THE FUTURE OF BUILDING ACOUSTICS IN A ZERO CARBON WORLD

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1 INTRODUCTION

In the world of acoustics, we look at the sound within a building and are often bound by standards and guidelines whether mandatory or advisory. Whilst these guidelines provide a concise steer on the acoustic performance requirements, they may not initially appear to offer the flexibility to allow us to directly reduce the carbon footprint of a building. And more often than not, we don't get engaged until the fundamental concept design has progressed past a position where it would be too late to make suggestions – for example, the early choice of building using cross laminated timber or concrete and steel structures.

However, there are still wide-ranging opportunities to integrate acoustics into zero carbon design. This paper presents a number of case studies of how acoustics design can support and influence zero carbon design, including:

- early engagement for acoustic performance expectations.
- defining acoustics targets into zero carbon design pathways.
- selection of products and materials.
- carbon and acoustic comparison of partitions; and
- environmental product declarations (EPD) in practice.

This paper is not intended as a complete solution to the climate change emergency, but rather as a compendium of how acoustics design can be integrated into zero carbon design.

2 BACKGROUND

2.1 Why zero carbon?

To minimise the risk of catastrophic climate change, the average global temperature rise must be kept to below 1.5°C in line with the Paris Agreement. According to the Intergovernmental Panel for Climate Change (IPCC)[1], the world has to take significant action to drastically reduce Greenhouse Gas (GHG) emissions by 2030 to avoid crossing this threshold. If we do not, the effects of this global heating will be dangerous, costly and irreversible.

Around the world, government, investors, agencies and communities are calling for stronger action on climate change in all sectors. The buildings sector has a very large carbon footprint when indirect emissions are accounted for. About 9% of global energy-related CO2 emissions result from the use of fossil fuels in buildings, another 18% come from the generation of electricity and heat used in buildings, and an additional 10% is related to the manufacturing of construction materials.[2]

2.2 What is zero carbon?

There are many definitions, standards and rating certifications for zero carbon buildings globally. These define which GHG emissions to include (Scope 1, 2 and 3), at what stage of the building life cycle (e.g. construction and/or operation) and how they are dealt with (e.g. targets, renewables, offsets). The typical GHG emissions that are associated with the construction and operation of buildings is shown in Figure 1.

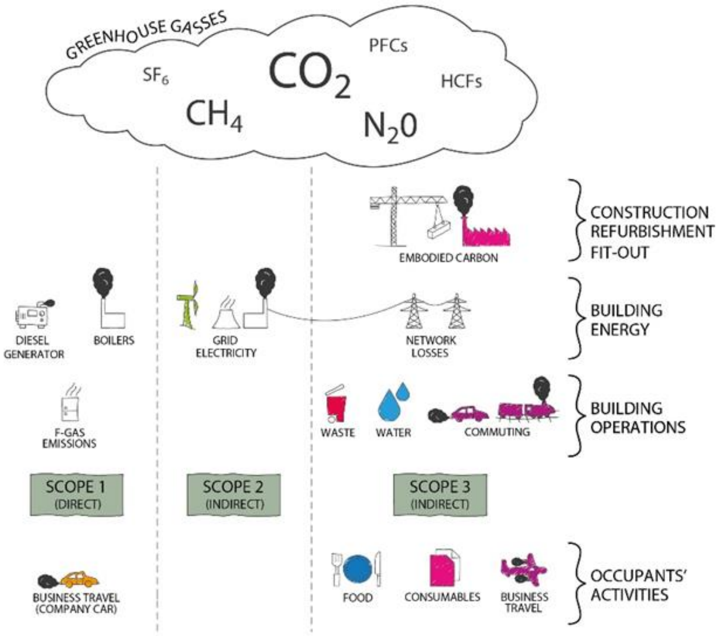


Figure 1: GHG emissions typically associated with the construction and operation of buildings (source: What Colour Is Your Building?[3])

2.3 Early engagement for acoustic performance expectations

Early engagement for acoustic performance expectations is essential to ensure a successful design outcome that aligns with intended usage, meets standards, avoids costly retrofits, and creates a positive experience for occupants.

Throughout an acoustic design project, we can aim to lower the upfront embodied carbon associated with the development by means promoting best construction techniques to maximise the potential for the acoustic design. This is in lieu of over-engineered solutions and proposing certified low carbon products/materials and engage the supply chain.

Where we are not directly involved with the construction and/or finalised fit-out of a space (e.g. where this is subject to contractor build or tenant fit-outs), we fully encourage others responsible for the acoustic design to adopt a similar approach, and we welcome feedback on its implementation for future projects.

One of the first steps to formalise this engagement is by contributing to, and preparing , a zero carbon design pathway for a project. An example case study of this methodology is subsequently presented in Section 3.

3 CASE STUDY 1: DEFINING ACOUSTICS TARGETS INTO ZERO CARBON DESIGN PATHWAYS

3.1 Project description

The project is a new multi-storey data centre in London (details confidential). The acoustics scope included site acoustic surveys, definition of noise emission limits for operational and emergency plant to comply with local authority requirements, 3-dimensional modelling of the proposed plant installations, and design of acoustic mitigation measures to comply with limiting criteria.

As part of the initial design process and engagement with the client we prepared a potential pathway to deliver a climate positive building through design, construction and operation. Main tasks included:

- Setting out the key steps to decarbonising the building, including potential energy and embodied carbon targets for consideration by the multi-disciplinary project team.
- Describing how we propose to contribute towards achieving the targets including key initiatives to consider and implement.

This pathway does not aim to provide a new definition of zero carbon. Instead, it sets out the steps to identify and then reduce the primary GHG emissions during the design, construction and operation of buildings. The pathway focuses primarily on eliminating fossil fuels in buildings, reducing operational energy consumption, supplying energy from renewable sources and reducing upfront embodied carbon as these are all strongly influenced by decisions taken during design and construction.

3.2 Steps to zero carbon

The steps to zero carbon table are provided to assist teams in communicating key issues and potential targets for energy consumption and embodied carbon. There is no standard way of achieving net zero carbon and some strategies to reduce operational energy represent high embodied carbon and as such their implementation should be carefully considered.

Table 1 sets out the steps to delivering a zero carbon building, with suggested targets to set the level of ambition and monitor progress at each step. Additionally, it identifies key actions to address at each step and who in the project team typically has primary responsibility for these.

Step to (net) zero carbon	**Key Actions**	**Primary Responsibility**
Defining targets Define emissions for energy use and upfront embodied carbon prior to zero carbon strategy.	Establish Carbon Footprint (Scope 1, 2 and 3 GHG emissions) for construction and operation Set energy consumption and embodied carbon targets (including occupants/tenants)	Client Whole project team
Fossil fuel free Eliminate natural gas infrastructure. Aim to eliminate other fossil fuel sources as soon as possible.	Prepare all-electric design solutions and consult with tenants for gas free retail and commercial kitchens. Develop strategies to eliminate gas for any other specialist uses. Prepare strategies to avoid/minimise diesel for generators and fire pumps.	Mechanical Electrical Public Health / Hydraulics
Reduce energy use Significantly reduce all building energy consumption through passive design, demand reduction, energy efficiency and effective controls.	Demand – reduce through passive design and design brief criteria. Efficiency – select efficient technologies and combinations of systems. Control – controls, metering, commissioning and fine tuning to turn systems off or down to match user needs.	Architect Building Services Specialists
Power by renewables Aim to provide all electricity from 100% renewable sources – on-site and/or off-site.	Maximise renewable energy generation on site. Maximise use of on-site renewable energy and support grid stability including energy storage All grid electricity, including for tenants, from 100% renewable energy sources (preferably new sources)	Architect Electrical Building Owner / Facility Manager

Step to (net) zero carbon	**Key Actions**	**Primary Responsibility**
Lower upfront embodied carbon Significantly reduce embodied carbon through design, construction activities and material/product selection.	Reduce embodied carbon by design (material types, efficient design, design out waste, etc) Select certified low carbon products/materials and engage the supply chain. Provide support for low carbon fit-outs and refurbishments.	Architect Structural Civil MEP
Reduce other GHG emissions Aim to eliminate or reduce other GHG emission sources within the carbon footprint.	Select low GWP refrigerants Prepare design strategies to minimise GHG emissions due to operational waste, travel and in-use embodied carbon (refurb, maintenance, etc)	Mechanical Architect Transport Consultant Specialists
Offset residual emissions Procure nature based carbon offsets for all remaining GHG emissions, in construction and in operation.	Prepare an offset procurement strategy including certification levels, sequestration versus mitigation offset projects, and environmental and social co-benefits.	Developer (embodied) Building Owner (operational)

Table 1: Steps to Zero Carbon

3.3 Acoustics zero carbon strategy

By carrying out the Steps to Zero Carbon process we can readily identify where the acoustics discipline can interject. In the case of this data centre design project, the stage for communicating issues and potential targets for embodied carbon related to acoustics is during the '*Reduce other GHG emissions - Aim to eliminate or reduce other GHG emission sources within the carbon footprint'* step.

The pathway will inform our design going forward with regard to opportunities to reduce carbon as part of the acoustic design. The status of each initiative at the time of issuing this pathway document is also defined:

- Evaluate – to be further tested with the project team before a decision is made.
- Included – already included in our design solution.
- Future Proof – not adopted but provision in the design will be made to allow simpler installation / adoption in the future.
- Not Adopted – the initiative will not be included in the design due to project constraints.

Table 2 below describes the specific acoustics initiatives we propose to explore and/or deliver in collaboration with the project team to support achieving the steps and targets described in Table 1. This is not a design report or return brief stating what will be included in the project – it is an opportunity to describe what the opportunities are for further discussion with the client.

Step	**Initiative**	**Impact / Benefit**	**Status**
Reduce other GHG emissions	Evaluate equipment selections and layouts to optimise selections/layout to reduce the amount of additional noise control required.	A more efficient design leads to lower embodied carbon.	Evaluate
Reduce other GHG emissions	Review acoustic mitigation selections (louvres, barriers, attenuators, etc) from various suppliers, compare use of recycled/recyclable materials, embodied carbon data, etc.	Lower upfront embodied carbon.	Evaluate

Table 2: Acoustics zero carbon initiatives

This Zero Carbon Design Pathway is provided to promote discussion on the potential to deliver a zero carbon building. We proposed the next steps as:

- Meeting with the client to discuss the pathway and whether to pursue the targets and opportunities identified;
- If agreed, facilitate a workshop with the project team to update the Zero Carbon Pathway and incorporate the targets into the project; and
- Through the normal design process, implement the initiatives necessary with respect to the targets.

4 CASE STUDY 2: SELECTION OF PRODUCTS AND MATERIALS

4.1 Project description

The Isaacs Building is a multi-tenanted office building in Sheffield city centre, comprising basement, ground and seven upper levels. The building had just been refurbished to Cat A fit-out and a Cat B fit-out on the three upper floor our client is intending to occupy.

4.2 Stage 3 acoustic design considerations

During RIBA Stage 3 of the fit-out, we considered the following with respect to reducing upfront embodied carbon of the fit-out scheme:

- The sound insulation requirements between adjacent spaces have been carefully considered so as not to be over-engineering separating partitions.
- The build-up of internal dry-wall partitions have been rationalised to suit specific acoustic requirements and save of plasterboard and mineral wool insulation where available.
- Mineral wool insulation above perforated ceiling voids can be omitted from the design. This is a potential saving of over 750 kg of CO2eq.
- Up to 94m^2 acoustic wall treatments can be omitted from cellular spaces. This is a potential saving of approximately 800 kg CO2eq (excluding transportation).
- Consideration of low carbon products where additional treatments have been proposed, e.g. acoustic soffit spray is ~ 2.7 kg CO2eq per m^2 compared to ~4.5 kg CO2eq per m^2 for a perforated plasterboard ceiling with mineral wool insulation over or ~6.4 kg CO2eq per m^2 for a mineral wool based proprietary acoustic raft (figures for A1-A3 production stage only).

Assessments were undertaken of acoustic materials within the design and their associated embodied carbon values, based on proposed area coverages in the building and either carbon data quoted in EPD documents provided by the manufacturer or for similar material types.

Further commentary was also provided on other factors relevant to sustainability considerations, such as lifecycle stages for which EPD data was applicable, the presence of hazardous materials, and its recycled/recyclable content.

Table 3 presents example calculations for a selection of the design’s proposed acoustic materials. The results of the assessment along with commentary on individual products EPD information availability were provided to the architect as to calculate the overall embodied carbon of the project and contextualise the selection of acoustic related materials.

Product	Use	Area	kgCO2eq	total kg CO2	Lifecycle Stage
Mineral Wool[4]	Above suspended ceilings	223	3.46	772	A1-A5
Autex Cube[5]	Acoustic Wall finish 1	24	6.49	156	A1-A3
Acoustic soffit spray[6]	Level 7 soffit	29	2.70	78	A1-A3
Perforated Plasterboard[4,7]	Ceilings - including mineral wool	1	5.66	6	A1-A5
Acoustic Rafts[8]	Ceiling absorption	1	6.4	6	A1-A3
Woodwool[9]	Alternative Wall panels	93	-198.00	-368.28	A1-A3

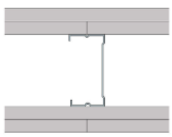
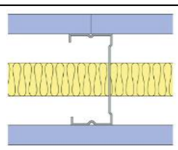
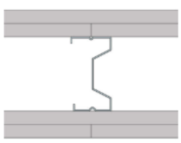
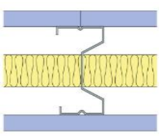
Table 3: Acoustics zero carbon initiatives

4.3 Further opportunities to reduce embodied carbon

4.3.1 Carbon and acoustic comparison of partitions

During the construction stages, the build-up of internal dry-wall partitions could be further rationalised to reduce or omit mineral wool insulation within the cavities. (Note: acoustic performance is not the only factor in dictating the configuration of a wall, and other considerations (e.g structural, thermal, fire, etc.) need to be factored into the design)

Table 4 presents a review of a selection of typical drywall options with weighted airborne sound reduction index performances of 45 to 50 dB R_w. The estimated embodied carbon for each partition configuration indicates that a 3 dB increase in acoustic performance could equate to approximately a 10% increase in the embodied carbon.

Partition type (British Gypsum reference[10])		Sound Insulation Rating, dB R_w	Embodied Carbon, GWP kgCO2eq			
			Board elements	Insulation elements	Metal elements	Total
A206015		45	170	0	58	**229**
A206197		47	141	37	58	**237**
A206A015		47	170	0	68	**238**
A206A302		48	141	37	68	**246**

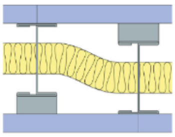
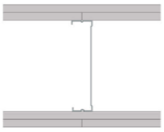
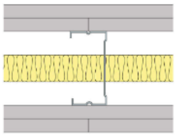
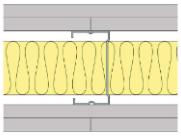
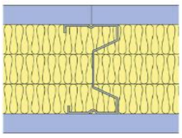
Partition type (British Gypsum reference[10])		Sound Insulation Rating, dB R_w	Embodied Carbon, GWP kgCO2eq			
			Board elements	Insulation elements	Metal elements	Total
A233001		49	141	37	70	**248**
A206027		50	170	0	88	**258**
A206047		49	170	37	58	**266**
A206142		50	170	63	58	**292**
A206A252		50	141	111	68	**320**

Table 4: Embodied carbon of 45 to 50 dB R_w partitions

Second to the fundamental plasterboard elements of a drywall system, the embodied carbon of mineral wool type products is likely to be significant contributor to the overall partition. A better, lower embodied carbon solution may be to suggest an alternative stud arrangement or deeper cavity rather than to fill the cavity with mineral wool. It is therefore vital that these assessments take place during the design process and with frequent engagement with the design team to investigate potential lower carbon solutions that still achieve the intended outcomes.

4.3.2 Environmental product declarations in practice

EPDs and quoted embodied carbon metrics provide a means to quantifiable assessments, although care should be taken in relying on these as the sole means of informing zero carbon strategies. A number of considerations with regards the use of EPDs relevant to acoustics are discussed below:

Where mineral wool insulation is included in partitions or voids for acoustic absorption, it could be possible to substitute this for natural alternatives (including sheep's wool, hemp or other plant based wools) which would significantly reduce the embodied carbon. However, in some cases, such as sheep's wool, the production is directly integrated with other livestock factors such as meat production and land grazing, such that product specific EPDs are not readily available. In these instances, the context of material usages and its non-quantifiable features (e.g. regenerative natural materials, ethical treatment of livestock) should be factored into a qualitative assessment.

Many of the proposed acoustic wall finishes in Table 3 are based on recycled PET materials and have a relatively low embodied carbon value during the production stage, compared to mineral wool based products. If EPD data only specifies 'Cradle to Gate' figures, they will therefore clearly show significantly lower credentials. Therefore, additional consideration must be given to the geographical region of manufacture and any additional carbon emissions associated with onward distribution to the project location.

Consideration can also be given to the use of wood-wool based (e.g Baux) acoustic panels which can have a negative embodied carbon due to sequestration of carbon dioxide during wood growth, although if higher acoustic performances are reliant on mineral wool backings this can offset the benefits.

For all products, often their raw materials are manufactured in one geographical region and then transported for manufacture in another, before being transported elsewhere for distribution to the market. Hence post-production/transportation embodied carbon can potentially off-set the production benefits. This is entirely dependent on the scale of production and transport methods; products manufactured in bulk and shipped across continents may have a different carbon per unit compared to smaller scale deliveries over vastly shorter distances made by road (which may rely on electric or fossil fuel vehicles, which will also result in different associated carbon values).

In all cases, care must be taken when reviewing EPD data, particularly as to the basis of the embodied carbon calculations which are often dictated by the extent to which a manufacturer has control or influence of the production lifecycle.

5 CONCLUSIONS

Many suppliers are already on board with the net zero journey and are looking at ways to reduce the carbon impact of their products. The faster the world of acoustic consultants can promote lower carbon options, the sooner manufacturers will need to act and develop new, innovative materials. There are a number of new acoustic products coming to market with sustainability as a forefront design principle. Examples including Sisalwool (an alternative to mineral wool for insulation made from a blend of recycled wool (from the Harris Tweed and English carpet making industries) and recycled sisal fibre (from coffee sacks which are sourced from coffee roasters) and EcoBoard (a sustainable construction board made from 100% post-consumer waste - specifically composite cardboard ‘Tetra Pak’ - which is a difficult -to-recycle material and has a strong mechanical fastening).

There is optimism for achieving net zero carbon emissions which have gained significant momentum as societies and industries unite in the urgent pursuit of a sustainable future. This ambitious goal reflects a shared commitment to curbing the adverse effects of climate change and transitioning towards cleaner energy sources and more efficient technologies.

6 REFERENCES

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