APPENDIX 9

Farnborough Culture & Leisure Hub

Sustainability Strategy

20/09/2023 - Rev A

Project Number: 23013
Produced by: JWa
Checked by: GT3

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1 • Introduction

Introduction
Overview

As designers we are frequently asked a variety of questions:

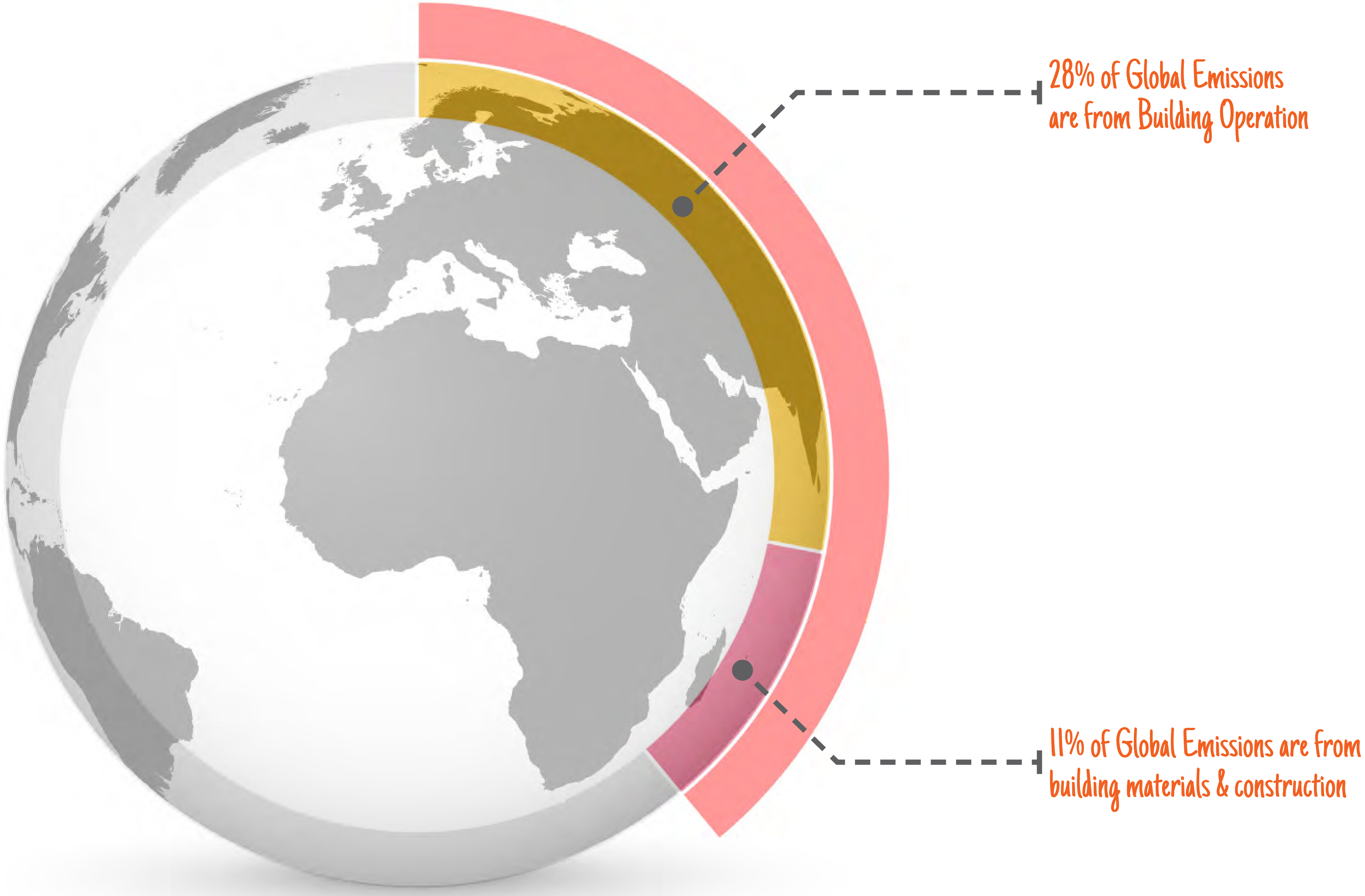
"How do we get a Net-Zero Leisure Centre?"

"What does Sustainability mean?"

"Where do we Start?"

The purpose of this report is to explore the sustainability strategy in the context of Sport & Leisure & aid understanding of the options available, as well as the return on investment in relation to Carbon. This report reflects the project's development up to RIBA stage 2.

It will also provide all the relevant information to allow the client to make an informed decision on whether the project will progress as a Passivhaus Accredited design or follow a Low Energy design approach. **Additionally it will aim to set out some of the defining principles that will be followed through into any of the applicable options into the next stage.** As such it is important that the document is reviewed and signed-off by the Client (or their advisors) so that the project team can proceed with confidence into the next stages of the project.



"Buildings are currently responsible for 39% of global energy related carbon emissions: 28% from operational emissions, from energy needed to heat, cool and power them, and the remaining 11% from materials and construction" - World Green Building Council
worldgbc.org/advancing-net-zero/embodied-carbon/

2 • Overview & Benchmarking

Global Sustainability
Overview

In 1987, the United Nations Brundtland Commission defined sustainability as "meeting the needs of the present without compromising the ability of future generations to meet their own needs."

Sustainable Development has been a central concern for many countries for many years. In June 1992, at the Earth Summit in Rio de Janeiro, Brazil, more than 178 countries adopted Agenda 21, a comprehensive plan of action to build a global partnership for sustainable development to improve human lives and protect the environment.

Following this, the Member states of the United Nations adopted the Millennium Declaration which led to the elaboration of eight Millennium Development Goals (MDGs) to reduce extreme poverty by 2015. – This was the first major international, goal-orientated set of targets that all countries could measure and compare against.

In January 2015, the General Assembly began the negotiation process on the post-2015 development agenda. The process culminated in the adoption of the 2030 Agenda for Sustainable Development, with 17 SDGs (sustainable development goals) at its core, at the UN Sustainable Development Summit in September 2015.

The 17 SDGs are overarching sustainability goals that are broken down into 169 targets and are measured through 231 unique indicators (247 in total with 12 indicators repeating across different targets). The SDGs address the key global challenges being faced, such as climate change, environmental degradation and socio-economic issues such as human health and well-being, inequality and justice, visioning and aiming for a better, more sustainable world for all.

The development goals are reviewed each year and a report is issued to note the progress. The SDGs are universal with all signatories expected to contribute to them internationally and deliver them domestically, and more importantly is a reminder of all the aspects of sustainability that can be targeted.

UK Sustainability
Overview

In 2008, The UK Government signed into law the Climate Change Act, which was amended in 2019, "to ensure the UK reduces its greenhouse gas emissions by 100% from 1990 levels by 2050"

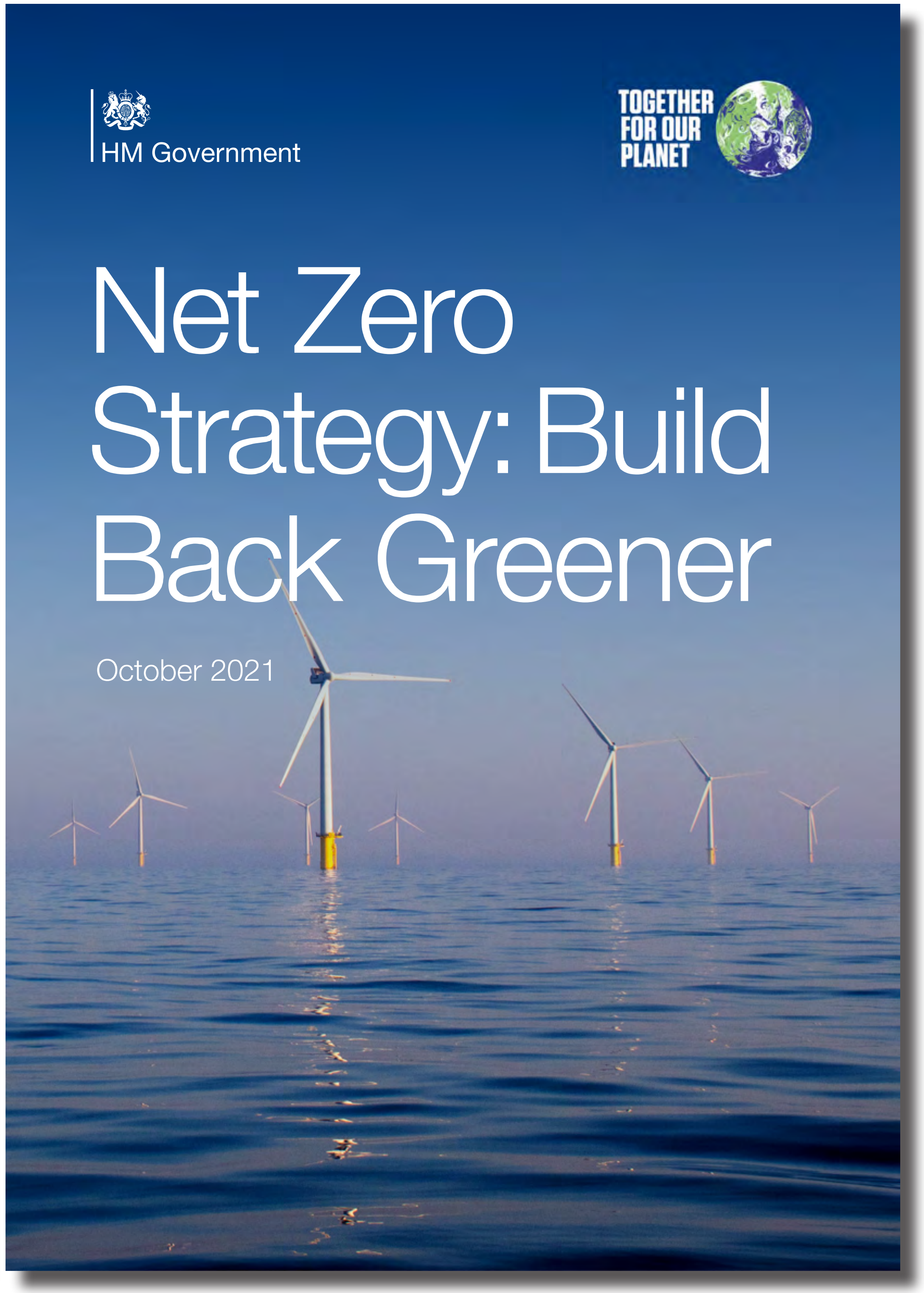
Following the SDG's, each government is responsible for setting and maintaining their own policy. The UK Government has responded by commissioning a report by the Committee on Climate Change (CCC), and in 2019, signing into law the NET ZERO by 2050. This is then supported by the 'Net Zero Strategy: Build Back Greener' report, which outlines key targets and methods for achieving Net Zero. Below are some of the key findings:

"The UK has around 30 million buildings and includes some of the oldest building stock in Europe."

"Including indirect emissions (e.g. from electricity generation) emissions from heating buildings make up around 78% of all buildings emissions and about 21% of all UK emissions."

"Non-domestic buildings account for around a quarter of [total] UK building emissions." & "Public sector buildings account for about 9% of [total UK] building emissions."

https://www.gov.uk/government/publications/net-zero-strategy



https://www.gov.uk/government/publications/net-zero-strategy

Sustainability
Lack of Policy

The 'net zero target' refers to a government commitment to ensure the UK reduces its greenhouse gas emissions by 100% from 1990 levels by 2050. If met, this would mean the amount of greenhouse gas (GHG) emissions produced by the UK would be equal to or less than the emissions removed by the UK from the environment.

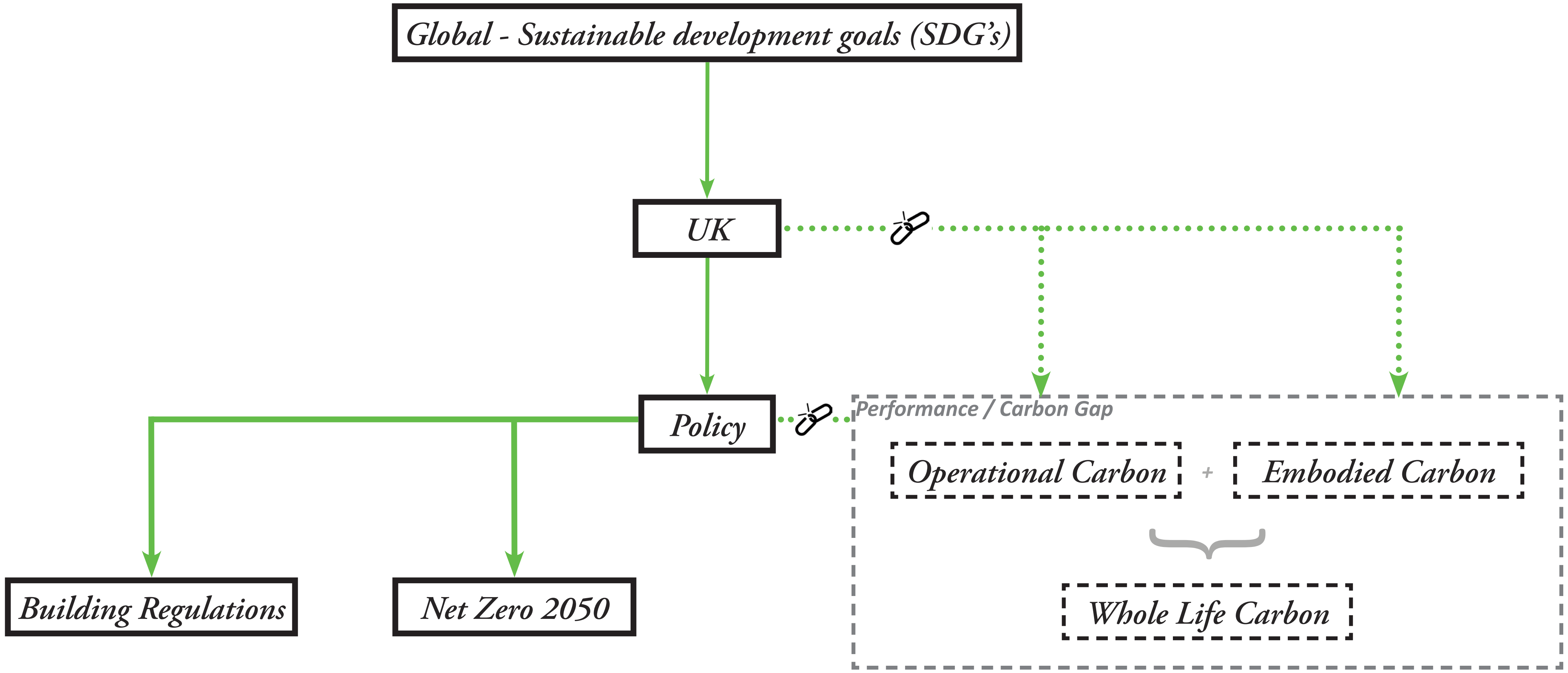
In real terms, this means that all inclusive, a building has to emit less than zero emissions across its whole life. In order to do this, embodied and operations carbon needs to have a set of key performance indicators to measure the overall carbon / GHG emissions.

The UK has a series of optional targets and measures that each try and tackle different aspects of carbon and energy, however:

Policy falls short, as there are no specific metrics or limits in legislation for operational carbon or embodied carbon.

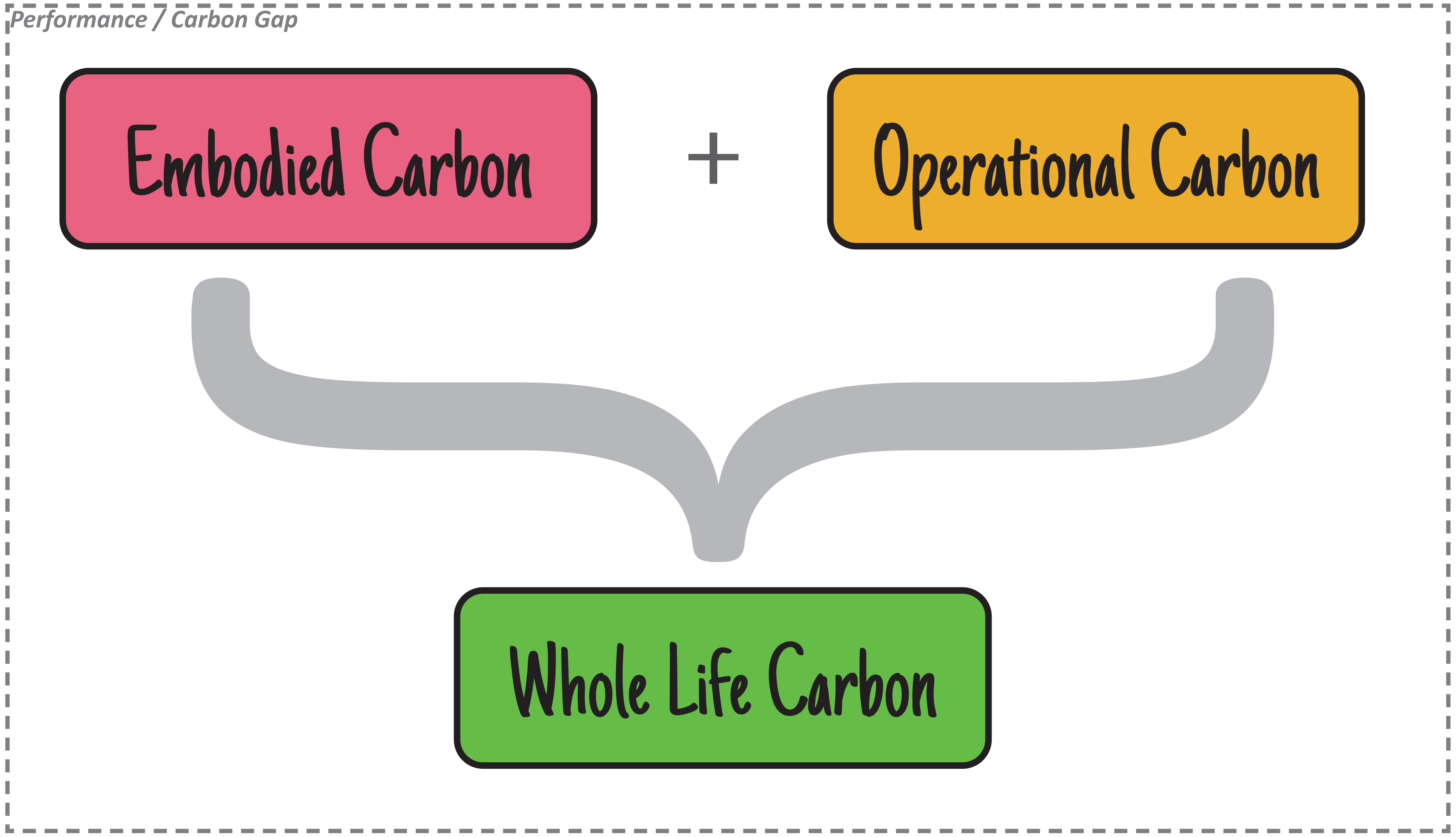
With a lack of specific guidance, our aim is to understand the carbon impact of buildings, and to set a series of Key performance indicators (KPI's) that are measurable and attainable.

Understanding that a building can never be truly Net Zero on completion / opening day is key to tackling the climate crisis. There are a number of things that we as designers can do, to reduce and eliminate the overall carbon.



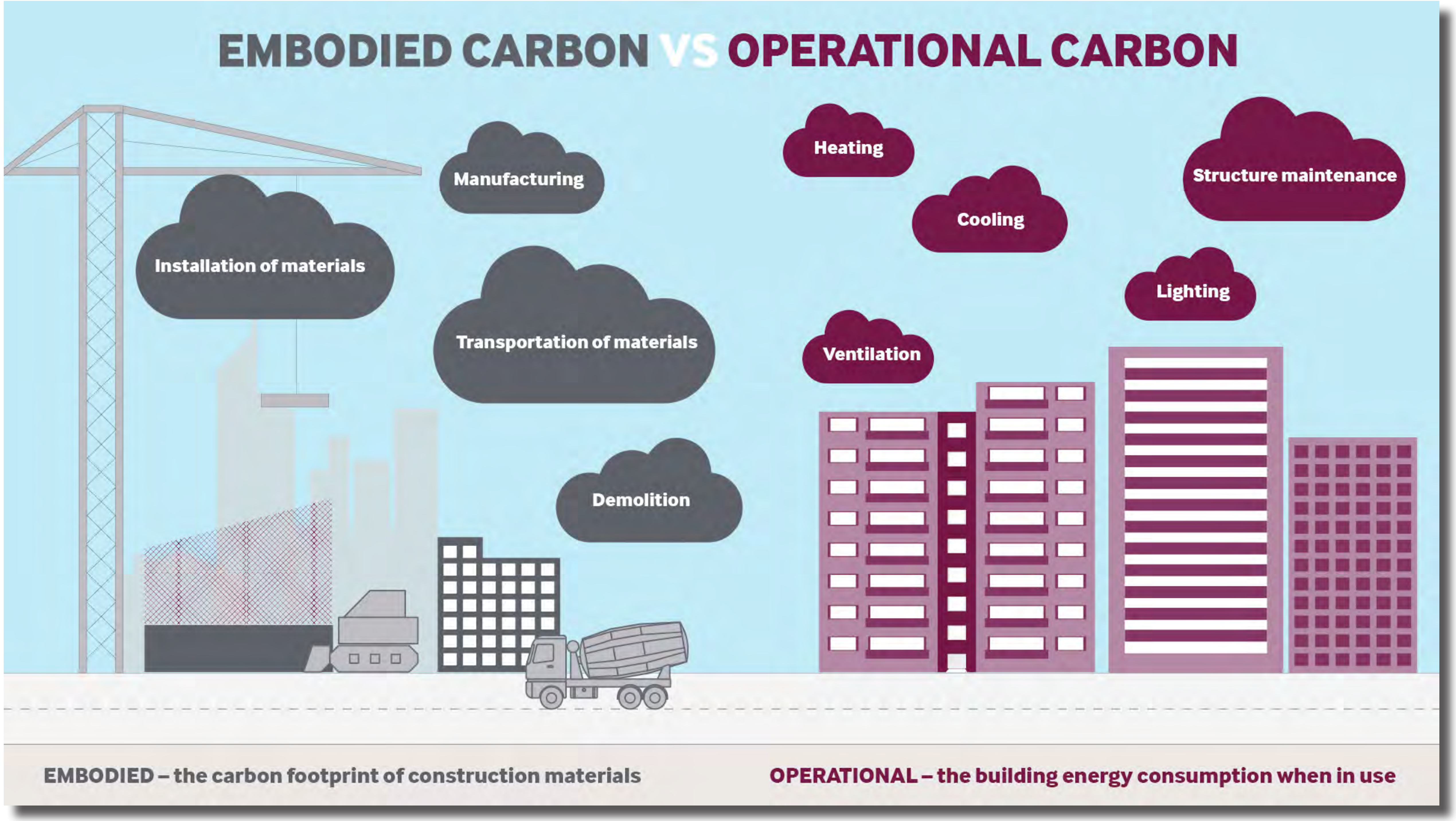
While a building can be operationally net zero (utilising sustainable power sources), the reality is no building can be embodied carbon zero, as current construction materials all have some carbon content.
To achieve whole life carbon zero, the approach should be to minimize the carbon as much as possible and then offset the remainder.

Whole Life Carbon
The Component Parts



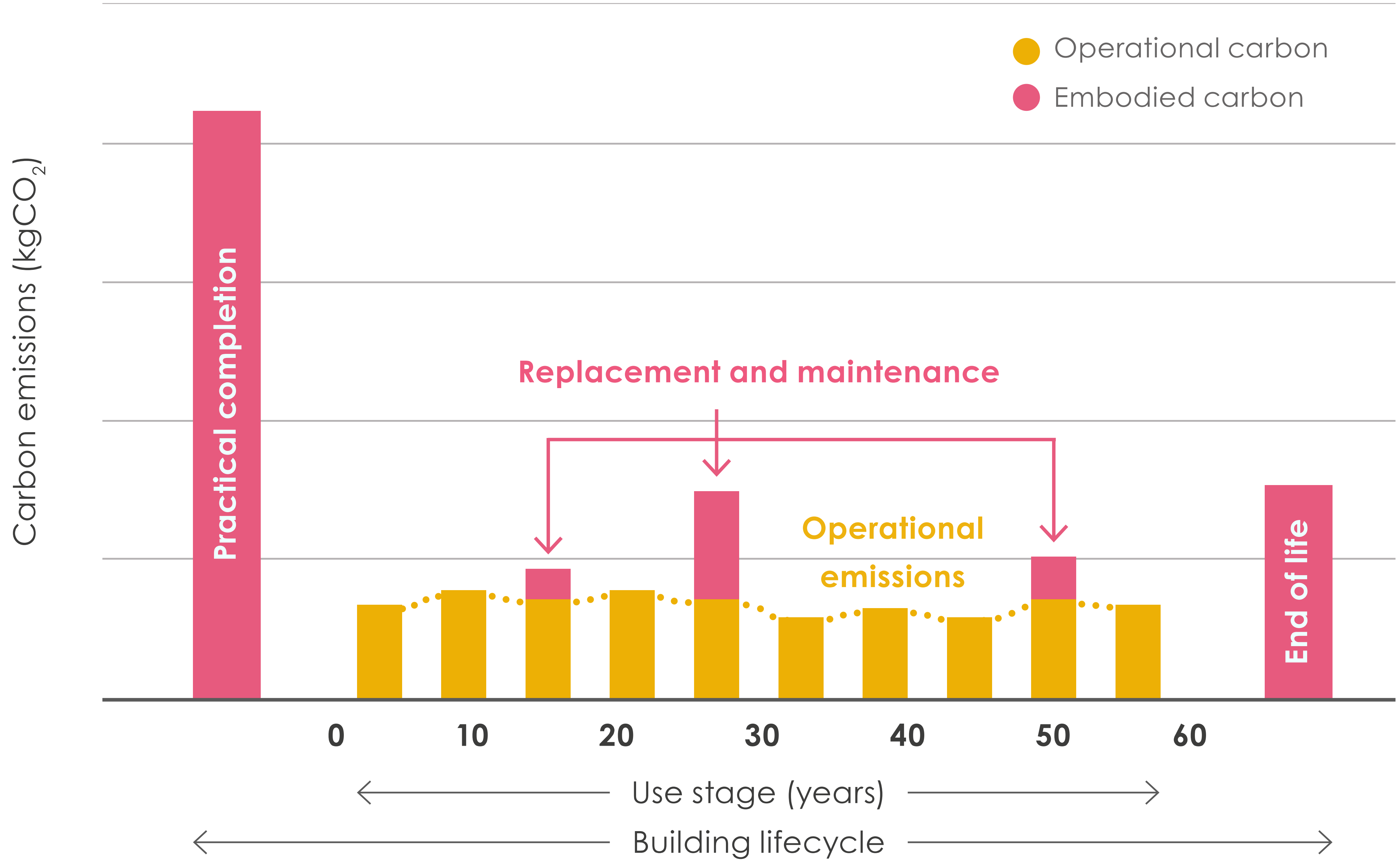
Combined, these create the 'whole life carbon' of a building. While this can never truly be zero (physical construction materials contain carbon), decisions made during the design process can enable us to significantly reduce the whole life carbon by tackling BOTH embodied and operational carbon.

Climate Emergency
Carbon Breakdown



Carbon (or more accurately CO2 equivalent ($KgCO_{2eq}/m^2$) is becoming the worldwide measurement for the environmental impact of an activity / economy / policy.
There are two parts to carbon in buildings:
- Embodied carbon used to construct
- Operational carbon - the carbon used to run the building (assumed 60 years)

Climate Emergency
Tackling Whole Life Carbon



Understanding where Carbon is used in a building is key in decision making. The Diagrams shown here indicate the approximate distribution of how carbon is used in a buildings life time and an approximate breakdown. Diagrams taken from 'LETI Climate Emergency Design Guide' - https://www.leti.uk/cedg

The majority of embodied carbon is typically used in lumps, operational energy / carbon is steadily used over a buildings life, however operational carbon is cumulatively higher, generally being up to 70% of the whole life carbon and potentially even more in high energy demand building types such as Leisure Centres

Sports & Leisure

Operational Carbon Visualised

Based on CIBSE 2021 collated data, Leisure Facilities use more energy (kWh, per m^2, per year) than almost every other category of building. The graph opposite highlights the latest data with Sport & Recreation facilities in red. This ranges from 'good practice' to 'typical use'.

Additionally plotted on the graph are; GT3 completed Sport & Leisure Projects (19 total (18 with wet side facilities)), are plotted in orange, and at the bottom in green, are low operational energy standards (as well as 2 Key projects meeting the Passivhaus - Spelthorne Leisure Centre & St.Sidwells Point).

Energy used translates into both COST & CARBON, both are key drivers for new build projects. Leisure and swimming pool centres have the two highest energy use intensity's (EUI's), ranging from:

690 - 1,579 kWh/$m^2{}_{.year}$

equal to

193.89 - 443.699 $KgCO_{2.eq}/m^2{}_{.year}$

[Conversion rate of 0.281 $KgCO_{2.eq}$ = 1kWh
European Environment Agency 2016 (latest) Data
www.eea.europa.eu/data-and-maps/daviz/co2-emission-intensity]

Extrapolate that over a 60 Year life span (assumed as standard for the purpose of whole life carbon assessments) of a building (assuming that emission rates remain constant) with an average 5291m^2 area (averaged across 18No. GT3 Projects), a Leisure Centre with a pool could emit between:

61,552 - 140,856 metric tons of Carbon Dioxide (CO_{2eq})

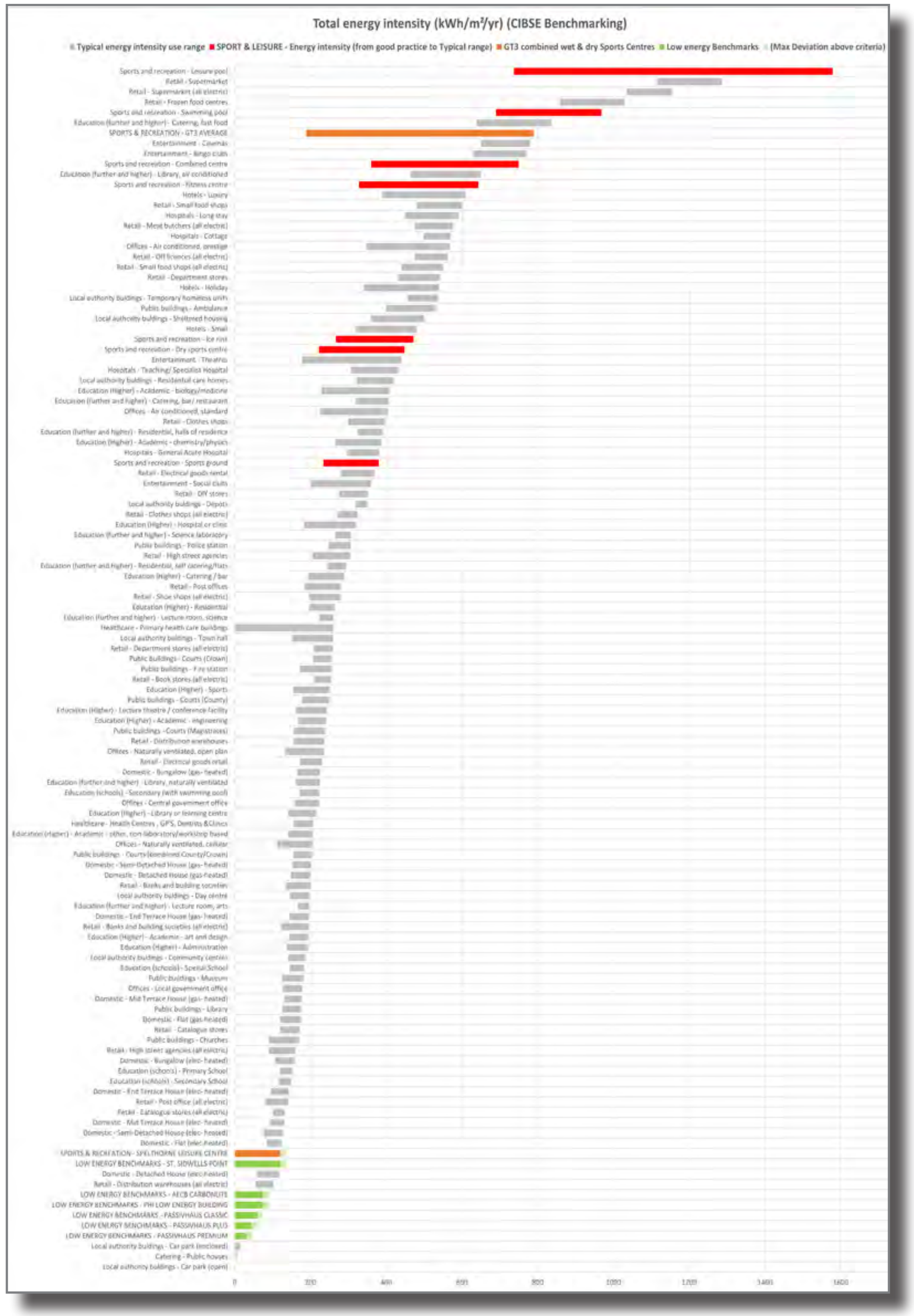
equal to

142,366 - 325,791

Barrels of Oil consumed in its lifetime

[Conversion rate of 0.43 metric tons $CO_{2.eq}$ = 1 barrel of oil
United States Environmental Protection Agency (EPA) "Greenhouse Gas Equivalences Calculator"
www.epa.gov/energy/greenhouse-gas-equivalencies-calculator]

*This is considered business as usual scenario**



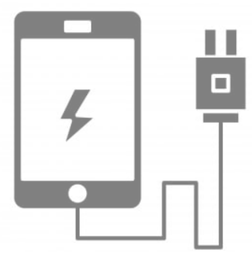
Considering 'Business as Usual' practice for $kgCO_2/m^2$.year emission rates. We can visualise what that relates to in real world terms below, in the context of leisure centre emissions:

690 - 1,579 kWh/$m^2{}_{.year}$ ≈ 194 - 444 $KgCO_{2.eq}/m^2{}_{.year}$

497 - 1,137 miles driven in an average car
(per square metre, per year)

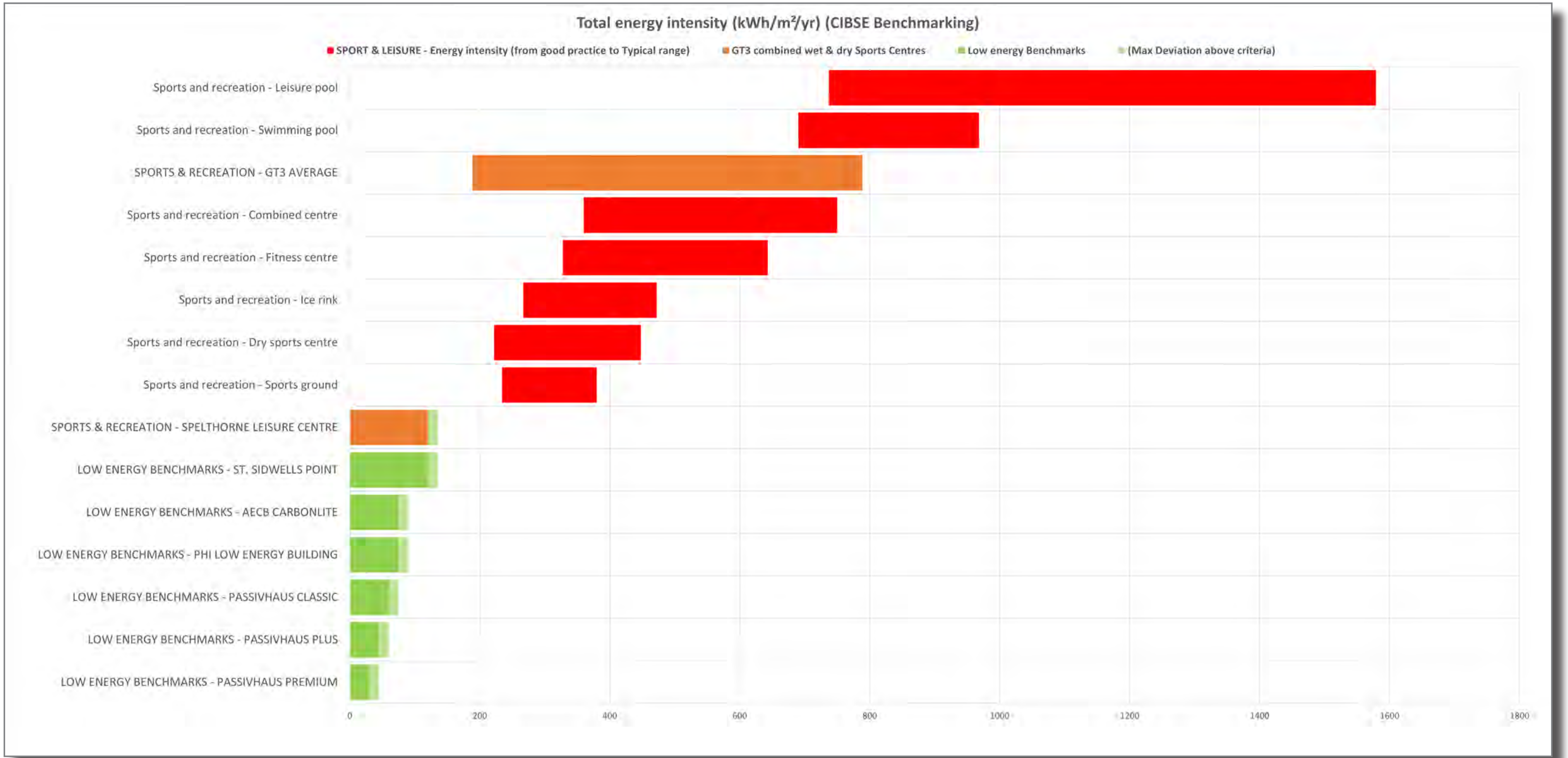
99 - 227 Litres of Petrol
(per square metre, per year)

23,585 - 53,973 Smartphones charged
(per square metre, per year)



Sport & Leisure

Operational Carbon Visualised



Extract from CIBSE 2021 collated data showing only: Sport & Leisure categories, GT3 completed projects (DEC data [19No. + Spelthorne Leisure Centre listed seperately]), and Low Energy Benchmarks (Including St.Sidwells Point).

GT3 ARCHITECTS

Leisure Sustainability
Operational Carbon / Energy Limits

As Sport & Leisure Facilities are amongst the highest Energy & Carbon users, <u>the opportunity for efficiency and reducing the usage is greater than any other building typology</u>. Small changes of efficiency can give significant savings on operating cost, energy use and carbon.

As there is a lack in prescriptive targets in both policy and building regulations, in order to achieve net zero, we have to set our own.

Subsequent to the previous charts, we can use the data to form 3No. achievable benchmarks for embodied energy use:

Option A - <u>"Business as usual"</u>

690 - 1579 $kWh/m^2._{year}$ equal to 299 - 684 $KgCO_{2.eq}/m^2_{.year}$

*Typically 800 kWh/m^2_{year} equal to 224.8 $KgCO_{2.eq}/m^2_{year}$

Based on CIBSE 2021 collated data, this ranges from 'good practice' (690 kWh/m^2.year) to 'typical use' 1579 (kWh/m^2.year). This is following the <u>current building regulations.</u>

Option B - <u>Low Carbon</u>

420 - 539 $kWh/m^2._{year}$ equal to 182 - 296 $KgCO_{2.eq}/m^2_{.year}$

*Typically 400 kWh/m^2_{year} equal to 112.4 $KgCO_{2.eq}/m^2_{year}$

Based on DEC's for 19No. completed GT3 Sport & Leisure projects, 18No. of which have Pools / Water facilities. The lowest performing Wet Facility (420 kWh/m^2.year), and the average across them (539 kWh/m^2.year).

Option C - <u>Passivhaus Standard</u>

*120 $kWh/m^2._{year}$ equal to 33.72 $KgCO_{2.eq}/m^2_{.year}$

Passivhaus is generally accepted as the best standard for in-use energy. It is an <u>optional accreditation</u> and has a strict limits for all aspects of the energy in-use.

<u>Operational Energy / Carbon Limits</u>

Based on the benchmarking guidance, we would prescribe the below limits for operational energy.

**These values will be used later in the document for calculation purposes.*

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GT3 ARCHITECTS

Sport & Leisure
Embodied Carbon

Similar to operational energy / carbon, there are no prescribed limits for embodied carbon in the building regulations, we can only prescribe targets based on the latest research.

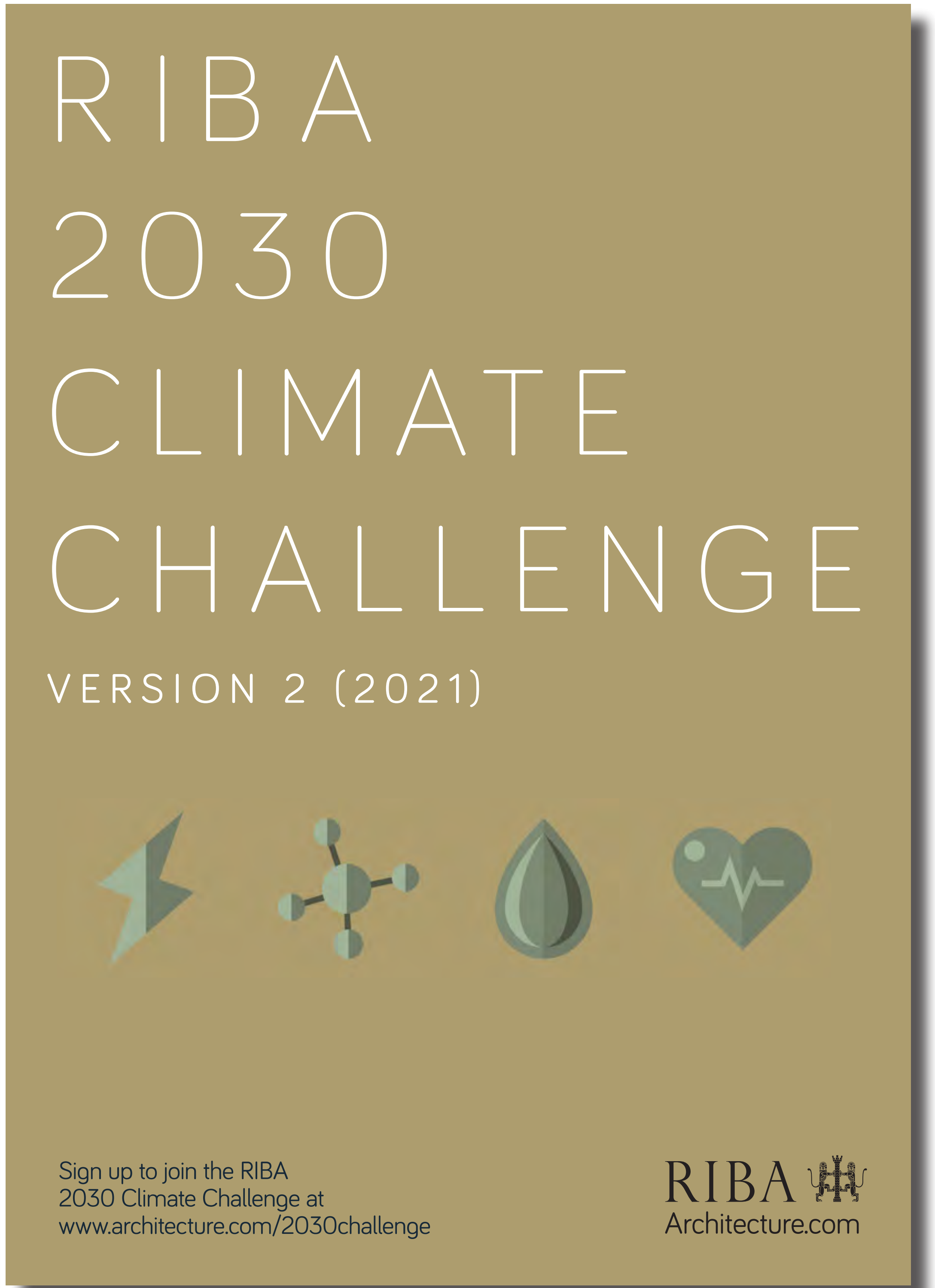
'Globally, Embodied Carbon of materials accounts for ~50% of all annual human-made GHG emissions from fossil fuels.

Global consensus agrees on the need for an immediate 40% reduction in embodied carbon today, moving towards 65% by 2030, and net zero by 2040.' - footprintcompany.com/embodied-carbon-roadmap

Below are some examples from key industry bodies:

- *World Green Building Council: -40% from average practice by 2030, Net Zero by 2050*
- *Royal British Institute of Architects (RIBA) & London Energy Transformation Initiative (LETI): -40% immediately, -55% by 2025, -70% by 2030, Net Zero by 2040*
- *American Institute of Architects (AIA): -40% immediately, -45% by 2025, -65% by 2030, Net Zero by 2040*
- *Green Building Council of Australia (GBCA): Net Zero by 2030*
- *Low Carbon Living CRC: Start Best Practice Method of Measurement & Report immediately, Mandatory Quotas by 2025, -70% by 2030, Net Zero by 2040'*

https://www.gov.uk/government/publications/net-zero-strategy



https://www.architecture.com/about/policy/climate-action/2030-climate-challenge

Sport & Leisure
Embodied Carbon Limits

The main two documents of relevance are the RIBA climate Challenge and the LETI climate emergency design guide. Both have set targets for Embodied carbon in construction, however the RIBA Challenge specifies directly towards; offices, schools, and the domestic sectors. There are however some comparables to offices in size and scale so could be considered a similar benchmark. The RIBA challenge set the below targets for Office sector projects:

<1400 $kgCO_{2eq}/m^2$ = “Business as Usual”
< 970 $kgCO_{2eq}/m^2$ = “2025 Targets”
< 750 $kgCO_{2eq}/m^2$ = “2030 Targets”

While these figures are higher than LETI, it has been proven that with large spans and even complex builds, these could be more ambitious.

London Energy Transformation Initiative (LETI), produced a thorough review of the Net zero target and proposed a path to zero carbon in the ‘Climate Emergency Design Guide’. LETI has set embodied carbon targets for the upfront embodied carbon emissions (Building Life Cycle Stage A1-A5).

LETI is the only guidance available that sets realistic targets on embodied carbon that is also non-sector specific. Therefore this will be used to set the limits for the Embodied Carbon of the project as a mid ground value between LETI and RIBA*

**Comparative to another recently measured project (Spelthorne Leisure Centre) with a reported figure, excluding external works outside the buildings footprint, of 672 $kgCO_{2eq}/m^2$ over a 60 year period life-cycle assessment* *- note stages A1-A5 = 720gCO_{2eq}/m^2*

Embodied Carbon Limits

Based on the LETI guidance, we would prescribe the below limits for the project.

**These values will be used later in the document for calculation purposes.*

Target / Option A

1200 ($kgCO_2/m^2$)

Target / Option B

<800 ($kgCO_2/m^2$)

Equivalent to 1/3rd reduction over baseline

1/3rd materials from re-used sources

50% materials can be re-used at end of life

Target / Option C

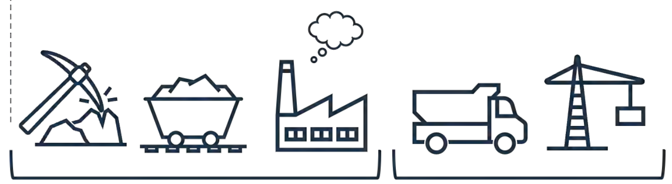
<400 ($kgCO_2/m^2$)

Equivalent to 2/3rd reduction over baseline

2/3rd materials from re-used sources

80% materials can be re-used at end of life

Upfront Embodied Carbon



A1 – A3
Product

Includes:
Raw material sourcing, transport & manufacture

A4 – A5
Construction

Includes:
Transport to site, installation

GT3 ARCHITECTS

Whole Life Carbon

Embodied vs Operational Ratio

Leisure facilities are high energy consumers & can be prone to comfort and overheating issues. Temperatures are maintained at high levels with plant operating 24 hours a day, 365 days a year. Space heating & hot water loads are far higher than all other building types. This means over a period of 60 years, <u>at least 66% of the energy is used in operation, going up to 98% in the business as usual scenario.</u>

Whole life carbon is the sum total of the Embodied + Operational Carbon. The typical methodology for assessing whole life carbon and is to add up the expected usage over a 60 year period.

LETI have done this for the 3 main typologies: offices, schools, and the domestic sectors and the representative pie charts are shown here denoting the percentage of energy / carbon used in its lifetime.

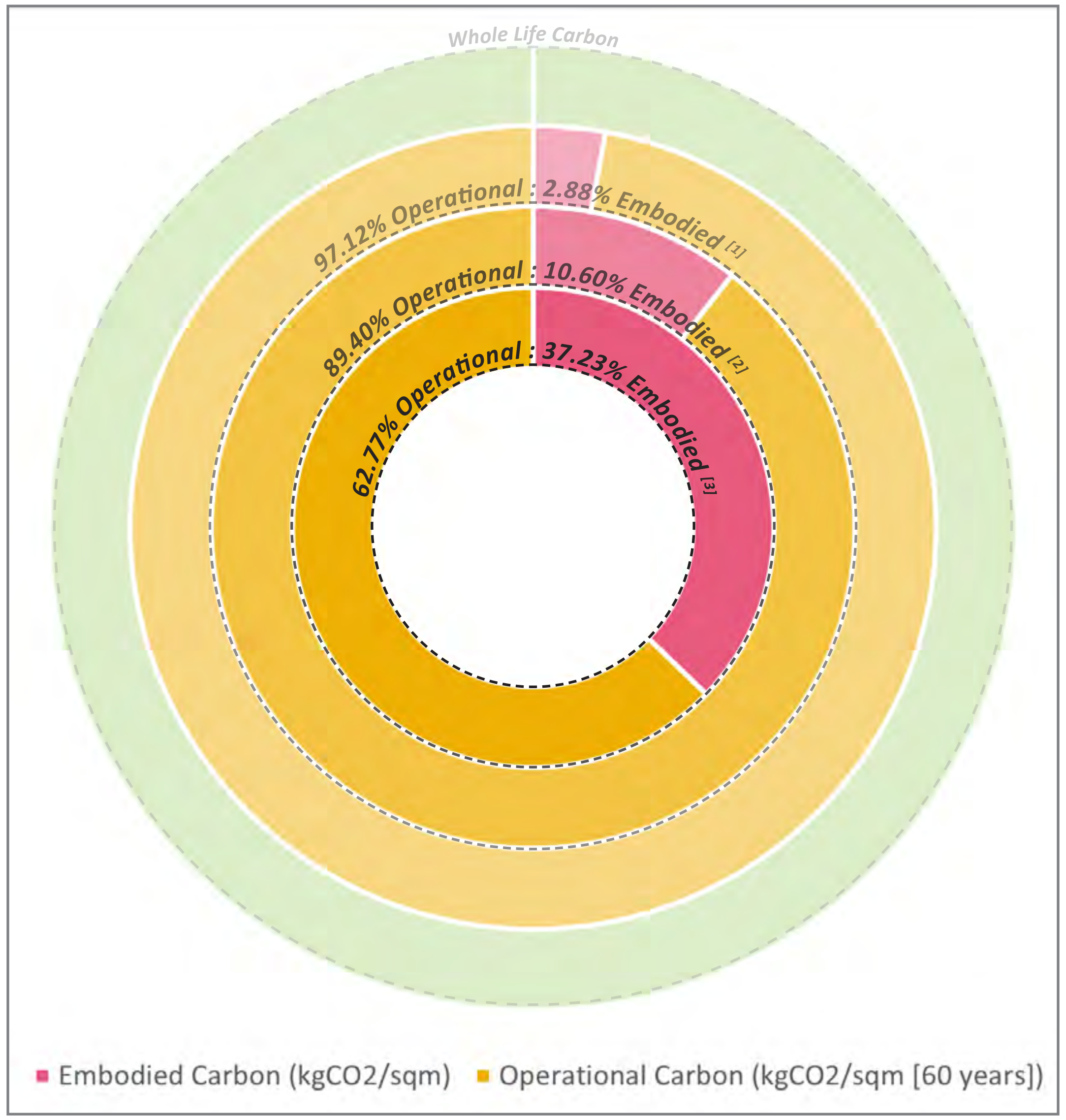
Following the same methodology we can estimate the ratio for Leisure Centre facilities.

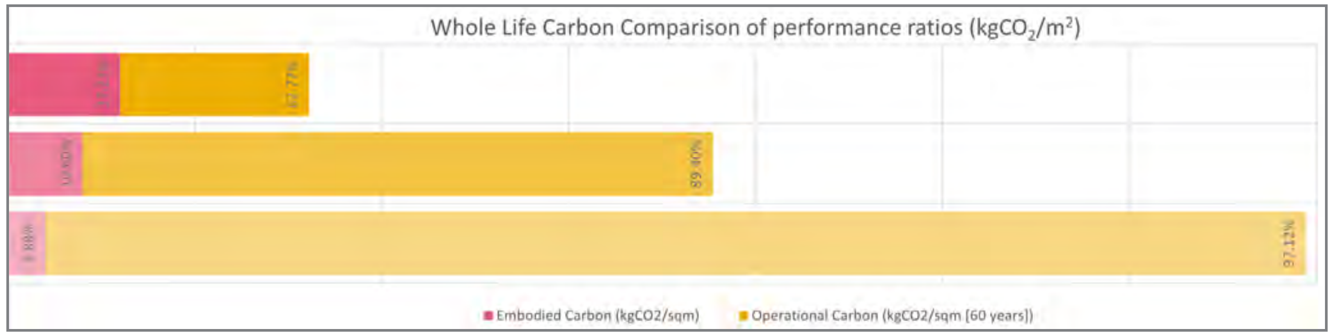
Leisure Centres have a significantly higher Energy Use Intensity (EUI) than other building typologies.

Over the period of 60 years. This means that in <u>even in the best case ratio scenario, in excess of 66%* of the overall Carbon and Energy emissions are in-use.</u> (Embodied Carbon not reduced at all & Operational Carbon reduced to Passivhaus levels of emissions)

**The min/max of the combinations of embodied vs operational carbon are shown on the pie charts opposite*

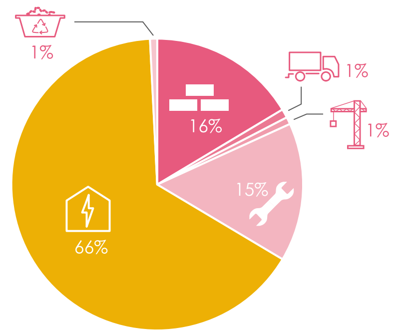
While it is important to understand the ratio of Embodied to Operational Carbon, it is worth noting that the Operational Carbon is by far the biggest contributor, especially in Sport & Leisure Buildings. Below the donut chart is a graph of the same data showing the sum total of the ratios as a comparison of the whole life carbon emissions per square metre.



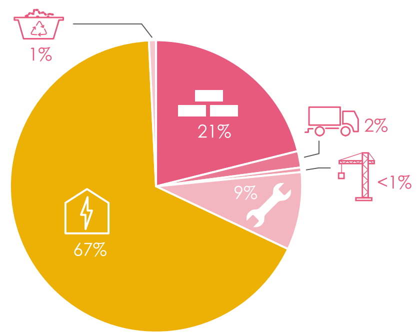


[1] Embodied Carbon **1200 ($kgCO_{2eq}/m^2$) : 2032.2 ($KgCO_{2.eq}/m^2$)** Operational Carbon (33.72 ($KgCO_{2.eq}/m^2$.year) x 60 years)
[2] Embodied Carbon **800 ($kgCO_{2eq}/m^2$) : 6,744 ($KgCO_{2.eq}/m^2$)** Operational Carbon (112.4 ($KgCO_{2.eq}/m^2$.year) x 60 years)
[3] Embodied Carbon **400 ($kgCO_{2eq}/m^2$) : 13,488 ($KgCO_{2.eq}/m^2$)** Operational Carbon (224.8 ($KgCO_{2.eq}/m^2$.year) x 60 years)

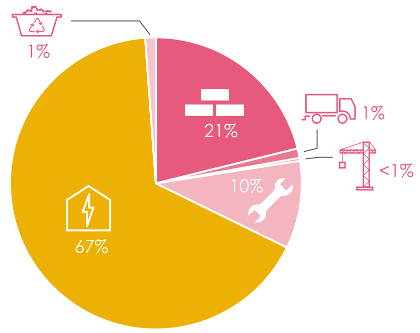
Office



Medium scale residential



School



- Products/materials (A1-A3)
- Transport (A4)
- Construction (A5)
- Maintenance and replacements (B1-B5)
- Operational energy (B6)
- End of life disposal (C1-C4)

The ratio of carbon is influenced the most by the operational carbon. Therefore, the greatest impact on the whole life carbon is to adopt 'Passive principles' or full 'Passivhaus certification'

GT3 ARCHITECTS

Carbon Targets
Summary

Below is a summary of the 3 benchmarks for both embodied and operational carbon. These will be used for the basis of calculations and comparing 3 options for the project.

Embodied Carbon Limits

Based on the LETI guidance, we would prescribe the below limits for the project.

**These values will be used later in the document for calculation purposes.*

Target / Option A

1200
($kgCO_2/m^2$)

Target / Option B

<800
($kgCO_2/m^2$)

Equivalent to 1/3rd reduction over baseline

1/3rd materials from re-used sources

50% materials can be re-used at end of life

Target / Option C

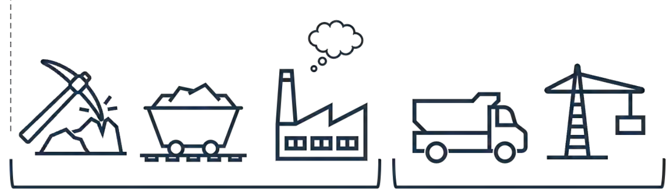
<400
($kgCO_2/m^2$)

Equivalent to 2/3rd reduction over baseline

2/3rd materials from re-used sources

80% materials can be re-used at end of life

Upfront Embodied Carbon



A1 – A3
Product

Includes:
Raw material sourcing, transport & manufacture

A4 – A5
Construction

Includes:
Transport to site, installation

Operational Energy / Carbon Limits

Based on the benchmarking guidance, we would prescribe the below limits for operational energy.

**These values will be used later in the document for calculation purposes.*

Target / Option A

800 kWh/m²/year

Target / Option B

-50%

400 kWh/m²/year

Target / Option C

-85%

120 kWh/m²/year

Proposed Framework
10 Things to Consider

Embodied Carbon *Operational Carbon*

In order to positively step towards the Net Zero Emissions goal for any project, the following areas were identified as the key building strategies that have the greatest impact on the whole life carbon. These will inform the Key performance Indicators (KPI's) for the options previously outlined. Circles indicate the aspect of the carbon that is impacted.

Building Orientation & Compact Form
Proper orientation impacts the heating & cooling loads and helps to balance where areas of glazing are useful for the internal room use.

Thermal Zoning
Properly distributing hot - cold zones through the building reduces the temperature differential between spaces. This helps mitigate unwanted internal heat gains and reduces overall system demand

Building weight & Substructure Design (Below Ground)
Reducing the building weight (swapping heavy floor/wall constructions for timber, hybrid timber/steel frame) creates a lighter building and therefore a much reduced foundation solution. Less structure = Less embodied carbon

Building Structure (above Ground)
Steel and concrete contain large amounts of carbon, while timber is considered carbon zero. The choice of frame has a large impact on the embodied carbon.

Pool tank construction
Stainless steel pool tanks provide a circa. 40% reduction in embodied carbon over a traditional concrete tank as well as steel can more easily be recycled. However advances in concrete can dramatically reduce the carbon content. Careful analysis of the most optimal solution is required per project.

Operational Temperatures & Water Use
Every ±1°C has a significant effect of the overall energy demand. Small changes to operating temperatures can have a significant impact on the sizing and specification of heating / cooling systems. Setting these early are a key factor for energy optimisation.

Heat & Power Source
The heat and power source directly impacts the amount of carbon used during the life of the building. Marginal gains in efficient systems provide significant savings on energy over the building life cycle. This also includes Pool filtration.

Building Glazing & Shading
Optimising both glazing ratios & shading factors can greatly effect both energy demand and load. Proper design should balance the right amount of solar gains across the year, maximising the low winter sun to reduce heating, and minimising excess gains in summer.

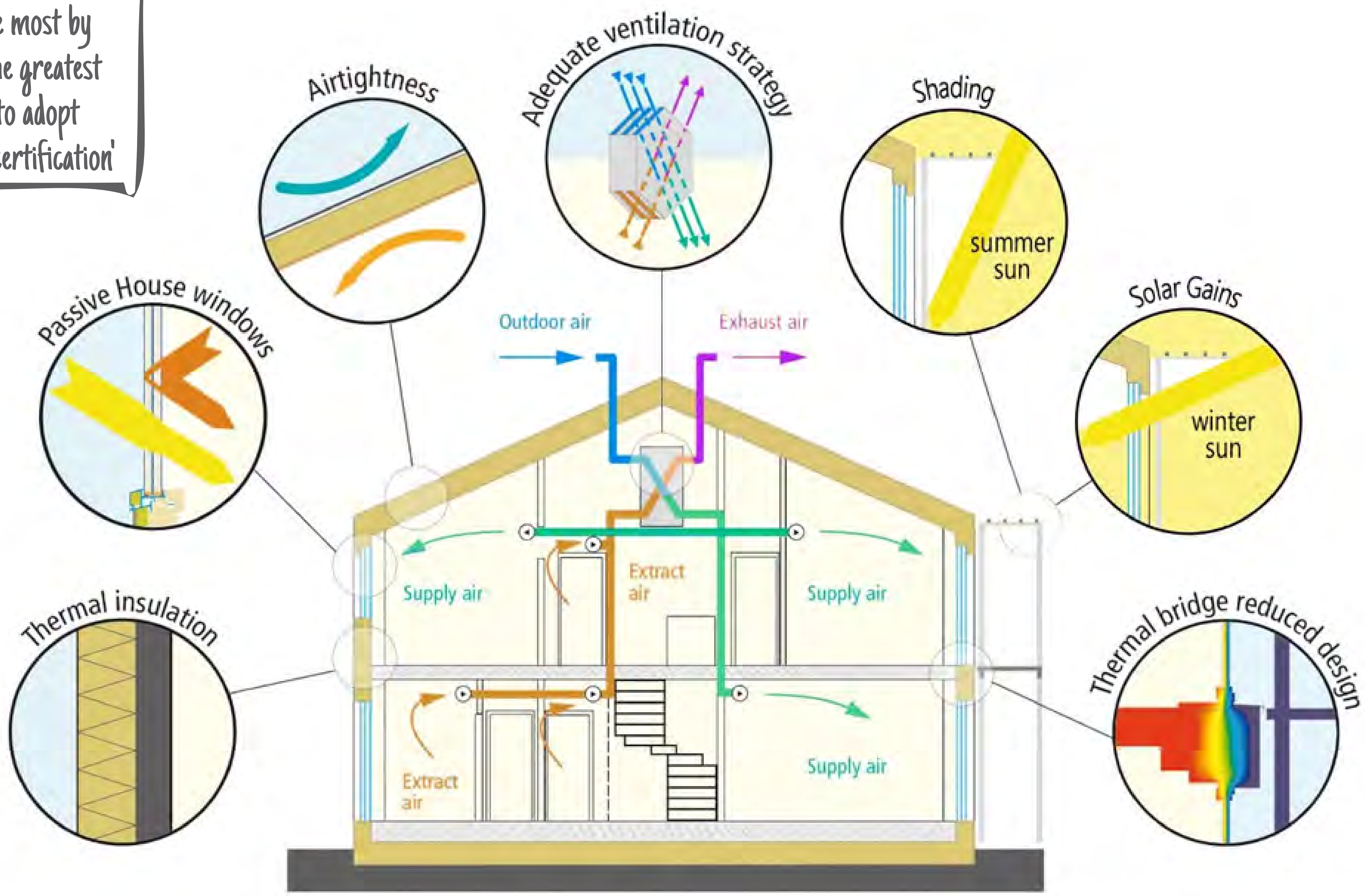
U-Values & Air Tightness
Both factors directly influence the heating & cooling requirements of the building. While increased U-values marginally increase the embodied carbon (additional insulation thickness), the payback period on reduced operational energy / carbon can offset this as quickly as 12 months.

External Material Choices
The overall impact of the external façade finish is marginal, Different cladding & envelope solutions have different amounts of embodied carbon, and heavier elements also require additional structure to support.

Proposed Framework
'Passive Principles'

The 10 things to consider collectively form the principles of Low Carbon Design. By following the 'Passive' Principles every project will make meaningful steps towards optimising the building performance, bringing the carbon emissions down, and be closer to Net-Zero

The ratio of carbon is influenced the most by the operational carbon. Therefore, the greatest impact on the whole life carbon is to adopt 'Passive principles' or full 'Passivhaus certification'



While a building can be operationally net zero (utilising sustainable power sources), the reality is no building can be embodied carbon zero, as current construction materials all have some carbon content. To achieve whole life carbon zero, the approach should be to minimize the carbon as much as possible and then offset the remainder.

3 • Project Options

Stage 2 Brief Output

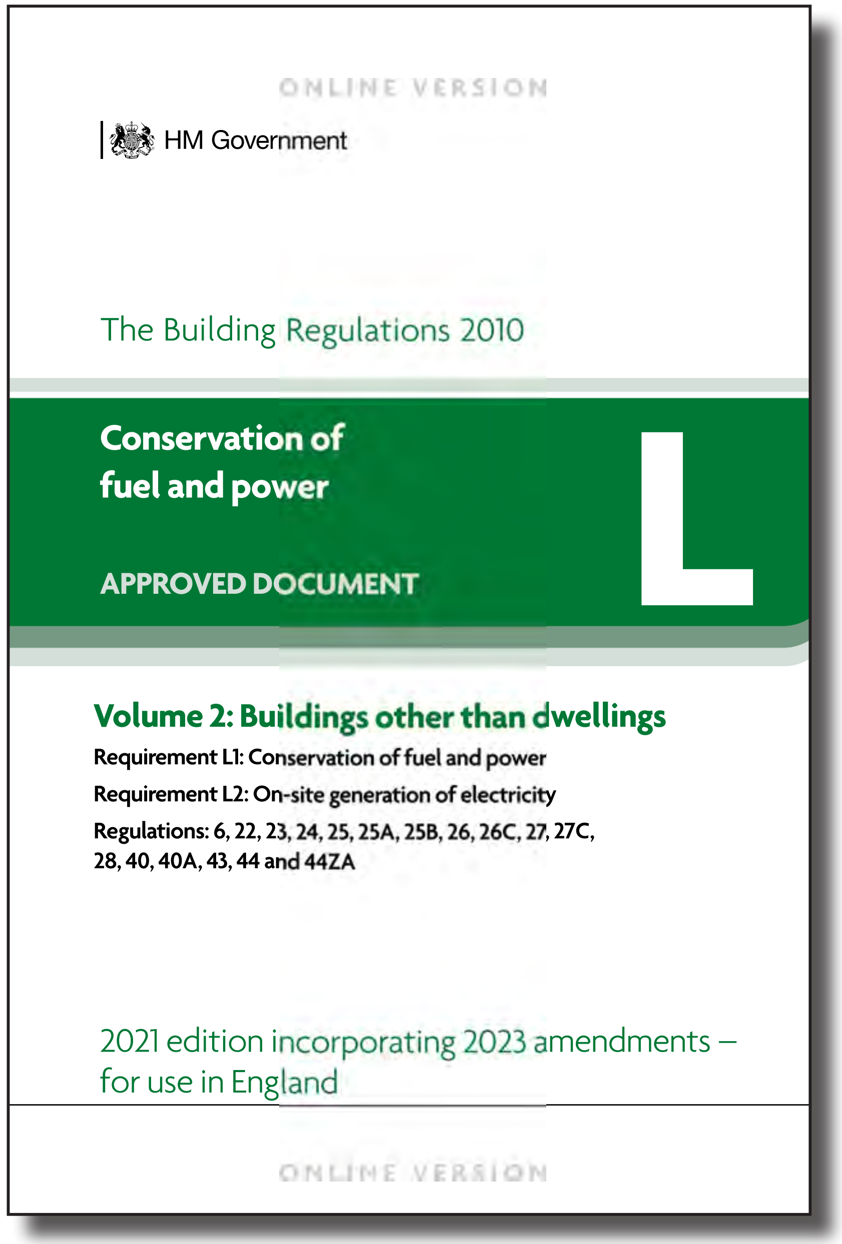
The 3 Project Options

For the purpose of the following exercises, there are 3 sustainability options proposed, each tackling with increasing levels of efficiency and carbon reduction. This can then be further used to cost each option for the project.

Option C - Full Passivhaus Certification

Option B - Low carbon / Passive Principles

Option A - 'Business As usual' i.e. Building regs compliant



ONLINE VERSION

HM Government

The Building Regulations 2010

Conservation of fuel and power

APPROVED DOCUMENT

L

Volume 2: Buildings other than dwellings

Requirement L1: Conservation of fuel and power

Requirement L2: On-site generation of electricity

Regulations: 6, 22, 23, 24, 25, 25A, 25B, 26, 26C, 27, 27C, 28, 40, 40A, 43, 44 and 44ZA

2021 edition incorporating 2023 amendments – for use in England

ONLINE VERSION

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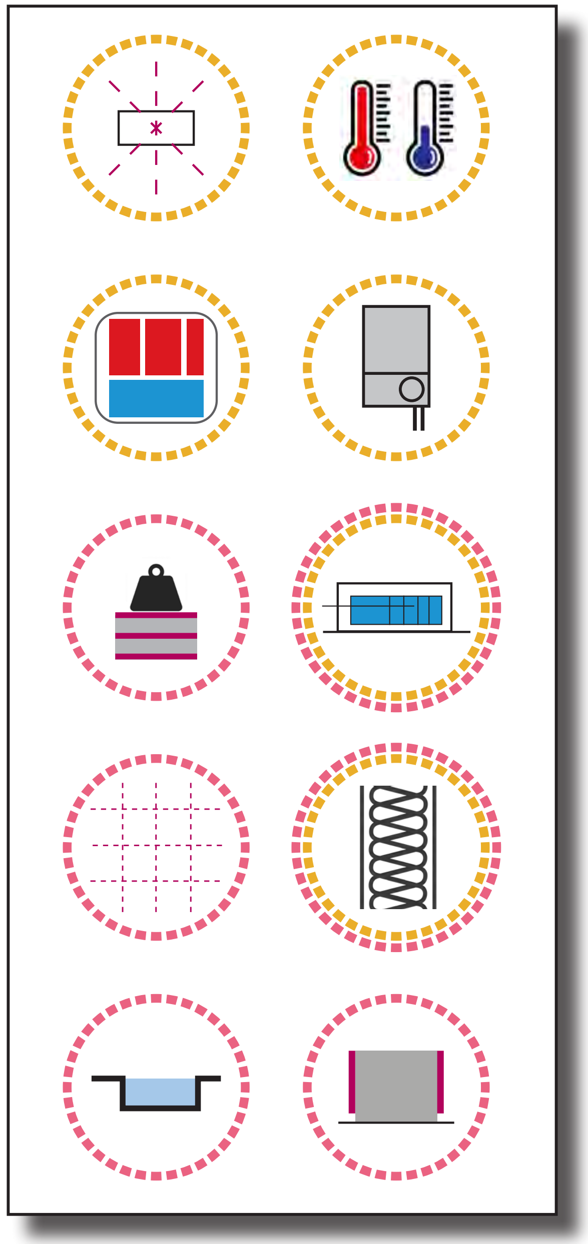

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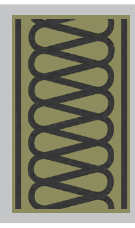
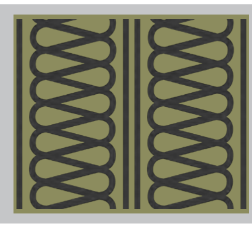
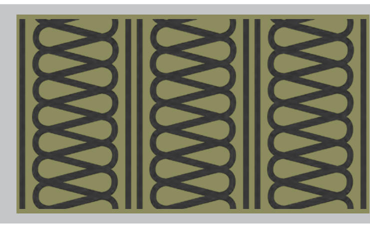
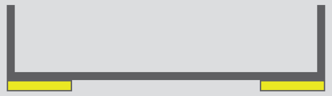
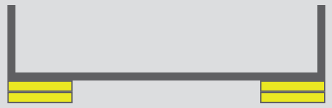
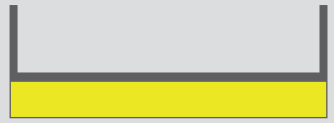
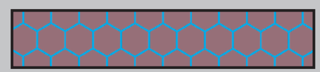
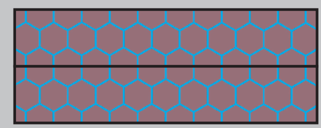
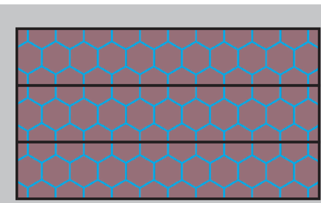
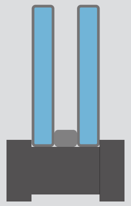
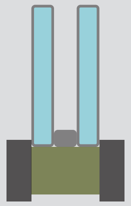
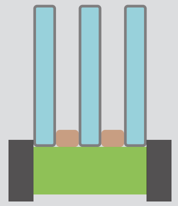
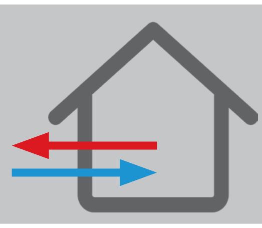
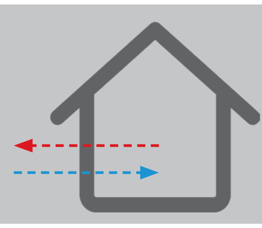
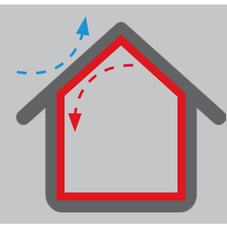
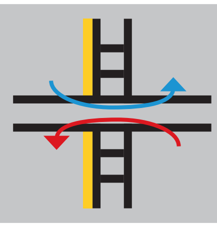
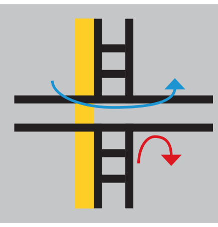
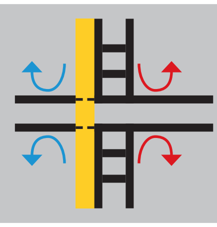
BREEAM is a further accreditation that is a holistic approach to sustainability. Many Local Authorities use it as a benchmark as it covers a wider spectrum of sustainability including: Energy, Land use and ecology, Water, Health and well-being, Pollution, Transport, Materials, Waste & Management. It provides a broad approach to construction and is recognised internationally as a sustainability standard, however it does not directly target carbon or energy, as it only accounts for a small amount of the overall credits / score.

BREEAM Very Good

Proposed Framework
Key Performance Indicators (KPI's)

In all 3 options, the primary difference is in the fabric performance. Below is the key 7 things that differ between them to inform that capital cost uplift and payback exercise. It can also form the KPI's for taking the project into the technical design phases.

	Option A - 'Business as Usual'		*Option B - Low carbon / 'Passive Principles'*		*Option C - Passivhaus Certified*	
U-value External Wall	**≤ 0.26 W/m²K (As per part L)** 100mm Insulation (mineral wool type)		**≤ 0.15 W/m²K** 200mm Insulation (mineral wool type)		**≤ 0.125 W/m²K** 300mm Insulation (mineral wool type)	
U-value Floor	**≤ 0.18 W/m²K (based on P/A ratio)** 100mm Insulation (rigid board Type)		**≤ 0.15 W/m²K (based on P/A ratio)** 150mm Insulation (rigid board Type)		**≤ 0.15 W/m²K (Whole Floor)** 250mm Insulation	
U-value Roof	**≤ 0.18 W/m²K (As per part L)** 200mm Insulation (rigid board Type)		**≤ 0.125 W/m²K** 250mm Insulation (rigid board Type)		**≤ 0.125 W/m²K** 350mm Insulation (rigid board Type)	
U-value Window & Doors	**≤ 1.6 W/m²K (As per part L)** Double glazed		**≤ 1.2 W/m²K** Premium glazing + Superior frames		**≤ 0.85 W/m²K** Triple glazed + Superior Frames + Superior Spacers	
Air Tightness	**≤ 8.0 m³/m².h** (As per part L)		**≤ 3.0 m³/m².h**		**≤ 0.4 m³/m².h ≤ 0.6 ach** building to achieve both values	
Internal Thermal Separation	**Only wet side to remaining facilities** 100mm Insulation (mineral wool type)		**Only wet side to remaining facilities** 100mm Insulation (mineral wool type)		**All spaces with ±4°C temp. difference** 150mm Insulation (mineral wool type)	
Thermal Bridging	**No requirement for quantification** - design to reduce where possible		**Some quantification** - design to reduce where possible		**All thermal bridges quantified & reduced**	

GT3 ARCHITECTS

Payback Periods
Cost & Carbon

AREA : **9,950m²**

Cost Per kWh : **£0.165/kWh**

Carbon Conversion Rate : **0.281 (kgCO_2/kWh)**

Embodied Carbon Target Intensity : **800 (kgCO_2/m²)**

	Option A - 'Business as Usual'	Option B - Low Carbon / 'Passive Principles'	Option C - Passivhaus Certified
Capital Cost	**£49,450,000.00**	**£54,855,000.00**	**£57,614,000.00**
Capital Cost Increase	-	**£5,405,000.00**	**£8,164,000.00**
Uplift Percentage from baseline	-	**+10.93% (over Option A)**	**+16.51%**
Embodied Carbon Intensity (per m² upfront)	800 (kgCO_2/m²)	800 (kgCO_2/m²)	800 (kgCO_2/m²)
Total Expected Embodied Carbon	7,960.00 (tonnes CO_2)	7,960.00 (tonnes CO_2)	7,960.00 (tonnes CO_2)
Operational Carbon (per m²)	224.80 (kgCO_2/m²)	112.40 (kgCO_2/m²)	33.72 (kgCO_2/m²)
Total Operational Carbon (60 years)	134,205.60 (tonnes CO_2)	67,102.80 (tonnes CO_2)	20,130.84 (tonnes CO_2)
Whole life carbon estimate (excl. Demolition)	142,165.60 (tonnes CO_2)	75,062.80 (tonnes CO_2)	28,090.84 (tonnes CO_2)
Whole life carbon saving	-	**-67,102.80 (tonnes CO_2)**	**-114,074.76 (tonnes CO_2)**
Whole life carbon (per m²)	14.29 (tonnes CO_2/m²)	7.54 (tonnes CO_2/m²)	2.82 (tonnes CO_2/m²)
Lifetime Carbon Saving	-	**47.20% (Whole Life Carbon Saving)**	**80.24% (Whole Life Carbon Saving)**
Energy Use Intensity (EUI)	800 (kWh/m².year)	400 (kWh/m².year)	120 (kWh/m².year)
Yearly Energy Demand	7,960,000 (kWh/year)	3,980,000 (kWh/year)	1,194,000 (kWh/year)
Estimated Operational Cost (per Year)	**£1,312,604.00**	**£656,302.00**	**£196,890.60**
Operational Cost Savings (per Year)	-	**£656,302.00 (Saving per year)**	**£1,115,713.40 (Saving per year)**
Payback Period	-	**8.24 (years)**	**7.32 (years)**
Operational Cost (per month)	£109,383.67 (month)	£54,691.83 (month)	£16,407.55 (month)
Operational Cost (per m²)	£131.92/m²	£65.96/m²	£19.79/m²

Assumptions made for the basis of the calculations:

- *All electric power and electric rates (Advised by Hydrock)*
- *Does not include future inflations of energy prices*
- *Assumed 60 year life for calculating the operational energy as per BS EN 15978 & leti guidance*
- *Embodied Carbon Option B (achievable based on Spelthorne Leisure Centre) & Operational Energy Targets set previously within this document.*
- *Conversion rate of conversion rate of 0.281 Kg$CO_{2,eq}$ = 1kWh - European Environment Agency 2016 (latest) Data - www.eea.europa.eu/data-and-maps/daviz/co2-emission-intensity*

Payback Periods
Summary

Leisure facilities are high energy consumers and can be prone to comfort and overheating issues. Temperatures are maintained at high levels with plant operating continuously 24 hours a day over 365 days a year. Space heating and hot water loads are higher than any other building type. In addition, electrical energy demand is high due to pool water filtration processes, and fan power and pump power loads, not to mention fit out items such as gym and catering equipment.

Of all building types, applying the proven and tested
low energy Passivhaus standard to Leisure Facilities makes most sense.

A high performing thermal envelope along with thermal bridge free details and triple glazing, coupled with airtight construction, will mitigate against rising energy costs, and will also better protect the fabric. Air tightness, will reduce the risk of warm moist air migrating into the fabric due to unwanted infiltration. Triple glazing and high insulation levels will reduce condensation risk.

A Passivhaus optimised design that focuses on orientation, glazing ratios, internal thermal zones layout, low energy services design and making the most of heat recovery processes to move energy between zones, all can result in significant energy savings when compared to standard new build designs.

By following the Passivhaus approach, minimum energy savings
in the region of 50-60%+ can be easily realised vs CIBSE benchmarks

The dramatically reduced energy consumption is through a number of factors including reduced heat loss, reduced pool water evaporation, reduced air change rate and fan power, reduced water heating loads.

GT3 ARCHITECTS

4 • Analysis

Building Strategy
Site, Climate & Comfort

Aside from the obvious benefits of low energy buildings having lower operational costs and carbon emissions, an unknown fact is that the higher levels of insulation also protect from overheating in the summer as well as increases user comfort. This is a direct result of building physics as more insulation generally creates warmer surface internally.

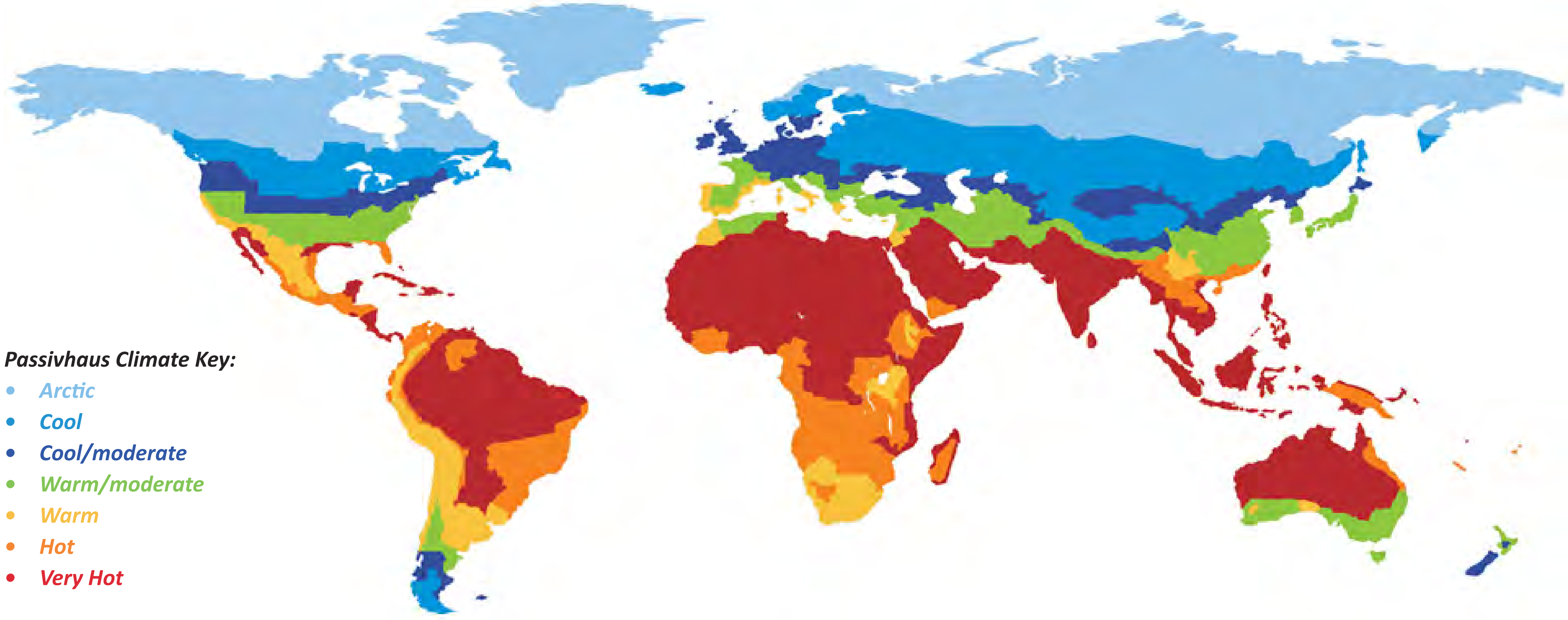
Generally buildings in the UK have a standard assessment method - known as CIBSE TM59, which feeds into SAP and SBEM modelling - and this is applicable as standard for calculations for Option A & Option B. This then produces the EPC rating of the building.

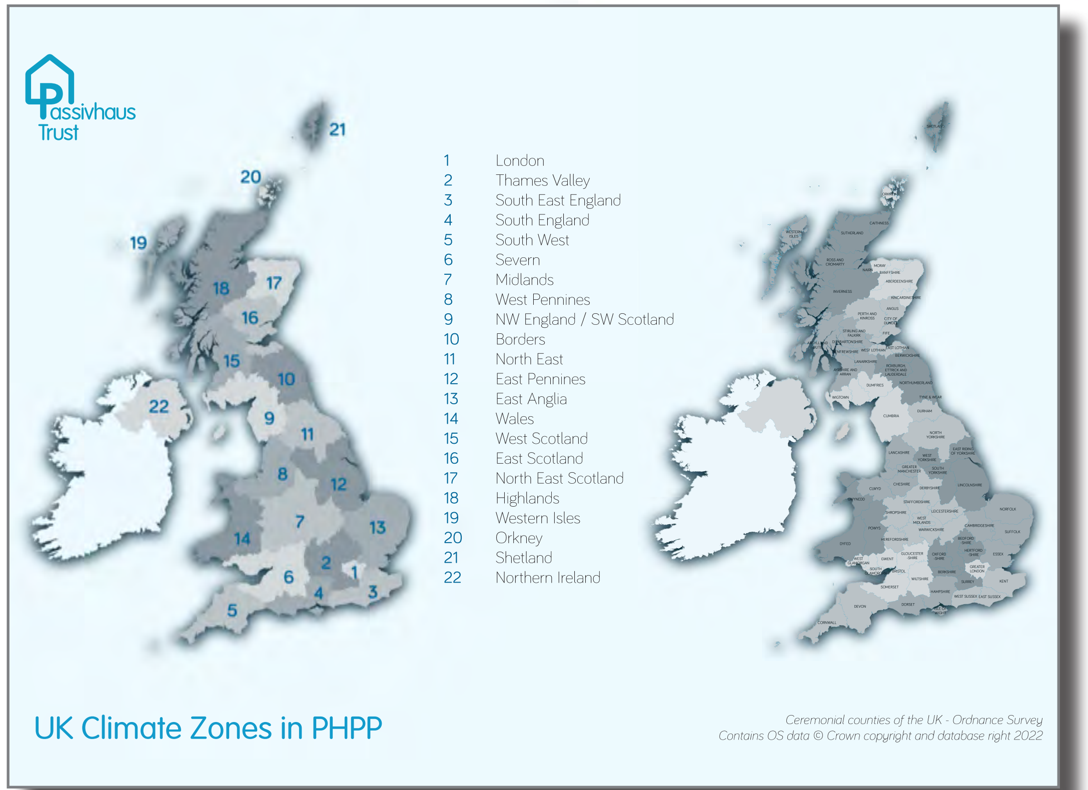
"To achieve consistency across the country, SAP [and SBEM] models every building in the centre of the country (East Pennines) so that the climate conditions are always the same.

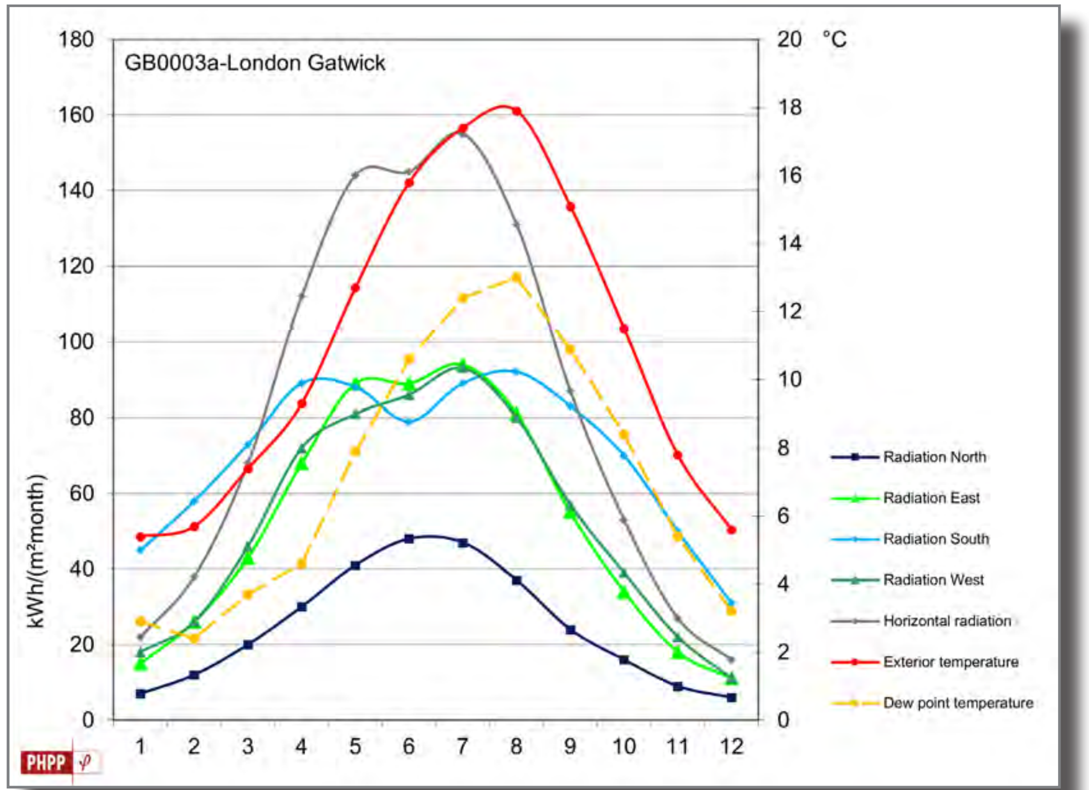
This means that if you built two houses to exactly the same specification, one in Cornwall occupied by a family of four who are out during the day and one in Scotland with a single occupant working from home, you would get the same EPC rating – which is exactly what SAP is supposed to deliver. However, in reality, the actual energy use of each property is likely to be different." - EPCs as Efficiency Targets, Passivhaus Trust 2020 - www.passivhaustrust.org.

"The Passivhaus standard includes an overheating criterion which requires that the building, as a whole, spends less than 10% of the year at temperatures of 25°C or above...It should also be noted that the Passivhaus modelling system uses local climate data rather than the generic mid-UK location used by SAP & SBEM in support of Building Regulation compliance" - Avoiding summer overheating - Passivhaus Trust 2021 - www.passivhaustrust.org.

**If the project brief pursues Passivhaus Certification as per Option C, then the climate criteria set here are to be input as the nearest applicable data for the site. Graph taken from PHPP.*







GT3 ARCHITECTS

Building Strategy
Form Factor

Based on the current massing of Farnborough Leisure Centre, the form factors are favourable for the design of a low energy building and for achieving passivhaus certification. The form factors calculated are the same for all 3 options.

Heat will gradually make its way to the outside of the building through building's external faces (e.g. walls, roofs, terraces). The larger the area of external faces, the more place heat has to escape to the outside. In principle, to minimise heat transfer through the building's external faces, the building shape should be as compact as possible.

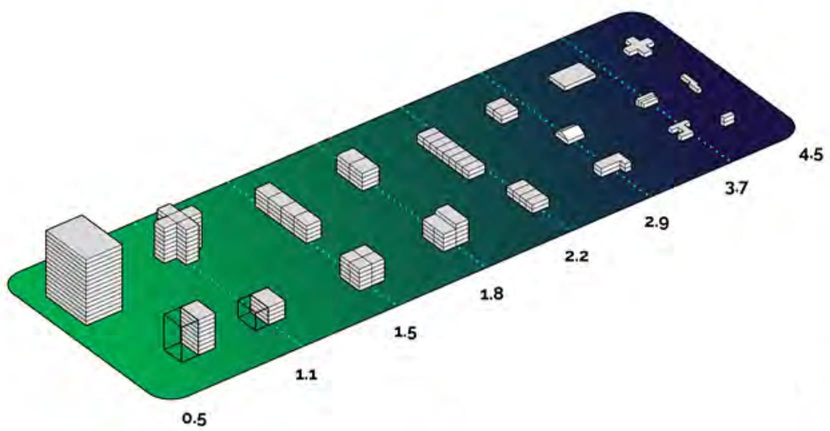
Form Factor is a useful tool for evaluating the relative compactness of a building and determining the feasibility of achieving low energy building performance, particularly for Passivhaus Certified Projects.

There are 2 main ways of evaluating the form factor for a building:

Heatloss form factor - external envelope : floor area
Achieving a heat loss Form Factors of ≤ 3 is a useful bench mark guide when designing Passivhaus buildings

A:V - Ratio of ventilated volume to external area
A favourable compactness ratio is considered to be one were the A:V ratio ≤ 0.7m²/ m³

On larger scale buildings such as leisure centres, the form factor is typically better than in small domestic properties. Even though the building as a whole is significantly larger, its relative compactness can be significantly lower.



Building envelope areas:

External walls ≈ 4,310m²
Roofs ≈ 5,396m²
Floor ≈ 4,644m²

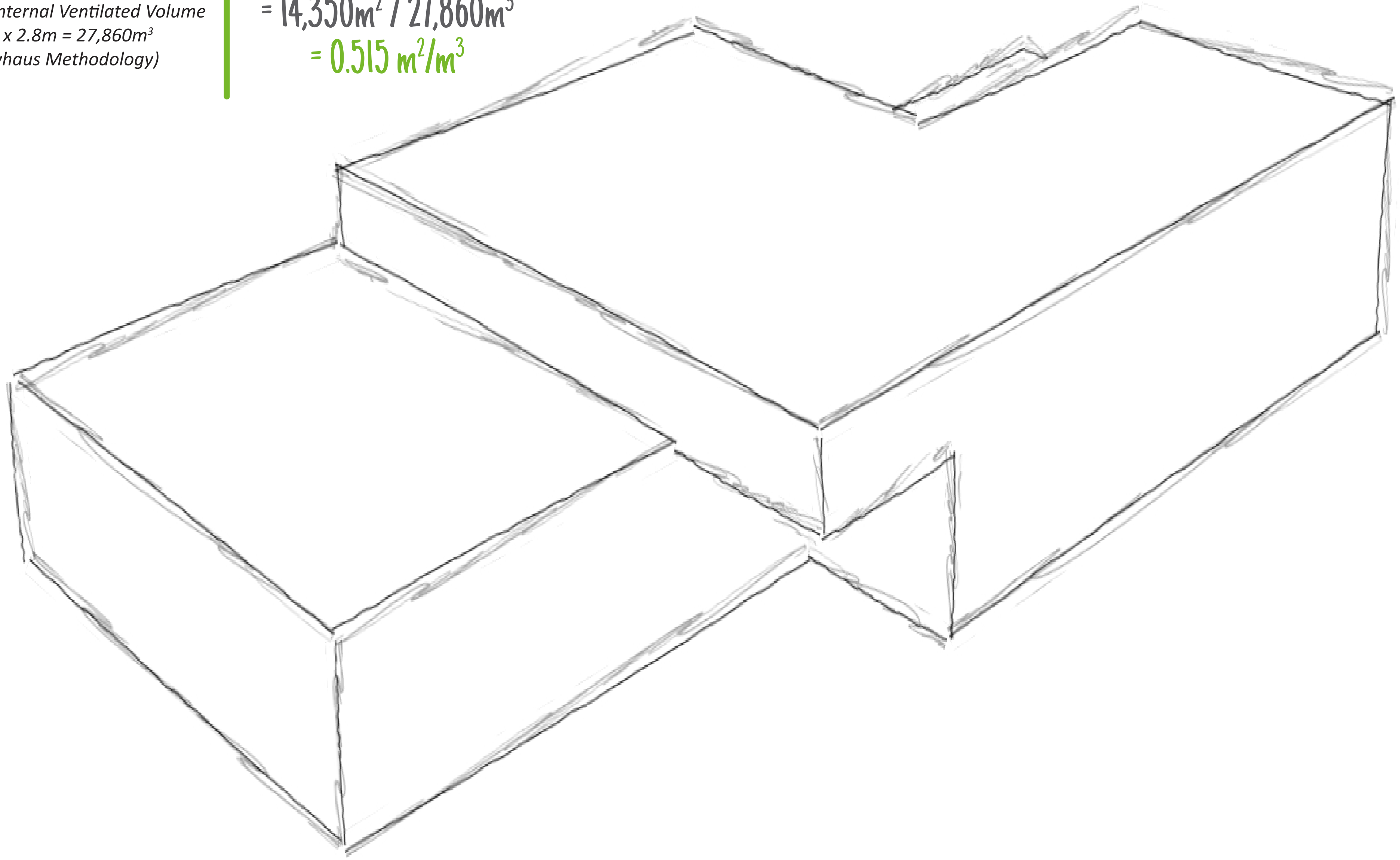
Total ≈ 14,350m²

Total GIFA = 9,950m²

Total Internal Ventilated Volume = GIFA x 2.8m = 27,860m³ (Passivhaus Methodology)

Heat loss form factor
= 14,350m² / 9,950m²
= 1.44

Area : Volume ratio
= 14,350m² / 27,860m³
= 0.515 m²/m³



**The Form factor will be revisited at each stage to ensure any changes that are made do not have a significantly adverse effect to the overall ratio. It will also develop with a greater level of detail as the design develops.*

GT3 ARCHITECTS

Building Strategy
Air Tightness

From Option A-B there should be no additional systems to achieve the ≤ 3.0 m³/m².h. - however to achieve the targets mandated for Passivhaus Certification, additional airtight systems are required. As they have such a small embodied carbon, they are insignificant in the embodied carbon of the building, but by drastically reducing the operational carbon, can have a significant impact on lifetime carbon.

Similar to carbon ratios described earlier in this report, Air tightness can be a significant amount of the overall energy loss of a building. Hence, for low energy optimised designs, a clear, concise and considered airtightness strategy is required.

Research suggests that up to 40% of all energy usage in a building is through unwanted air infiltration; either through hot air leaking out of the building causing more energy use to reheat the inside space, or through hot air coming in the building causing more energy usage to cool the space. By increasing the air tightness of the building, those losses can be reduced significantly.

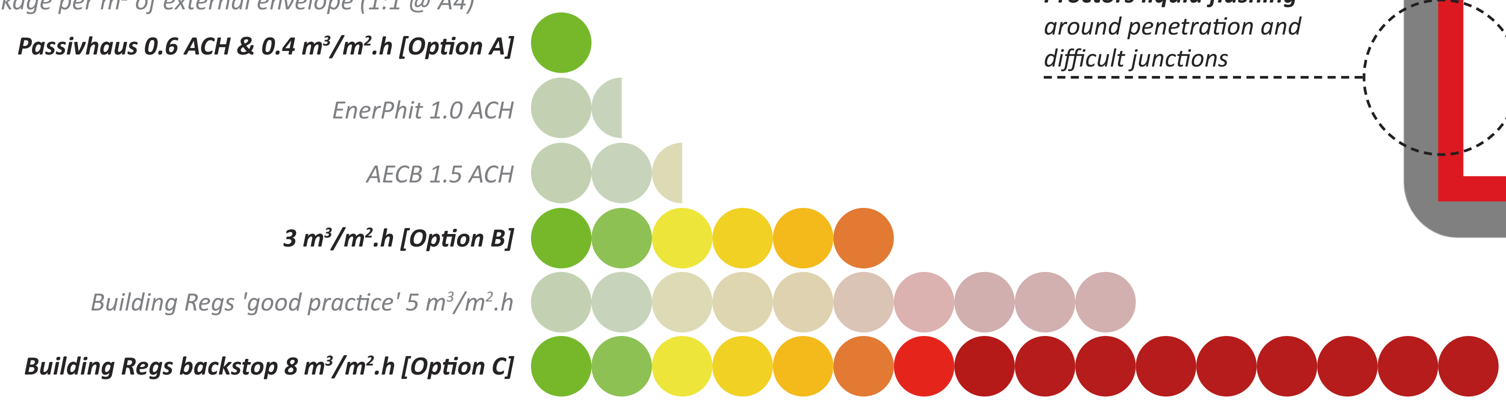
Air leakage is not only direct heat loss, but air movement through insulating components which can reduce their effectiveness by up to a factor of 5.

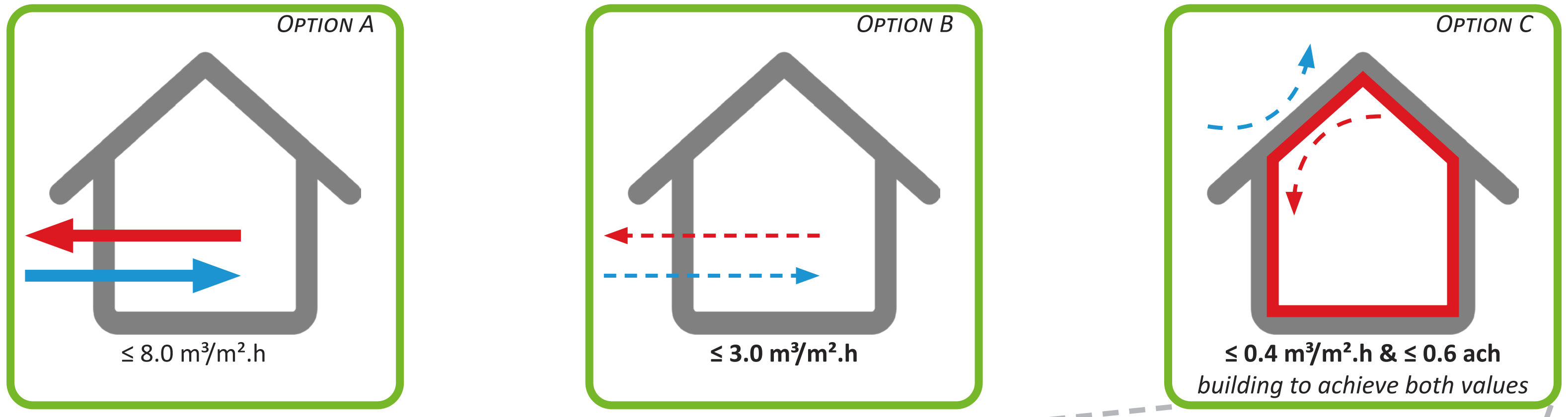
UK Building Regulations express air tightness as the volume of air that escapes per m² of external surface area per hour, this is referred to as Air Permeability (m³/m².h), and for large scale projects aiming for Passivhaus Certification, it must also achieve a specific Air Change Rate (ACH).

Simplicity is key in airtightness design. The fewer junctions, balconies, & other features, the simpler the airtightness design & delivery will be.

Below is an excerpt from the 'Good Practice Guide to Airtightness' from the Passivhaus Trust 2020.
www.passivhaustrust.org.uk/news/detail/?nId=900

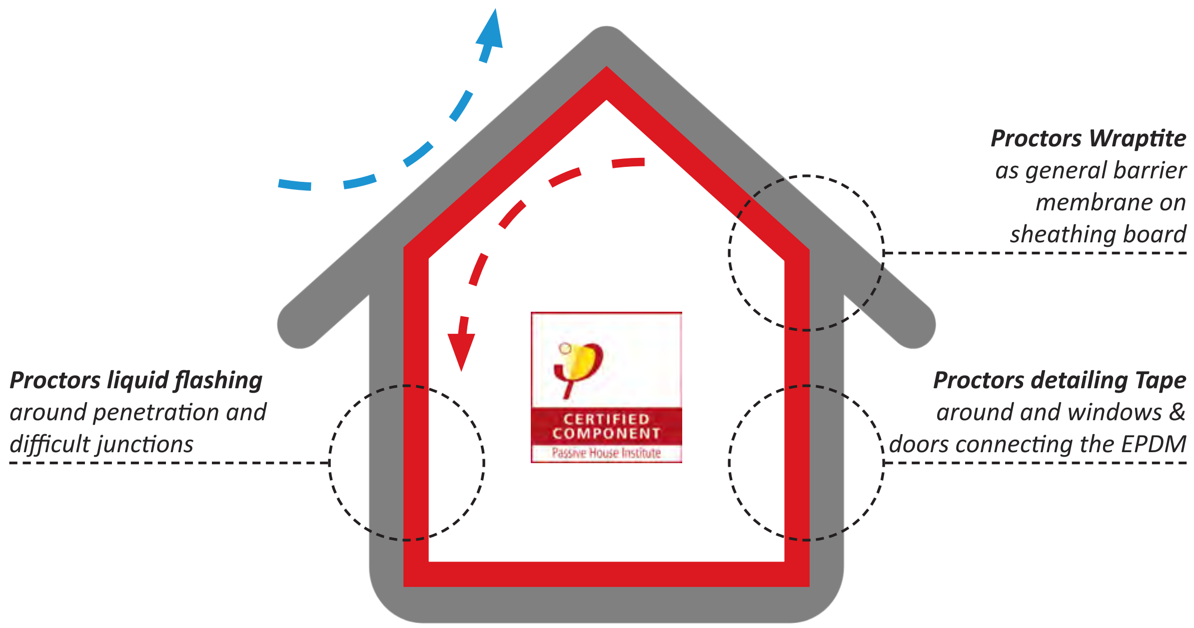
Relative air leakage per m² of external envelope (1:1 @ A4)





In the case of Farnborough Leisure & Culture Hub, the Air tightness strategy is to use a series of membranes mostly on the external façade) to form a complete system in combination with the general construction. Some materials used in construction can form part of the air barrier even though they are not marketed as such and these include: Concrete cast in situ, screed, plaster > 5mm depth, EPDM's & glazing/doors > class 3.

Below is an overview of a tried and tested system (Proctors Wraptite system) that can form the air tightness barrier - If the project brief is to achieve Passivhaus Certification then these items will form part of the NBS specification. https://proctorgroup.com/products/wraptite



GT3 ARCHITECTS

Building Strategy
Shading & Temperature Zones

Overheating needs to be considered from the start of a project. This is becoming more and more important as that overall global temperature is rising and we are collectively facing warmer summers. This means that suitable shading strategies are considered from the start of the Farnborough Leisure centre design process.

"The building orientation should be optimised as far as possible to benefit from the opportunity of solar gains in the winter without the risk of too much gain in the summer. The ideal situation is a north-south orientation with daylight-optimised glazing on the north façade and somewhere between 15 and 25% glazing on the south façade" - Avoiding summer overheating - Passivhaus Trust 2021 - www.passivhaustrust.org.

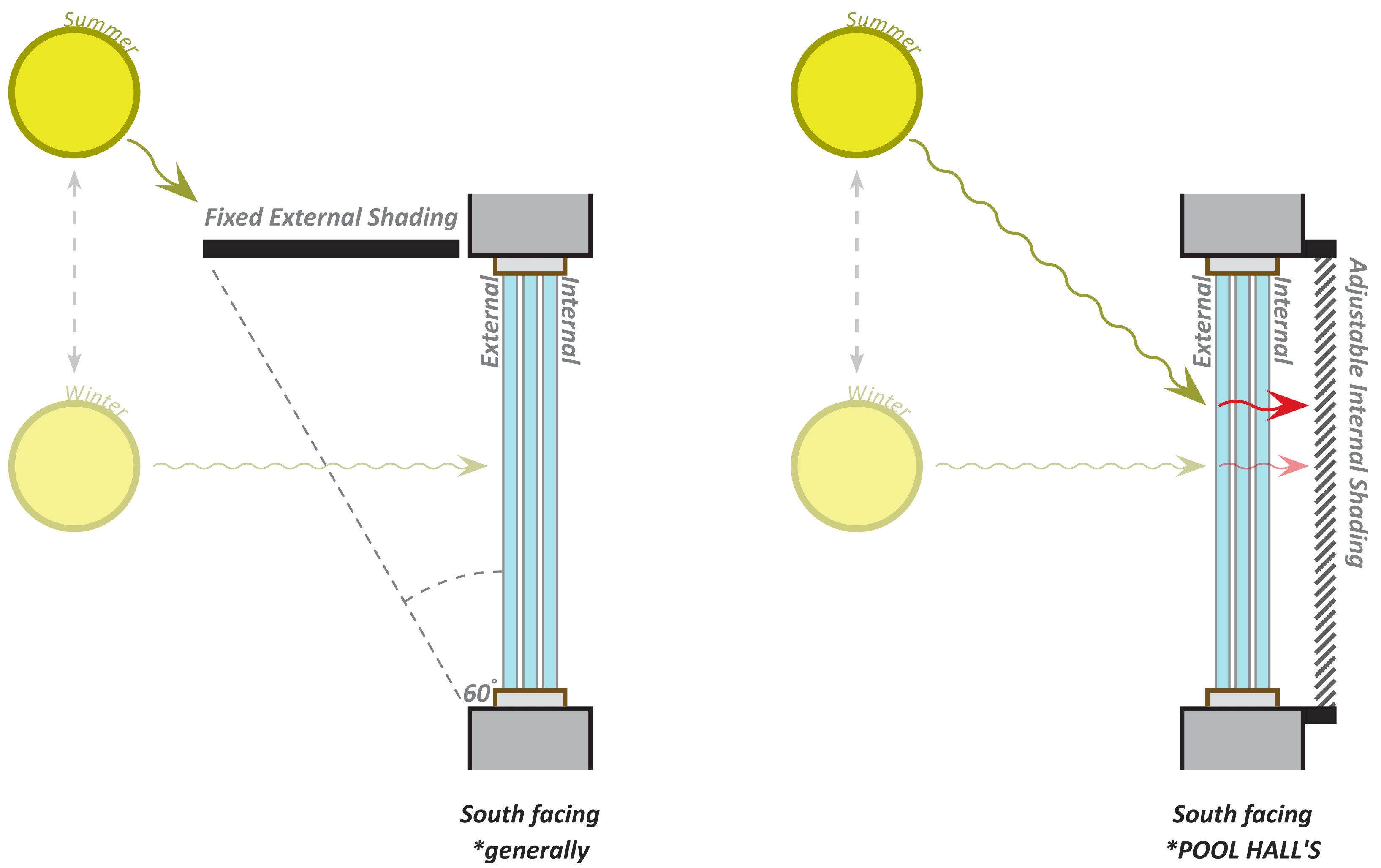
The above ratio is true for typical spaces that have a set temperature range similar to a domestic space. For Sport & Leisure however, it is important to maximise the solar gains in the highest temperature zones such as the *Pool Hall's, to do this it is recommended that adjustable internal shading is used as this maximises the solar gain year round by letting the light (and heat in), while also preventing spectral reflection (glare) on the pool water.

Pool Halls should be orientated towards the south & south-west in the FLCH design where possible, and cooler spaces towards the north & east.

The two main things that effect the amount of solar gain in an internal space are:

- G-value of glass - the percent of heat let through - this will be between 25% and 65% (covered in the nbs specification)
- Shading - internal vs external

**The recommendation for Farnborough generally based on the orientation and internal facilities are recommended here, however at stage 3 there will be a further study on a room by room basis to evaluate the effectiveness of the shading strategy and implications on optimising the solar gain to heat loss ratio*



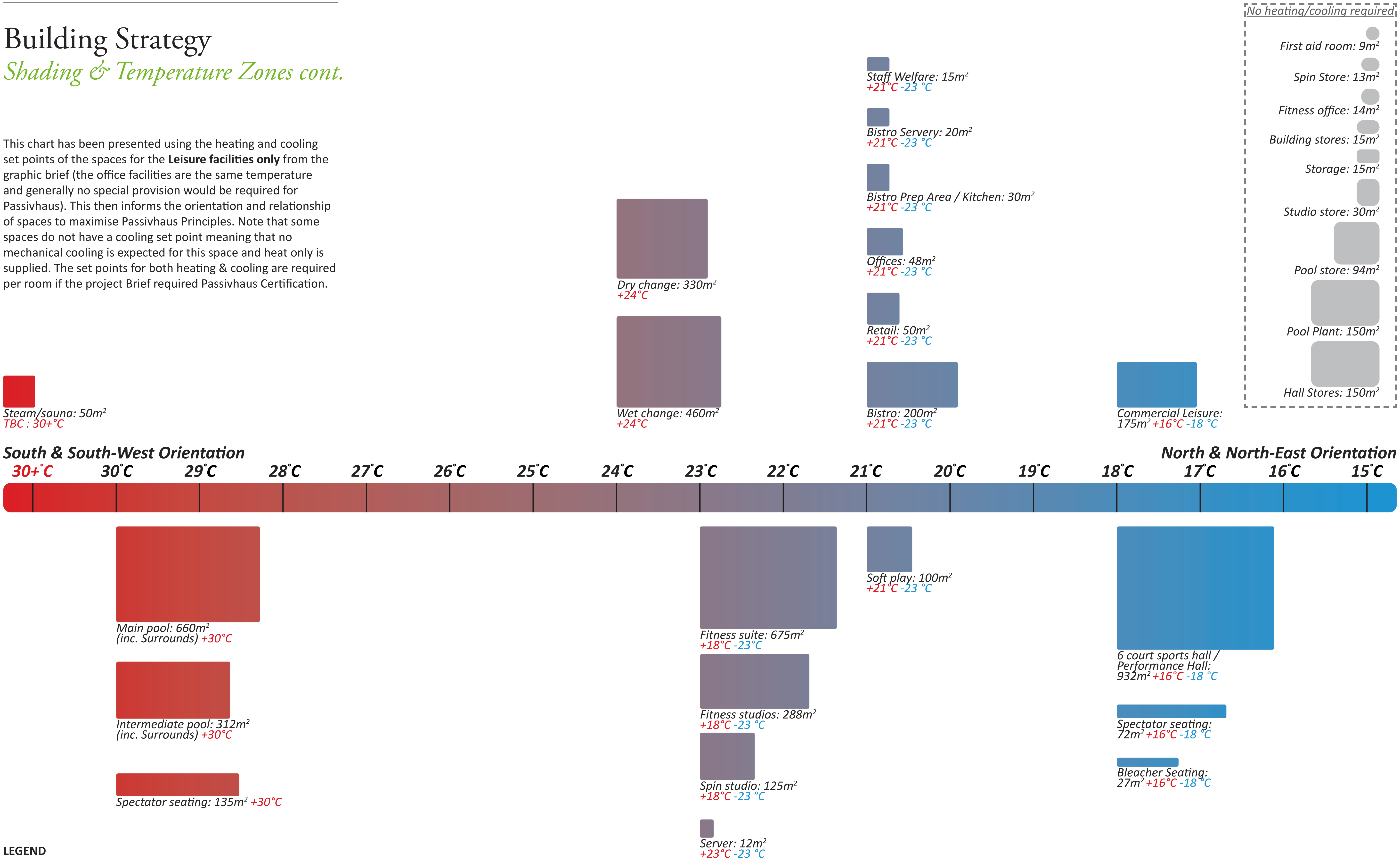
**The current building design is still under design development. During stage 3 (for all options) a further analysis will be done on the shading extents and types, as well as a review of the orientation.*

GT3 ARCHITECTS

Building Strategy

Shading & Temperature Zones cont.

This chart has been presented using the heating and cooling set points of the spaces for the **Leisure facilities only** from the graphic brief (the office facilities are the same temperature and generally no special provision would be required for Passivhaus). This then informs the orientation and relationship of spaces to maximise Passivhaus Principles. Note that some spaces do not have a cooling set point meaning that no mechanical cooling is expected for this space and heat only is supplied. The set points for both heating & cooling are required per room if the project Brief required Passivhaus Certification.



LEGEND

+X°C = Heating Set Point

-X°C = Cooling Set Point

Building Strategy
Filtration, Hot & Cold Water

Our recommendation is to use micro-filtration system for the pool water regardless of the option selected. It is a tried & tested solution both in general projects & in Passivhaus certified Projects, successfully being used in St.sidwells point & Spelthorne Leisure Centre.

One of the primary energy users in any building is the hot and cold water, not only in the volume of the water being used, but also where long runs of pipework pass through cool spaces and lose heat to their surrounding, thus overheating the space.

Additionally in the case of Leisure Centres with water facilities (any type i.e. standard pools, splash water, steam rooms etc), there is a significant amount of energy used to both heat the water required. Further, the evaporation of the water increases the heating demand on the building.

For context, Spelthorne Leisure Centre & St.Sidwells Point (both Passivhaus Project) has almost 35% of the total energy of the building to heat the water and the pools.

BREEAM water category credits address the distribution and usage of domestic. It is then split into 3 sections: domestic water consumption, water metering and further evaluation of other water uses (i.e. pool filtration). By specifying low flow devices with 50% reduction of water use, installing a water meter, and evaluating sand vs micro-filtration, 7/10 credits are achievable in any of the options which is the equivalent of excellent rating for water use as required in the local Plan.

Aside from the volume of water used, hot and cold water distribution and heating should form a key part of the energy strategy. The strategies and suggestions shown here can also be used to address the WAT03 category for BREEAM as above.

The pros vs cons of micro-filtration vs standard sand filtration can be found on the FTLeisure website (manufacturer & consultants). Further information can also be found in the document below. - ftleisure.co.uk/pool-design-and-build/water-technology/ftmicron4-ceramic-membrane-filtration-system/

Design challenges:

- Plantroom space for filters and future replacement.
- Plantroom height, typically 3.5m minimum.
- Logistics/access during install and future maintenance.
- Structural loading – up to 20 tonnes operational weight.
- Drainage systems for backwashing – up to 50ltrs/sec.

Operational challenges:

- Ensuring correct backwash flowrates.
- Manual backwashing and air scouring processes.
- Ensuring PAC dosing system is correct.
- Media replacement every 7-10 years.
- Steel filter shotblasting and relining.
- GRP filter replacement.

Benefits of Micro-filtration for the Building:

- 40% Less plantroom footprint than media bed filters
- Greater flexibility on location of filtration plant
- Only 2.5m plantroom height required
- No backwash attenuation tank required
- Less drainage infrastructure
- Smaller balance tanks for level deck pools
- Less structural load on plantroom slab
- Reduced access requirements
- Lower mains power supply

Benefits for the Operator:

- Up to 40% less absorbed power – as a result of the regular washing process, the friction loss across the membranes is kept to a minimum. Pumps can therefore be designed with as low as 12m head (against 18m head for a media bed filtration system).
- Up to 40% less water – microfiltration removes more particulate than media bed filtration, thereby helping keep TDS levels under control. Microfiltration pools can operate using only 15-20ltrs per bather dilution.
- Less heating and chemicals – the potential to reduce water consumption leads to a reduction in the amount of chemicals and heat load.
- Less operator time – a completely automated and remotely monitored systems. No manual operations.

Building Strategy

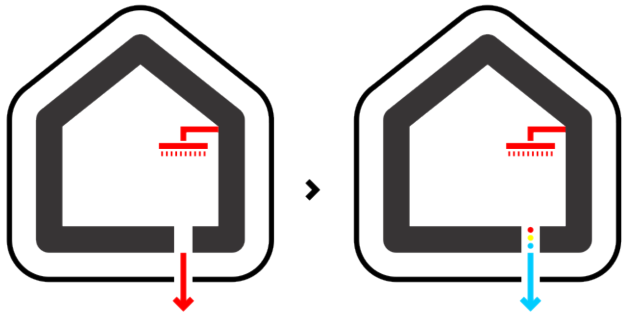
Filtration, Hot & Cold Water Cont.

Significant amounts of water and energy is used (and subsequently wasted) in Leisure Centre Facilities from showering both pre and post swim. This is from water being heated, travellng a long distance through cold zones, coming out of the shower and directly down the drain. A simple rethink of this process can save significant amounts of energy by heating water at the shower, and then recoveing the heat within the drainage channel before existing to drain.

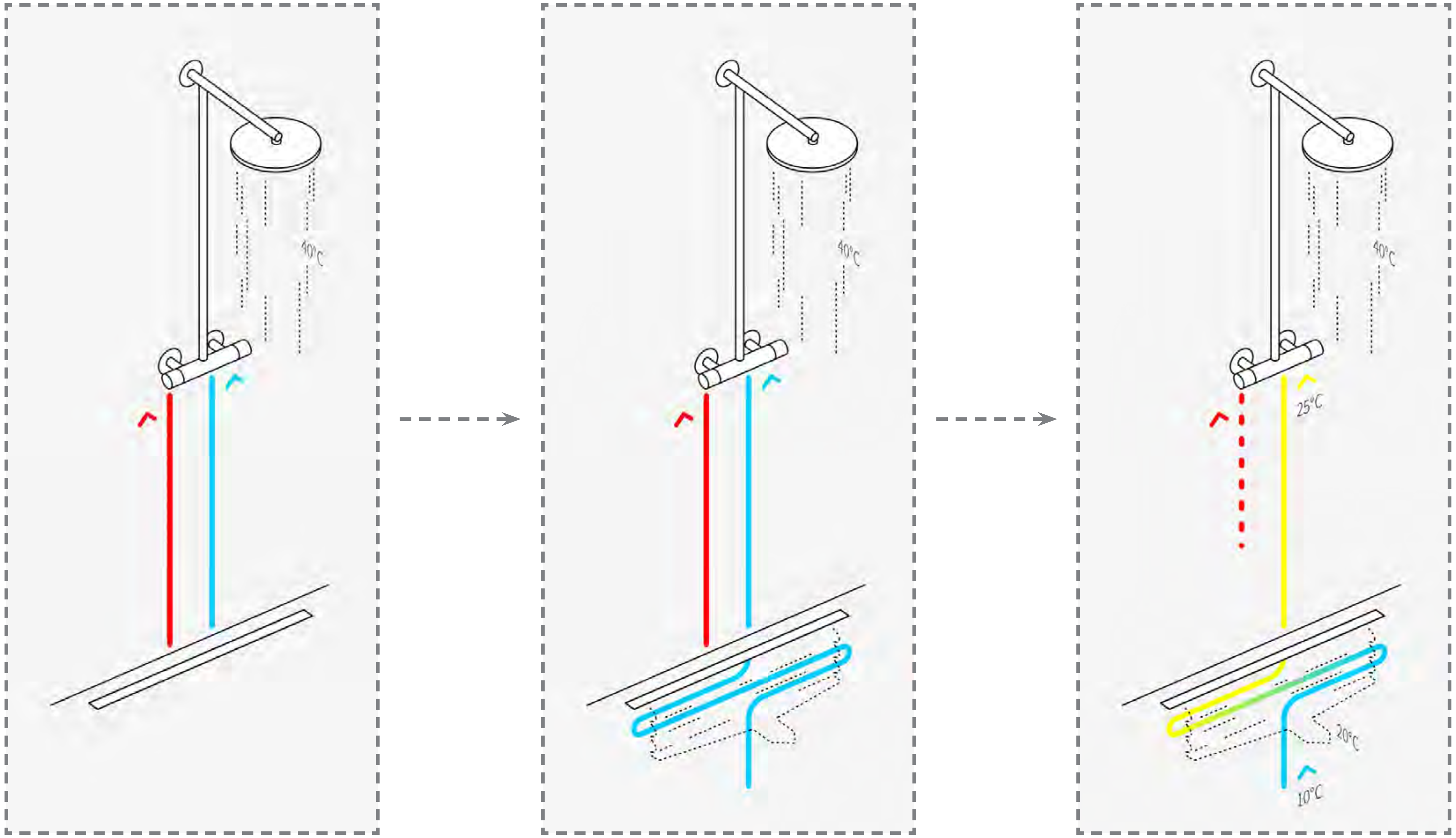
Up to 15% of the overall energy use of a Passivhaus building can be attributed to heating hot water, and in domestic projects can be as much energy as heating the rest of the building. In the case of Leisure Centres, it makes sense to invest in drain heat recovery systems regardless of which Option (A/B/C) if chosen for this project.

There are a number of products on the market that can recover heat from showers, all with varying degrees of efficiency. The Passivhaus Institute actively promote efficiency and have pre-certified a number of products. This means that the efficiency is already calculated so inclusion is straight forward for PH projects. The products can be used on any of the options, the certification simply streamlines the process to Passivhaus Certification.

**Images and information are based on the 'Joulia' product line, which achieves a 60% measured heat recovery rate - https://joulia.com/en/*



'Business As Usual' *Recovered heat*



'Business As Usual'
Hot & Cold water directly connect to the mixing valve, flows out of the shower and directly into the drain

Re-directed water supply
The cold water is redirected through the drainage channel prior to reaching the mixing valve.

Recovered Heat
The hot shower waste water is directed over the cold water, upt o 60% of that heat is extracted and used to warm the new incoming cold water, creating significant savings on hot water heating energy

GT3 ARCHITECTS

5 • Conclusions & Further Information

Conclusions

Summary & key findings

The aim of this report was to establish 3 options for costing and review based on a series of key performance indicators and existing Sport and Leisure performance data.

With a distinct lack of sector specific data regarding embodied carbon and operational carbon limits in Sports & Leisure, the benchmarks set were based on the CIBSE guide F values, Passivhaus and a middle ground (option B).

Once the benchmarks were set, these were then used for the basis of the calculations to identify the below for each option:

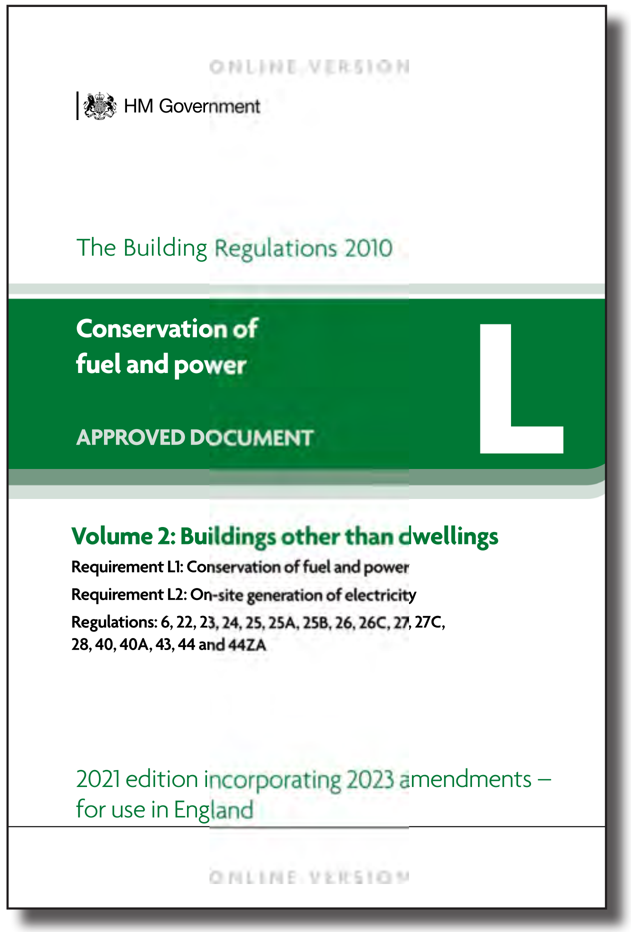
- Capital Cost
- Operational Cost per year
- Lifetime Carbon emissions

These were then used to calculate the relative carbon emissions as well as the payback period. This page summarises the Key findings from this excercise.

Subsequent analysis on the design of Farnborough culture and leisure hub, concluded that should the client wish to pursue full Passivhaus Certification [Option C] as the most ambitious strategy, then this should be achievable.

As such, it is important that the document is reviewed and signed-off by the Client (or their advisors) so that the project team can proceed with confidence into the next stages of the project on the chosen sustainability strategy.

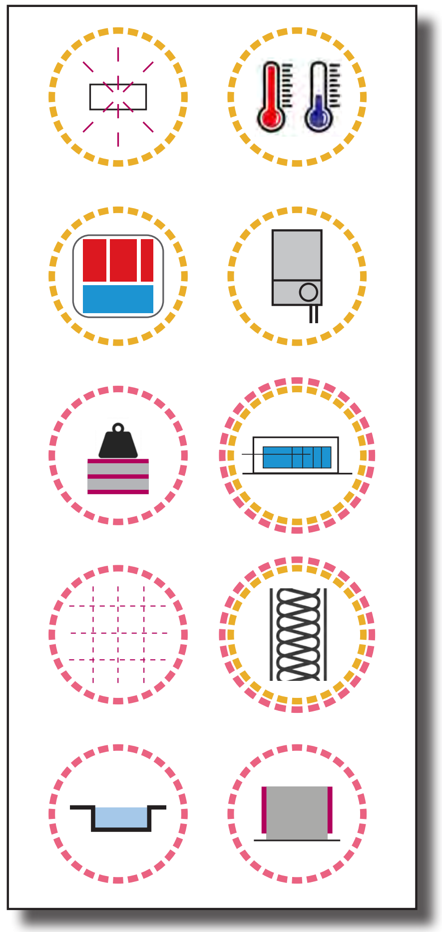
Option A - 'Business As Usual'



*Capital cost = **£49,450,000***
*Operational cost per year = **£1,312,604***
*Lifetime carbon emissions = **142,165.6 Tonnes (CO_2)***

+

Option B - Low carbon / Passive Principles



-47.2%
Lifetime Carbon Emissions

8.24 year payback period

*Capital cost = **£54,855,000** (+10.93%)*
*Operational cost per year = **£656,302** (-50%)*
*Lifetime carbon emissions = **75,062.8 Tonnes (CO_2)***

+

Option C - Full Passivhaus Certification

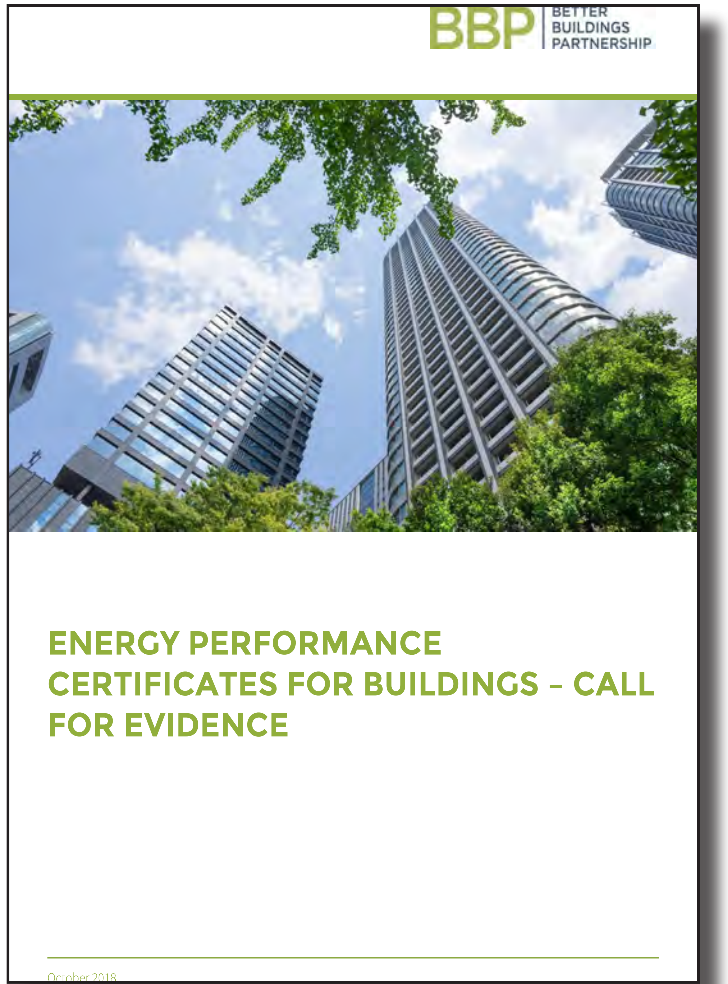
-80.24%
Lifetime Carbon Emissions

7.32 year payback period

*Capital cost = **£57,614,000** (+16.51%)*
*Operational cost per year = **£196,890** (-85%)*
*Lifetime carbon emissions = **28,090.84 Tonnes (CO_2)***

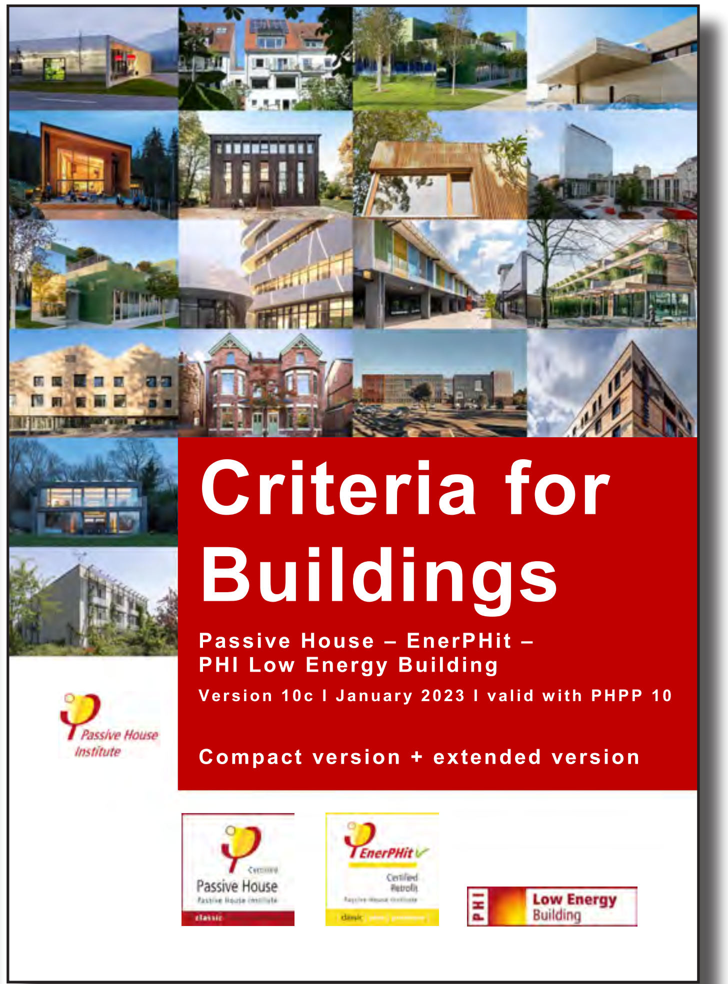
Appendix
Further Reading

The below are a series of useful reads that elaborate further on the wide ranging topics of sustainability and Passivhaus for both clients and contractors. Snippets have been used throughout this report and credited as necessary.

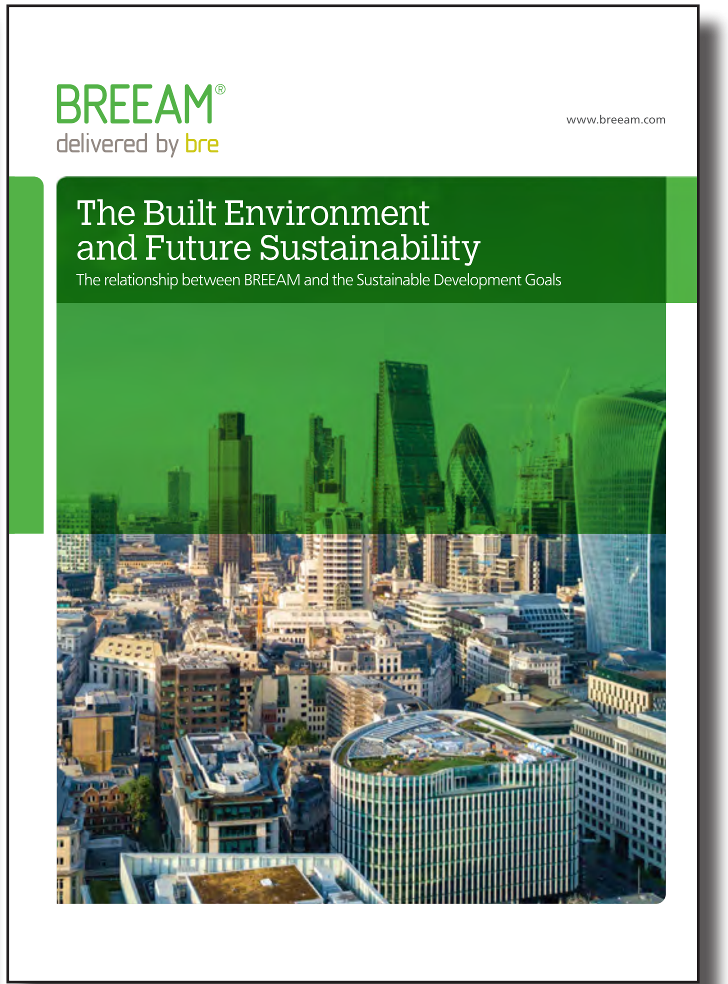


www.betterbuildingspartnership.co.uk/energy-performance-certificates-buildings-%E2%80%93-call-evidence

www.passivhaustrust.org.uk/guidance_detail



www.passiv.de/en/03_certification/02_certification_buildings/08_energy_standards/08_energy_standards



www.bregroup.com/products/breeam/sustainable-development-goals/

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