LETI opinion piece

Whole life carbon - Separate or combined targets?

Dec 2020

Executive summary

We need to consider carbon emissions of the whole life cycle to make sure we are designing, constructing and operating buildings that have low carbon emissions. One approach might be a whole life carbon target in kgCO_2e/m², the other would be to adopt separate, granular targets for Operational Energy and Embodied Carbon. The latter is consistent with the current LETI targets. This paper outlines both of these viewpoints. Firstly, the case for adopting separate metrics for the targets is made. The case for a combined target follows in the second section.

Section A: Whole life carbon: The case for keeping targets separate

This section makes the case to utilise different metrics for operational energy and embodied carbon targets and suggests that LETI should develop the following targets:

→ an operational energy target kWh/m²

→ an upfront embodied carbon target (A1-A5) kg CO_2e/m²

→ a life cycle embodied carbon target (A1-C4 excluding B6 and B7) kg CO_2e/m².

Operational and Embodied Carbon can be brought together and reported in whole life carbon, but there should be no target for this. Within the updated Embodied Carbon Primer a section should be developed that outlines the requirement of calculations that bring together embodied and operational carbon (as outlined in section 4.3 of section A), with guidance provided on what carbon factors to use for this.

Section B: Whole Life Carbon: The case for a combined whole life carbon target

This section makes the case that we must have a single whole life carbon target and that this should be the primary metric in understanding the carbon credentials of a project:

→ Projects should meet a Whole Life Carbon target kgCO_2e/m², (A1-C4) with D separately reported, in addition to the following subsidiary targets:

  → an operational energy target kWh/m2 (B6)

  → a life cycle embodied carbon target (A1-C4 excluding B6, B7) kgCO_2e/m²

  → an upfront embodied carbon target (A1-A5) kg CO_2e/m².

Definitions

Embodied Carbon: Carbon dioxide and other greenhouse gases associated with the following stages:

→ Product: extraction and processing of materials, energy and water consumption used by the factory or in constructing the product or building, and transport of materials and products

→ Construction: building the development

→ Use: maintenance, replacement and emissions associated with refrigerant leakage

→ End of life: demolition, disassembly waste processing and disposal of any parts of product or building and any transportation relating to the above.

Operational Carbon: Carbon dioxide and other greenhouse gases are associated with the operational energy of the building. This includes the emissions associated with heating, hot water, cooling, ventilation, lighting, cooking, equipment and lifts.

Whole Life Carbon (WLC): This includes both embodied and operational carbon as defined above.

Operational Energy: The energy consumption of the building. This includes 'regulated' energy consumption such as heating, hot water, cooling, ventilation and lighting, and 'unregulated' energy consumption such as cooking, equipment and lifts.

Documents that may be useful

→ LETI - Net zero operational carbon one pager
→ LETI - Climate Emergency Design Guide
→ LETI - Embodied Carbon Primer

Section A: Whole life carbon: The case for keeping targets separate

Summary

A key reason for separate targets is that most embodied carbon emissions occur up to the point of construction[1], which means that we can make a good assessment of these emissions for buildings which are designed and constructed now. In contrast, operational emissions will occur over 60 years or more, during which time the carbon intensity of the grid will change considerably and unpredictably. Significant technology changes are likely which will also impact associated carbon emissions. Comparisons between these two calculations are therefore limited in their appropriateness and accuracy. When considering the efficiency of a building, energy demand is a more appropriate metric as there is no confusing secondary factor: a building which is efficient now will still be efficient in 2050.

Best practice voluntary standards, such as the CaGBC zero carbon building standard, use separate metrics for operational carbon and embodied carbon.

Introduction

Currently LETI has Operational Energy targets and an upfront Embodied Carbon target. Throughout the last 3 years LETI has gathered evidence to inform a consensus that meeting Operational Zero Carbon relates to meeting energy targets, rather than carbon reduction targets as per current regulations.

In January LETI published upfront embodied carbon target (A1-A5), mainly so that people could have a target to comment on and measure their designs against.

What is required from a metric and a target?

→ A metric that is simple and understandable. Professionals at various levels of skill can use the metric to help inform their design

→ Is directly related to the design of the building - for which the design team and developers have direct control

→ A target that is future proofed, as milestones change, the target can be updated

Summary of why targets should be kept separate

1. **Converting energy to carbon in future scenarios is subject to risk/uncertainty:** There is no industry consensus on how this is calculated, even if there were consensus this is likely to change continuously over the next ten years. We cannot predict exactly how the carbon intensity of the grid will vary hour to hour, year to year over the next 60 years. In contrast, a 1kW heat source used for 1 hour, will use 1kWh now and in 2050. Operational efficiency should thus be tracked in energy, not carbon, and not mixed with embodied emissions which will mostly be calculated using today's carbon factors.
2. **Incorrect trade-offs:** A combined target starts to encourage trade-offs between operational energy and embodied carbon. Care must be taken when these calculations are made. If done incorrectly this could lead to decisions actually resulting in greater emissions and this hinders rather than moves us towards meeting the climate emergency. A combined target muddies the waters rather than creating clarity.

3. **Levels of certainty:** There are different level of certainty to each element of a Whole Life Carbon calculation. Decisions based on adding together elements with different levels of certainty are likely to lead to misleading outcomes.
4. **Consistency helps bed in messaging:** Last year LETI published operational energy targets and upfront embodied carbon target, since then the numeracy in the industry of what 'good looks like' surrounding operational energy and upfront embodied carbon has increased, but time is still required for these to bed-in.
5. **Keeping things simple** allows more people, with different skill sets, to engage.
6. **Keeping metrics separate and granular is more future proof:** Currently the metric that is used to define buildings with low embodied carbon is $kgCO_2e/m^2$. With operational energy, we have seen a switch in the last few years from carbon being used as the primary metric to energy and with good reasons, based on finite renewable capacity and simple to use metrics. It may be that in the future different metrics are more relevant for embodied carbon.

Getting into the details

This section outlines some of the relevant background information.

Operational Carbon

Net Zero carbon means meeting an energy budget

→ The carbon emissions associated with Operational Energy[2] depend on the electrical demand of the building and the carbon intensity of the electricity grid at the time when the electricity is used

→ The carbon intensity of the UK electricity grid in turn depends on the kW capacity of renewables and the amount of energy required by the UK

→ The National Grid has published Future Energy Scenarios for zero emissions energy[3], which are reliant on a reduction in total national energy use. These scenarios indicate a finite amount of renewable energy available in the UK[4]

→ Thus in order to have a decarbonised grid that aligned with zero carbon there is a fixed UK energy budget in $kWh/m^2/yr$

→ From this total renewable energy budget, energy budgets per building type have been established: see the LETI Climate Emergency Design Guide Chapter 1.

→ Exceeding this budget would mean the use of fossil fuels to produce the excess energy, which would increase the carbon factor of the electricity grid

→ The grid also has a finite peak load capacity. Energy-hungry buildings with poor fabric performance are likely to require heating and hot water loads at similar times and thus, when the peak load capacity is exceeded then the electricity consumed by the building will have to be generated using fossil fuels, regardless of whether there is theoretically enough renewable energy available over the course of a year

→ We therefore need to work in terms of both energy (kWh) and load (kW) to ensure that our buildings can achieve net zero – this subtlety would be missed if we were to work only in carbon.

A decarbonised grid means buildings need to be 'energy flexible' and have low peak demand

→ In the past, the majority of electricity was generated through burning gas or coal, this means that when more electricity is needed, more fossil fuels could be burnt to provide this electricity, the supply of electricity can match the demand

→ With a future fully decarbonised grid that is powered by renewables, (solar, wind, tidal, wave) the energy supply is inherently intermittent. The amount of electricity is governed by how much the sun is shining, whether it is windy etc.

→ This means our future grid will need to have more storage capacity in order to deal with the peaks and troughs. However, storage is expensive (both financially and in terms of Embodied Carbon) and the greater the peaks and troughs, the more storage we will need

- → Even in 20 years' time, with a near 100% renewable grid, if a building requires heat, and there is no renewable electricity left and the storage is exhausted, it is likely that a gas turbine will need to be switched on to supply the electricity required
- → What is important is not just how much electricity is used but when it is use. Buildings that have less demand on the grid and are flexible to when they require energy will help the grid to be able to decarbonise. Reducing energy demand is a key part of the National Grid's zero carbon Future Energy Scenarios
- → This thinking is why the LETI Climate Emergency Design Guide set recommend space heating peak consumption at 10 W/m^2 and why LETI is looking to develop Demand response KPI's
- → The variability of the UK grid carbon factors over the course of the day and year are shown in Appendix 1
- → Achieving low Operational Carbon is not just about meeting an annual energy consumption budget, but also about whether the building can choose to draw its energy at different times during the day/year whilst still meeting the needs of its occupants
- → Current assumptions of grid carbon treat all renewables as zero carbon – but hydro, PV, nuclear, wind, biomass and tidal all have embodied impacts, and potentially operational impacts (e.g. methane emissions from hydro) which although small in the context of fossil fuels, have relevant impacts that need to be considered. A decarbonised grid will not be zero Whole Life Carbon.

Translating operational energy to carbon is variable

Options for carbon factors used in B6

Converting Operational Energy to carbon seems simple, for example in current Building Regulations Operational Energy is just multiplied by a static carbon factor. There are many different carbon factors that could be used, a few are outlined below:

- → Carbon factors used in Building Regulations (0.519 kg CO_2/kWh)
- → SAP 10.0 carbon factors – used for GLA energy assessments (0.216 kg CO_2/kWh)
- → **SAP 10.1 carbon factors (0.136 kg CO_2/kWh)**
- → **Lifetime average carbon factors based on a decarbonising grid (0.054 kg CO_2/kWh)**
- → If the building does not have a PPA or use a green tariff then the residual grid carbon factor should be used – the UK's 2019/20 residual fuel mix factor was of 0.348 kgCO_2e/kWh – this is compared to the location-based grid average factor of 0.233kgCO_2e/kWh
- → A dynamic carbon factor - that takes into account when throughout the day and year the energy is used - see Appendix 1 for the current variability of the UK grid carbon factors over the course of the day and year
- → **A stepped carbon factor that assumes if the energy budgets are not met, a gas turbine is used to generate the residual electricity requirements**
- → A carbon factor that somehow rewards energy flexibility.

A worked example is shown in Appendix 2 that shows the impact of the different carbon factors.

As part of the consultation there is a question on carbon factors, where respondents can give their views in what they think is most appropriate.

Electricity grid carbon factors are also used to estimate the operational energy used as part of replacement of materials and products in Stage B and C.

When adding together embodied and operational carbon, the carbon factors relating to energy use should be the same – but currently this is not possible. In most life cycle calculations, the embodied carbon of a product is the same whether it is installed when the building is first constructed or 40 years after it has been constructed. It is assumed that the carbon emissions associated with raw material extraction and energy consumption by the factory is the same, no matter when the product is manufactured. This means that the grid is assumed not to decarbonise within the Embodied Carbon calculation piece of the life cycle calculation.

When combining Embodied Carbon and Operational Carbon, the same assumptions on grid decarbonisation should be made. For B6 - Operational Energy - it makes sense to use assumptions for a decarbonised grid, otherwise Operational Carbon is overestimated. But if you were to use a decarbonised grid for the replacement of product in Stage B, this would be difficult as EPDs and other databases don't currently contain this information.[5] This discrepancy adds another layer of complexity to the decision around carbon factors.

Additionally, renewable energy supply is likely to be key for allowing these stages to decarbonise in the future, and exceeding EUIs (energy budgets) in buildings will not allow this process to happen.

Whilst grid decarbonisation is one aspect of the transition to net zero, it is highly likely that there will be other predicted changes in the UK over a normal building's life cycle. These include improved energy efficiency in industry, increased use of thermal energy from renewables or hydrogen in industry, improved recycling rates and increased use of recycled content. There are also predicted to be significant changes in production techniques to enable reduced carbon. However, the rate at which these changes will be made, and how significant they will be is much less predictable than for electricity. There is also no unified source providing this data for all construction products. Allowing Operational Energy to show the benefit of reduced emissions, whilst limiting the ability of materials to show their reduced emissions in the gate to grave stages will create an imbalance in whole life carbon assessment between operational and embodied emissions.

Allowing materials to show the benefits of future changes will introduce huge uncertainty and greenwash into assessments.

Trade-offs between embodied carbon and operational carbon

A combined target starts to encourage trade-offs between operational energy and embodied carbon. Care must be taken when this is done, if done incorrectly this could lead to decisions that hinder, rather than move towards, meeting climate emergency targets.

If calculations are carried out to interrogate the additional embodied carbon emissions due to an enhanced building fabric or more efficient systems, the following must be ensured:

→ Energy consumption figure must originate from in-use energy data or predicted energy modelling[6] (not from Part L calculations) – i.e. a measured or predicated performance gap should be included

→ An appropriate carbon factor must be used and should be the same for all life cycle stages

→ The carbon factor might be different in the scenarios based on the amount of energy used or the peak energy consumption

→ Takes account of the benefits of Demand Response or energy flexibility measures - this could include reduced peak demand as buildings with a high performing fabric can keep stable temperatures for longer, without the need for heat input - see Appendix 3 for diagrams.

→ The increase of embodied carbon of energy infrastructure for options with higher energy consumption and consideration of how energy outside of renewable budgets is produced. Energy infrastructure has a high embodied carbon content and is rarely taken into account in options assessments. In effect, a relevant share of the additional Embodied Carbon arising from additional storage capacity required in the grid should be allocated back to the building's Embodied Carbon

→ The calculation should be subject to sensitivity testing based on different building lifetimes to illustrate how this will affect the final outcome. In reality, we have little idea how long a building will be used for and thus we should not be making decisions based on a single arbitrary number.

Embodied and operational carbon design decisions are often aligned.

The table below outlines typical factors which reduce Embodied Carbon and demonstrates that these measures typically align with Operational Energy savings. With our current knowledge our position is that potential trade-offs are only relevant for a few design decisions.

Measure	Embodied Carbon	Operational Energy
Improve form factor	👍	👍
Increase insulation*	👎	👍
Optimise facade window size/area	👍	👍
Improve cross ventilation – opening windows	-	👍
Introduce shading / solar blinds	👎	👍
Mechanical Ventilation and Heat Recovery	👎	👍
Improve airtightness	-	👍
Reduce number of thermal bridges	👍	👍
Use of lower embodied carbon cladding	👍	-
Timber partitions in place of steel studs	👍	👍
Offsite construction	👍	👍
No plasterboard / internal finishes	👍	-
High cement replacement concrete	👍	-
Wood fibre insulation instead of PIR	👍	-
Heat source from ASHP/GSHP	-	👍

*The building services equipment relating to heating are smaller, this reduces the embodied carbon of the building services and the building footprint required to store them.

Skills gap

→ Most built environment professionals have skills in either Operational Energy/ Operational Carbon (typically the MEP / Energy Consultant) or Embodied Carbon (typically the Architect) in greater details. Few understand both in sufficient detail.

→ There is generally more literacy in Operational Energy than Embodied Carbon. There is not currently a body accrediting degrees where embodied carbon is taught. We have not yet fully formed the first generation of graduates who are Embodied Carbon literate and most are self-taught

→ There are complexities in bringing together operational and embodied carbon as outlined in this paper

→ When Operational Carbon and Embodied Carbon are brought together by a specialist in Operational Energy, the scope of the various elements of Embodied Carbon are not necessarily fully understood, nor is the requirement for maintenance and replacement cycles

→ When Operational Carbon and Embodied Carbon are brought together, Operational Carbon is often under-represented. Energy consumption from building regulations calculations might be used, which typically vastly underestimate energy consumption. The calculation may also assume that the electricity grid is decarbonised no matter how much energy the building needs

→ Keeping targets separate allows for non-experts to fully engage and the analysis usefully steer the direction of the project

Future casting

Right now there is consensus that a building that achieves operational zero carbon meets a certain energy budget (along with other requirements) – the metric that industry uses is energy (previously carbon was used, which was problematic as described above).

For Embodied Carbon, a carbon metric is clearly a useful indicator, for now at least. It may be that this metric changes in the future, to embodied energy, or quantum of materials, or might include a factor that brings on board Circular Economy principles.

Section B: The case for a combined Whole Life Carbon target

Summary

The built environment industry is starting to respond much more to the climate crisis and to that end the issue of measurement, assessment and targets has come to the fore. This section makes the case for a single clear carbon target for each building type. The case for separate targets which are on the one hand KWh/m² and on the other $KgCO_2e/m^2$ is confusing and makes it very difficult to compare the performance of two similar buildings. If Building A performs better than Building B in KWh/m² but Building B performs better than Building A in $KgCO_2e/m^2$, which is the better performing building? With separate reporting and targets there is no clear answer.

The above case for separate reporting/targets states that "Operational and embodied carbon can be brought together and expressed in whole life carbon, but there should be no target for this." The question is why not? If they can be brought together then why no target? The reasons given are essentially to do with technical complexity. We need to look at the bigger picture, and that benefits of a single Whole Life Carbon reporting figures and targets makes sense for a number of reasons outlined below and is where we need to get to.

Consistency with international and UK national practice

The United Nations (Paris 2015), the Intergovernmental Panel for Climate Change (Report 2018), the Climate Change Committee (various, e.g. Letter to prime Minister May 2020), the Office for National Statistics (definition for 'Net Zero'), the Institute for Government (re UK Net Zero Target 2019) etc., all mention 'Net Zero' as referring to 'Greenhouse Gas emissions' (i.e. CO_2e or 'Carbon' for short) as the metric that relates directly to Climate Change. kWh is mentioned but overwhelmingly it is GHG (i.e. CO_2e) that is the currency of climate change. Conversations with the likes of the Environment Agency show that there is a concern over silo'd reporting which is effectively what separate targets is, and they are keen for it all to be 'pulled together' into a total cradle to cradle approach. We have no alternative but to be consistent with this.

Simplicity of reporting

Reporting the carbon footprint of a building is much simpler and clearer as a single figure, that aligns with International Practice. Reporting the two separately using different metrics is highly confusing. If you are reporting the carbon performance of a building as a single figure in $kgCO_2e$ that is clear, simple and comparable. Reporting partially in $kgCO_2e$ and partially in kWh does not give you a basis for overall comparison between buildings. If one building is high in $kgCO_2e$, and low in kWh, how do you compare it with another building (or design option) that is low in $KgCO_2e$ and high in kWh? Which is the better performing building? It is not possible to say with split reporting. All other building metrics; construction cost, rent, value, GIA, NIA, N/G etc. can be reported as a single figure with associated targets.

Speaking one language

A continuing problem for clients, consultants, local authorities etc. is that currently there are two different languages being spoken with respect to measurable environmental performance and buildings, and consequently there is no effective 'joined up thinking' with respect to energy and carbon. Architects and structural engineers tend to operate from a materials perspective ie $kgCO_2e/m^2$, whereas environmental engineers tend to operate in kWh/m2. These must be brought together to achieve the most environmentally efficient outcomes. Building designers need to know both the embodied and the operational costs and benefits of a given design solution as a single comparable figure. Without this is not possible to properly evaluate a given 'fabric first' design solution. To do this we need the operational performance, the embodied performance and the life expectancy (replacement carbon) all to be considered together. To do this effectively kWh/m2 has to be translated into $KgCO_2e/m^2$ so that the GHG impacts of design options can be properly compared.

Credibility

The way we report the climate change impact of buildings needs to be straightforward, clear and simple to ensure credibility at all levels, whether it be between consultants, to clients or to government. Split reporting and separate targets using different metrics is fundamentally muddled and confusing, and this undermines credibility.

Complexities

The case for separate reporting and targets outlines a range of issues that explain how difficult this is. We have no choice but to move to single figure reporting, and that to a degree the 'complexities' are overstated, and if they are not, then they really need to be simplified and urgently. The LETI Climate Emergency Design Guide already has a definition for operational carbon in $kgCO_2e$, and therefore if that is possible then, as the currency is the same for embodied carbon, these two must be capable of being combined into single figure reporting and a combined target. Building designers need to be able to make decisions with the understanding of the full carbon impacts of what they are doing at the point of design. If you are comparing the carbon performance of brick built cooling towers (as in Haworth Tompkins Everyman Theatre) with central plant, from both an energy use and embodied carbon perspective you need a common language as in a single combined figure metric for each option, otherwise you cannot make a meaningful comparison and informed design decision. Separate figures are not helpful. To progress to much lower carbon buildings this sort of design information is vital. 'Lower carbon' buildings need to be lower in all respects and for this a single combined figure is essential.

The skills gap has been mentioned above, but this shouldn't be reason for not doing things correctly, we all have to upskill. This is something increasing numbers of architects are becoming aware of. In the case for separate targets above, the following statements have been made to which I attach responses:

→ *"the carbon intensity of the grid will change considerably, but perhaps unpredictably. We are also likely to see significant changes in technology which will impact the amount of carbon associated with operational use".*

This statement also applies to all of Modules B, C and D. If taken literally it would mean that we would cease to project any carbon emissions past practical completion which I don't believe is the intent. Future modelling has to be based on what we know today. It is perfectly possible to make sensible assumptions today as to what the decarbonisation of the grid is likely to be sufficient to enable WLC future modelling and the design comparisons described above.

→ *"When considering the efficiency of a building, energy demand is far more appropriate metric as, regardless of carbon factors or heat pump COPs, a building which is efficient now, will still be efficient in 2050."*

Energy efficient and carbon efficient are not the same thing. From a climatic perspective it is important for a building to be carbon efficient over its life that matters not whether it is energy efficient.

→ *"A combined target starts to encourage trade-offs between operational energy and embodied carbon. Care must be taken when this is done, if done incorrectly this could lead to decisions that hinder rather than move towards meeting the climate emergency"*

Agreed that care must be taken, however if trade-offs make sense from a whole life carbon perspective then why not? What we want to achieve is the most carbon efficient buildings over the entire life cycle.

The climate energy and targets

It is generally agreed that we need to have made significant reductions by 2030. Many, particularly large, schemes take many years to complete. Therefore, schemes starting today, should already today be aiming to meet the sort of targets that LETI and the RIBA 2030 Challenge are identifying for 2030, i.e. when they are complete. The climate emergency therefore means we do not have the luxury of waiting until the detailed issues referred to in this paper are fully resolved. That is why we need to get on with this, and produce simple, clear whole life carbon targets as a matter of urgency.

Section B conclusion

Therefore, if we want to make an impact on the climate crisis, be consistent with international and government policy and have credibility at a wider level with clients and Government we need to urgently resolve the issues outlined in the paper above, the climate impacts of buildings holistically as a single straightforward figure. Not to do so means that the built environment industry will be talking to others and each other in two languages that are not joined up, whilst everyone else will be talking about GHG/Carbon. We don't really have a choice, and whatever the problems, we must resolve them and get to a combined, simple, single reporting figure for every building.

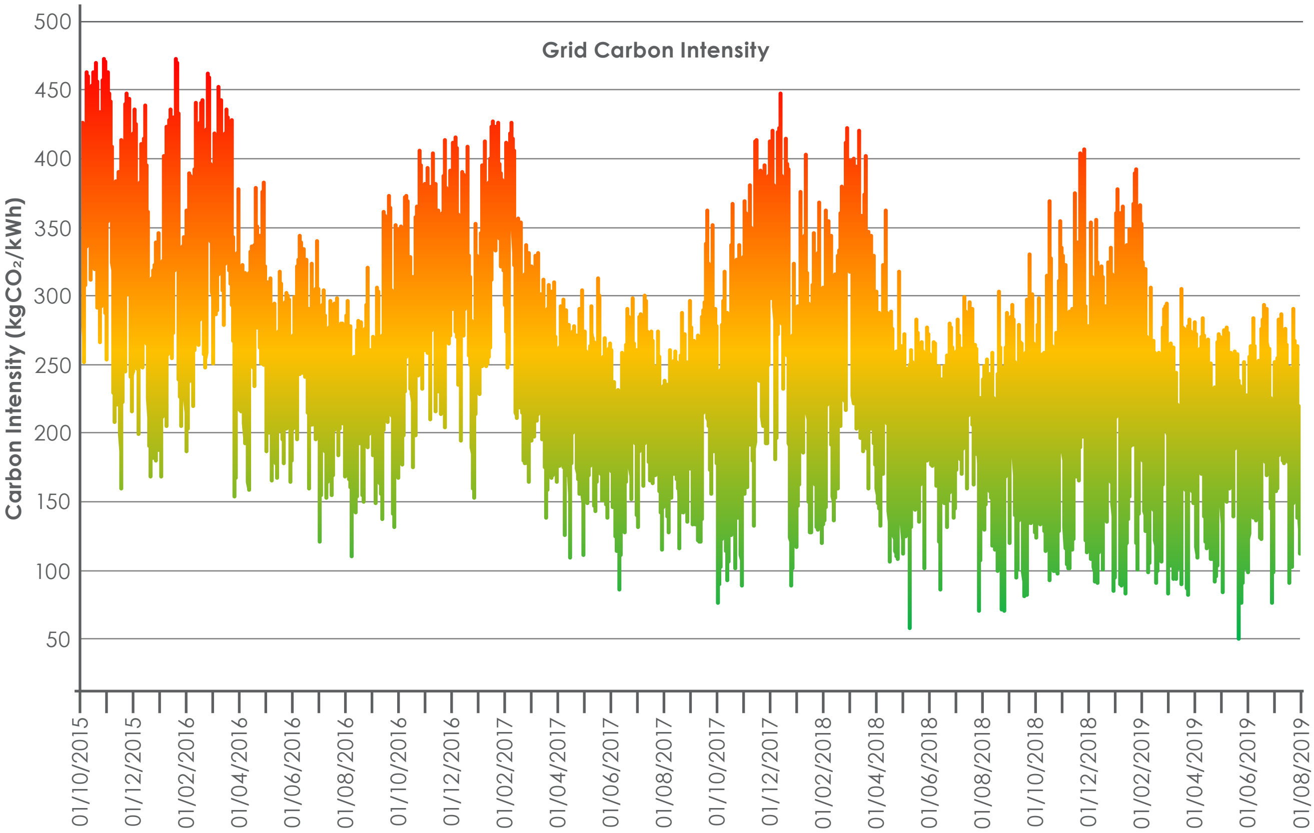
Conclusion

Section A made the case to utilise different metrics for Operational Energy and Embodied Carbon targets. This section stated that Operational and Embodied Carbon can be brought together and reported in Whole Life Carbon, but there should be no target for this.

In contrast, Section B argued that we must have a single Whole Life Carbon target and that this should be the primary metric in understanding the carbon credentials of a project.

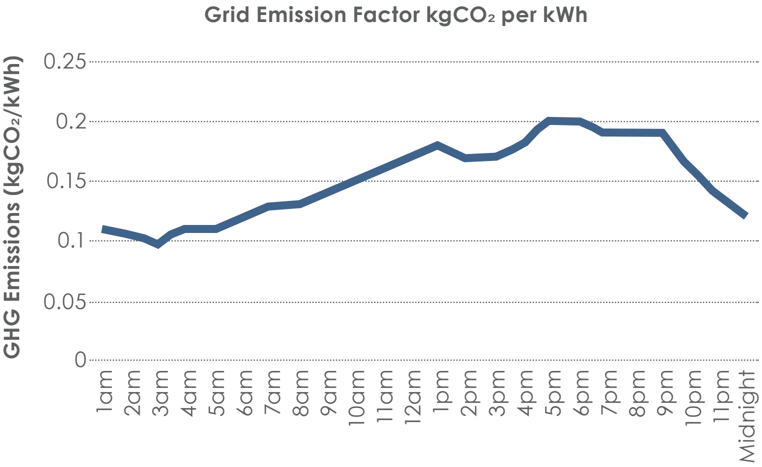
Both sections recognise the complexities and uncertainties of converting the energy use of a building into carbon emissions within a Whole Life Carbon Assessment. There is therefore a need to develop and test methodologies for this conversion. A LETI workstream is currently looking to develop these methodologies.

Appendix 1:
Grid Carbon intensity variations



Variation in the UK grid electricity carbon intensity in 2019, the carbon intensity of the electricity on the grid varied from 50 gCO2e to 400gCO2e per kWh.
Source: WSP using a combination of Elexon data and other sources for solar.

The graph shows how the grid varies over a typical summer day. Solar electricity generation during the middle of the day can reduce the emission factor. In the evening the peak is caused by additional demand met by fossil fuels. There is around two fold variation over the day varying from 100g CO2e per kWh up to 200g CO2e per kWh.



Source: WSP using a combination of Elexon data and other sources for solar.

Appendix 2:
A worked example

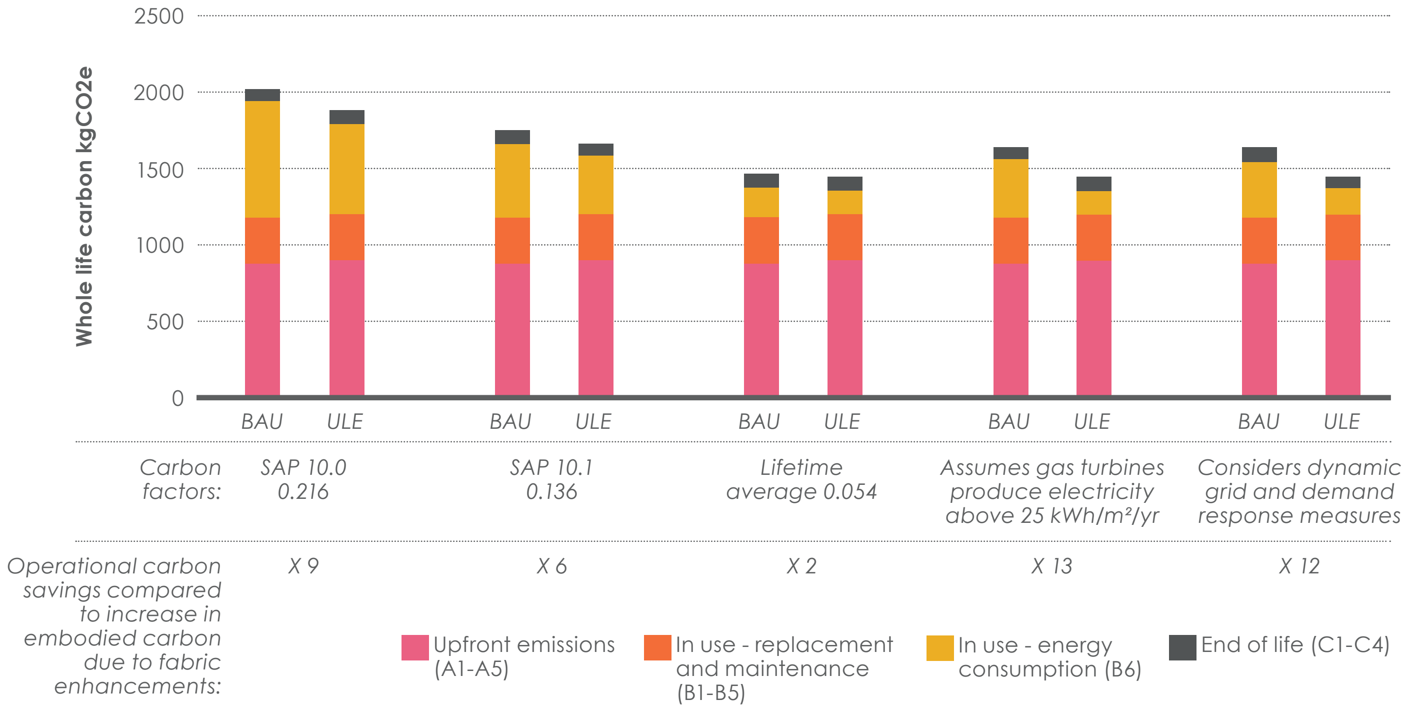
A whole life carbon calculation was carried out for a residential development in London. The embodied carbon calculation was carried out aligning with RICS methodology and the predicted energy consumption was calculated using PHPP. Two options were tested - one with Business as usual fabric (BAU) and with ultra- low energy fabric (ULE) in both cases individual heat pumps were assumed for each flat to provide heating and hot water. The diagram below shows the estimated whole life carbon emissions with a variety of carbon factors used in the calculation of B6.

The table below shows that although the difference in EUI is relatively small (20%), the difference in space heating demand and heating load is much greater. If flat rate carbon factors are used to assess the difference between the two options the nuances of demand response and ability of the building to help the grid decarbonise will not be taken into account.

	BAU	**ULE**
Space heating demand kWh/m²/yr	30	11
EUI kWh/m²/yr	43	34
Heating load W/m²	22.1	11

In addition, if decisions on building fabric performance are made on whole life carbon, what carbon factors are used greatly affect the results, and thus potentially the design decision outcome. Due to the increase in insulation requirements and triple glazed windows, the embodied carbon was slightly increased, and the operational carbon emissions is reduced in the ULE option. Depending on the carbon factor used the saving in operational carbon due to the enhanced fabric is between 2-13 times the additional embodied carbon.[7] This shows that carbon factors used B6 greatly effects the trade-off between operational and embodied carbon.

Whole life carbon - depending on the carbon factors used



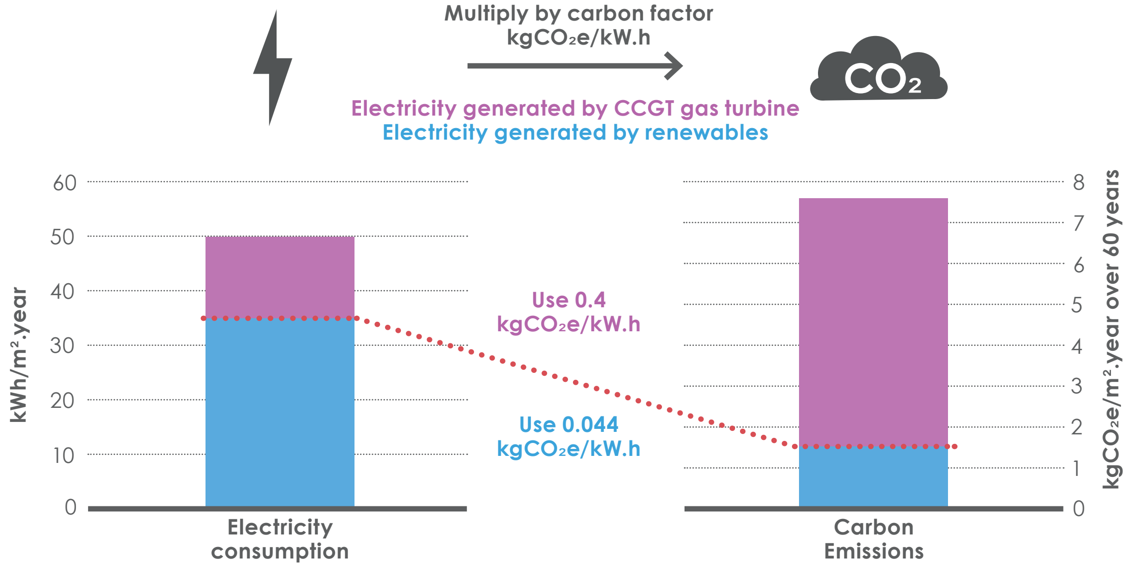
Details on consultation question relating to carbon factors

As part of the consultation we are asking a question on which carbon factors you think should be used when reporting Whole Life Carbon.

This section provides a little more detail on the options provided

1. SAP 10.1: A flat rate carbon factor using SAP 10.1 carbon factors (0.136 kg CO2/kWh)
2. Lifetime average: A flat rate carbon factor using a lifetime carbon factor of around 0.054 kg CO2/ kWh[8]
3. A stepped carbon factor: that uses the average lifetime carbon factor, for energy consumption within the zero carbon energy budget as set out in the operational zero carbon one pager. For any energy consumed above the EUI target a carbon factor equivalent to equivalent to electricity produced by a gas turbine in used (0.35 kg CO2/ kWh). This is based on the fact that the UK grid can only decarbonise if all building meet the zero carbon energy budget
4. I don't know/ I don't have an opinion

Worked example of option 3



Appendix 3: Demand Response

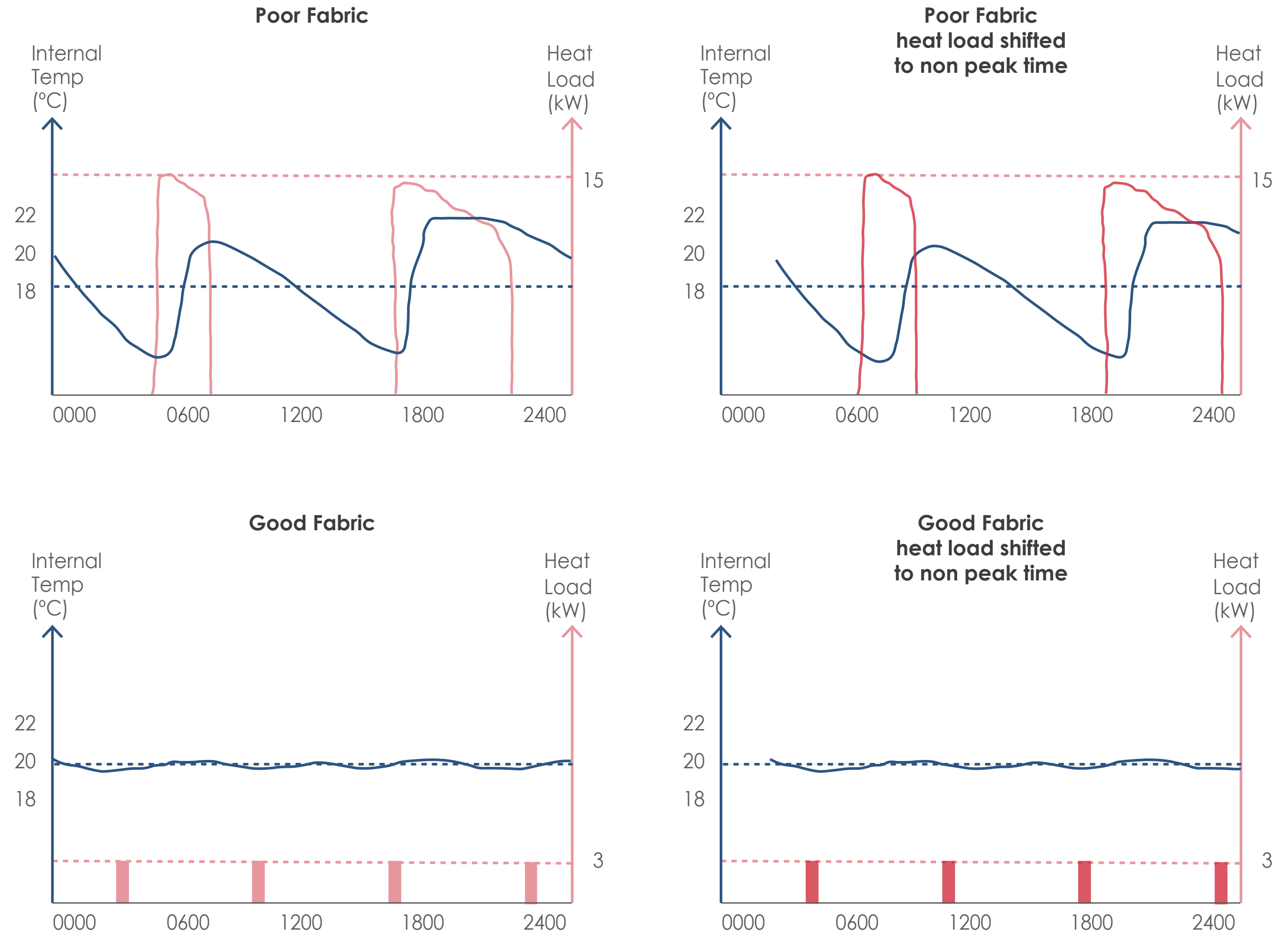
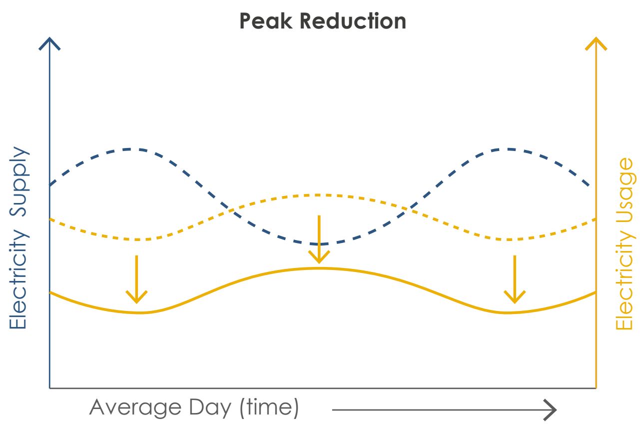
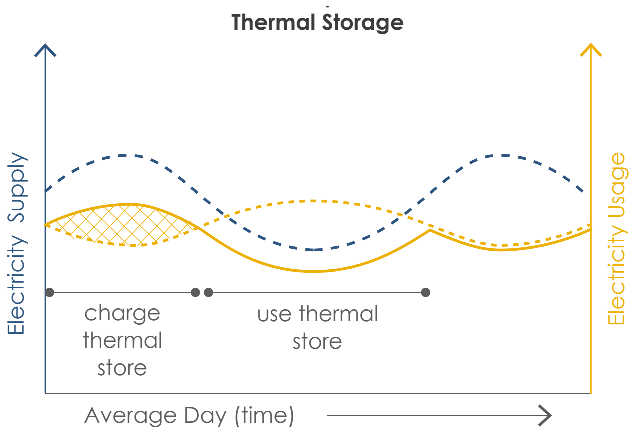


Figure 4.2 The impact that a thermally efficient fabric has on reducing the peak heating load for an example day.





Notes and references:

[1] With the exception of timber, where the A:C share is more towards 50:50 depending on the end-of-life scenario

[2] For a building that only uses electricity for heating, hot water and cooking. If a building uses gas, then the operational carbon is the sum of the operational carbon due to electricity and the operational carbon due to the gas consumption.

[3] https://www.nationalgrideso.com/document/173821/download

[4] Whilst the renewable energy capacity is potentially very large, the rate at which renewable energy production can be scaled up is limited by time, cost, management, land area and development permissions. The embodied carbon emissions of this infrastructure is relatively unknown, but likely to be high as it is typically constructed from metal, plastic and concrete.

[5] It's also important to bear in mind where products are manufactured. Supply chains tend to follow cheap labour, this is one of the main reasons lots of products are manufactured in China. Africa is said to be the manufacturing continent of the future, and currently has a high carbon electricity grid.

[6] Predicted energy modelling can be carried out using CIBSE TM54 or using software such as PHPP.

[7] This does not account properly the benefits of Demand response or energy flexibility measures, the increase of embodied carbon of energy infrastructure for options with higher energy consumption and it should be noted that carbon factors are not consistent across life cycle stages.

[8] Source: https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal

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