels & Resorts, Holiday Inn Express, avid hotels
- Suites: Atwell Suites, Staybridge Suites, Holiday Inn Club Vacations, Candlewood Suites

InterContinental Hotels Group PLC is the Group's holding company and is incorporated and registered in England and Wales. Approximately 325,000 people work across IHG's hotels and corporate offices globally.

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Costs

The costs for the interventions throughout the report include for the supply and installation for the works being undertaken by suppliers directly, rather than through a main contractor. If numerous interventions are undertaken as part of a refresh at the end of the refurbishment cycle, it is likely that design, management, and supervision will be required to coordinate the installations, particularly if the hotel remains operational and phasing is required.

The cost model opposite indicates budget costs for the interventions based upon the different scenarios for the case study hotel considered in this report. Costs will be dependent upon the size, form and condition of the hotel, particularly the existing services and fabric installations.

VAT has been excluded and it is important that specialist advice is obtained. It is hoped that the government will incentivise retrofitting and create a tax incentive to favour this over demolition and new build. Many in the industry are calling for this, given the extent that embodied carbon influences whole life carbon emissions.

The costs included are for the interventions detailed in the report only and do not include for general refresh costs e.g. new finishes, new fittings, furnishings, and equipment etc. It may be sensible for these to be incorporated if the more significant interventions are undertaken to give efficiencies on preliminaries and fee costs and also to avoid needing to undertake these works at another time.

A breakdown of how costs in the report were derived is summarised in the following pages.

	Necessary in next 5 to 10 years		**Targeting Net Zero Carbon**		
Measure	**Item**	**CAPEX**	**Item**	**CAPEX**	**Initial extra over CAPEX**
Control and Monitoring	N/A	£ -	Upgrading BMS and guest room controllers	£190,000.00	£190,000.00
Passive	Replacing windows in guest rooms	£ 729,750.00	Upgrading guest room façade	£959,700.00	£229,950.00
			Triple glazing on pool hall	£233,000.00	£233,000.00
Active	Replacing VRF (AC in guest rooms)	£105,000.00	Upgrading VRF (AC in guest rooms)	£345,000.00	£240,000.00
	Replace shower heads	£6,000.00	Replace shower heads with low flow fittings	£8,000.00	£2,000.00
	Kitchen refit	£260,000.00	Higher spec kitchen refit	£350,000.00	£90,000.00
			Ground/water source heat pump	£400,000.00	£400,000.00
Low carbon energy	N/A	£ -	Installing renewable energy generation	£109,000.00	£109,000.00
	Total:	£1,100,750	Total:	£2,594,700	**£1,493,950**
			Energy savings over 30 years (in constant prices):		£3,765,000.00
			Simple Payback:		14 to 15 years
			IRR over 30 years accounting for lifecycle replacement:		9 to 10%

Costs

Guestrooms

Base case: replacing the double glazing

£730k

Base case CAPEX

				Budget cost
Remove existing and replace with opening/non-opening window units; indicative size 1500x850mm; including allowance for access equipment	1,050	m^2	£695	£ 729,750

Facade with natural ventilation

£230k

Extra CAPEX above base case

Over-clad façade with rainscreen cladding façade.				Budget cost
Remove existing window units	1,050	m^2	£15	£15,750
Over-clad façade; aluminium cladding panel; mineral wool insulation; thermally broken helping hand bracket to support cladding bracket; including cavity barriers etc.; internal leaf and finishes remain as existing except where former window areas require infilling	1,479	m^2	£495	£732,300
Double-glazed window unit; indicative size 1044x1145mm	246	m^2	£650	£159,900
Allowance for access equipment	1,725	m^2	£30	£51,750
Sub-Total	1,725	m^2	£556	£959,700

Facade with mechanical ventilation

£681k

Extra CAPEX over base case

Over-clad façade with rainscreen cladding façade; large triple-glazed windows				Budget cost
Remove existing window units	1,050	m^2	£15	£15,750
Over-clad façade; aluminium cladding panel; mineral wool insulation; thermally broken helping hand bracket to support cladding bracket; including cavity barriers etc.; internal leaf and finishes remain as existing except where former window areas require infilling	1,219	m^2	£528	£643,750
Triple-glazed window unit; indicative size 2163x1135mm	506	m^2	£900	£455,400
Access equipment	1,725	m^2	£30	£51,750
MVHR unit 3.12 m^3/s	1	Item	£30,000	£30,000
MVHR unit 1.0 m^3/s	1	Item	£12,000	£12,000
Ductwork (average)	450	m	£450	£202,500
Sub-Total				£1,411,150

Costs

Pool

Roof insulation

£138k
CAPEX

				Budget cost
Stripping and disposal of existing roof felt and insulation	250	m²	£50	£12,500
200mm PUR insulation, plywood and roof membrane	250	m²	£400	£100,000
Access equipment	1	Item	£25,000	£25,000
Sub-Total				£137,500

Double glazing

£174k
CAPEX

				Budget cost
Rooflight area	60	m²	£1,000	£60,000
Window area	98	m²	£750	£73,500
Double door	2	Nr	£5,000	£10,000
Allowance for removal of existing glazing and access equipment	1	Item	£30,000	£30,000
Sub-Total				£173,500

Triple glazing

£233k
CAPEX

				Budget cost
Rooflight area	60	m²	£1,500	£90,000
Window area	98	m²	£1,000	£98,000
Double door	2	Nr	£7,500	£15,000
Allowance for removal of existing glazing and access equipment	1	Item	£30,000	£30,000
Sub-Total				£233,000

Costs

Active Systems

Boilers

£90k

CAPEX

				Budget cost
350 kW Boiler and associated works	2	Nr	£ 45,000	£90,000
Sub-Total				£90,000

VRF system

£240k

Extra CAPEX above base case

				Budget cost
Outdoor condensing units 25 kW	4	Nr	£20,000	£80,000
Branch selector boxes	24	Nr	£10,000	£240,000
New refrigerant piping (included shared tray)	~500	m	£50	£25,000
Sub-Total				£345,000

Air source heat pump

£770k

Extra CAPEX above base case

				Budget cost
350 kW Polyvalent heat pump	1	Item	£150,000	£150,000
New CHW and LTHW piping	~4,100	m	£85	£350,000
New four pipe fan coil units	~250	Nr	£1,500	£375,000
Sub-Total				£865,000

Costs

Active Systems

Ground and water source heat pumps

£400k
CAPEX

				Budget cost
Ground source heat pump installation 250kW	1	Item	£400,000	£400,000
Sub-Total				£400,000

Lighting

LED Lamps

£161k
CAPEX

Lamps to be switched over to LED within the existing luminaires (assuming most of the existing fittings are retained).

				Budget cost
Bedrooms	3,650	m²	£20	£73,000
Circulation	1,200	m²	£12	£14,400
Conference and function	900	m²	£40	£36,000
Kitchen	285	m²	£12	£3,420
Pool and gym	600	m²	£30	£18,000
Remaining Back of House	1,340	m²	£12	£16,080
Sub-Total				£160,900

Luminaires

Luminaires (whole fitting) switched over to more efficient units at the end of a typical refurbishment cycle (what is the uplift on fluorescent fittings), alongside installation of DALI control, with occupancy and daylight sensing.

				Budget cost
Bedrooms	3,650	m²	£125	£456,250
Circulation	1,200	m²	£100	£120,000
Conference and function	900	m²	£300	£270,000
Kitchen	285	m²	£80	£22,800
Pool and gym	600	m²	£175	£105,000
Remaining Back of House	1,340	m²	£60	£80,400
Sub-Total				£1,054,450

ARUP

Costs

Transition to low carbon energy

Solar hot water

£92k
CAPEX

				Budget cost
2.5m - Flat panel; including parts and installation	100	Nr	£920	£92,000
Sub-Total				£92,000

Photovoltaic panels

£70k
CAPEX

				Budget cost
Polycrystalline photovoltaic panels installation	450	m²	£156	£70,000
Sub-Total				£70,000

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