Building Acoustics Group

Sustainable Building Acoustic Design – A Practical Framework (Jan 2024)

This document is published in draft form for consultation and the contents may be developed further in future updates. The advice contained within the latest published version should always be used.

Introduction and Purpose

Intent of this Document

In 2022 the UK's built environment is responsible for 25% of the UK's greenhouse gas emissions[1], compared with UN figures released at COP27 indicating 37% globally[2]. The UKGBC report 'Net Zero Whole Life Carbon Roadmap' 2021 confirms that net zero is achievable for the built environment sector by 2050 by only with urgent Government action"[3]. Acousticians must contribute to this with urgency and this paper sets out a framework for how.

The IOA code of conduct also places an expectation on members at A2.1 to 'act in the principles of sustainability'. As specialist engineers, academics, manufacturers, and consulting professionals, those acousticians involved in the design of the built environment ~~with regards to acoustics~~ and specification of materials have a unique opportunity to influence many other sectors and aspects of the build environment. These professionals often work across all of the mainstream aspects of structural design, mechanical-electrical-and-plumbing engineering (*MEP*), architecture and environmental design.

The purpose of this paper is to provide some practical and pragmatic means by which acoustics professionals can contribute through research, practical implementation, or the provision of materials with the right information to producing multi-faceted and regenerative acoustic designs, solutions, and strategies for the built environment fit to tackle the climate crisis and deliver sustainable design in practice. The most pressing and urgent issue with regards the climate crisis is around carbon, and so this paper focusses significantly on the reduction of carbon through design, although it should be recognised that true sustainability considers a much wider array of issues including matters around social equity and economic prosperity, alongside environmental quality (which is impacted by carbon). Future thinking and versions of guidance should seek to expand and broaden the area of focus, particularly once net zero carbon designs have become standard in the built environment.

[1] https://committees.parliament.uk/committee/62/environmental-audit-committee/news/171103/emissions-must-be-reduced-in-the-construction-of-buildings-if-the-uk-is-to-meet-net-zero-mps-warn/

[2] https://www.unep.org/news-and-stories/press-release/co2-emissions-buildings-and-construction-hit-new-high-leaving-sector

[3] https://ukgbc.org/news/new-report-confirms-that-net-zero-is-achievable-for-the-built-environment-sector-by-2050-but-only-with-urgent-government-action/

Intent:

'Even a net zero building is not sustainable unless its design, and operational use delivers on its intended outcomes, over its lifecycle. Getting the acoustics right is an important part of achieving this for users of that built environment, with the aim being the optimised building environment should deliver more than the minimum of sustainability. In this way it becomes regenerative, supporting enhancement of all life and restoration of it through its use'.[4]

Engineers Declare Position Statement

Engineers Declare is a global petition uniting all strands of the built environment engineering profession. It is both a public declaration of our planet's environmental crises and a commitment to take positive action in response to climate breakdown and biodiversity collapse. The position statement produced by Engineers Declare in 2019, and linked to Built Environment declare representing the broad spectrum of built environment professions and academics is as relevant to acoustics professionals as anyone else who provides engineering consultancy on, conducts research on, or manufactures products to be used in the built environment.

We know that we have just over a decade to address these global emergencies, or we risk catastrophic damage to the natural world. Yet as the earth's life support systems come under increasing threat, the scale and intensity of urban development, construction, infrastructure, transportation, manufacturing and energy production globally continues to expand, resulting in greater greenhouse gas generation and loss of habitat each year.

For everyone working in the field of engineering, meeting the needs of our societies without breaching the earth's ecological boundaries will demand a paradigm shift in our behaviour. If we are to reduce and eventually reverse the environmental damage we are causing, we will need to re-imagine our work as indivisible components of a larger, constantly regenerating and self-sustaining system.

Such a transformation cannot happen without a wide-ranging declaration of intent, followed by committed action, international cooperation, and open-source knowledge sharing. A united declaration will support more effective lobbying of policy makers and governments to show leadership and commit resources. The next few years will be decisive in shaping our collective future - now is the moment to act.

[4] Rogers, P – IOA Sustainability Lead

Role of Acoustics Professionals

As with many of the specialist engineering and consulting professions many acoustics engineers and consultants typically work in advisory or consulting roles. In these roles, acousticians often provide advice which is adopted into formal design documentation produced by others (i.e. detailed, dimensioned drawings or formal specifications) and are rarely involved in making a final product or material selection. They may also not currently be involved early enough in a project to be able to influence certainly fundamental things like layout or energy strategy.

It is acknowledged that this can result in a feeling of less direct responsibility for individual elements, or strategic direction of the design, but the overall reach and opportunity to enable sustainable thinking to permeate all aspects of building design and the wider environment is a valuable opportunity that is open to acousticians and should not be underestimated. In considering the carbon and climate related outcomes in the strategic acoustic design, the downstream installation can be significantly altered for the better, as well as making sure the embodied energy in the structure and operational energy use is optimised through acoustic design interventions. It should be remembered that beyond carbon there are many ways an acoustician can influence a design positively from the materials used to the design for wellbeing and biodiversity revival. These areas present chances for design innovation and creativity as part of the overall solution in ways that can be qualified.

Within the built environment, progress against assessing carbon has been made where significant quantities of embodied or operational carbon are associated with a single, simple product or strategy (e.g. understanding of embodied carbon "CO2e" in concrete compared with. steel or timber for instance; or the carbon burden of natural VS mechanical ventilation). Many of the products or strategies associated with the building acoustics industry are more complex and are represented by inter-dependent systems with many components or material types (for example a lightweight partition which might include gypsum, metalwork and mineral fibre insulation).

This inevitably means that the understanding of the impacts of various sustainable choices and approaches around building acoustics are still under development, and the acoustician can be a part of an accelerated evolution. It is beyond the scope of this document to be able to contain all of the answers or provide detailed design strategies. Instead, the aim is to outline a simple method for approaching acoustic design in a carbon/climate-and-planet-conscious manner.

Acknowledgements

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Client, Project and Financial Demands vs Sustainability

Theoretically a professional involved in the industry could research every material mentioned or specified in a design. They could do a full lifecycle analysis, consider where it was manufactured, how far it travelled, how long it lasts, its recyclability, etc. The reality is often that the time available, related to the commercial position of a consultant, designer, or manufacturer means that it is extremely difficult to tackle all of these issues, on every project. It is possible to have enough awareness to flag the general direction and the need for this to be done by the design team. Reference to the Engineers Declare position statement means the time has passed where it is reasonable to accept that designing with sustainability in mind is too difficult, expensive or complicated. Acousticians need to work with other disciplines to strive to achieve this goal.

Buildings being designed now will become operational at a time when the UK needs to be nearing net zero, so the time horizon is now upon us. With Whole Life-Carbon in mind whilst some clients, customers etc. may see the sustainable options as more costly and a luxury that can be overlooked on their project (e.g. in terms of cost or performance), all professionals engaged in the built environment have a responsibility to attempt to inform, encourage and educate clients and collaborators about the need for action and ways to achieve this in the build environment of tomorrow. More often this is becoming a driver for projects, and so acousticians need to make sure they are prepared.

Sometimes this role is fulfilled by a professional sustainability consultant, and acoustics professionals just need to know how to feed into their work. Other times there is no such consultant and some of the skills needed to carry the deepest aspects of carbon and climate analysis may be outside of an acoustics professional's abilities. The principles should never-the-less be understood. To assist, a simple approach is proposed to improve how the industry can work in a sustainable way in building acoustic design, within the bounds of competence.

This document presents a series of overarching principles alongside more detailed considerations relating to each main topic area of sustainable building design. The document is intended to create a simple and accessible means for acousticians with any level of experience to engage with low carbon/climate and planet conscious design. It is hoped that future iterations of building-acoustics specific policy and guidance will challenge and expand upon these starting points.

Overarching Strategies

The following sections present overarching strategies that can have a significant overall influence on a building's sustainable credentials and which acoustic designers have most influence over, during the course of our involvement.

Enabling vs Blocking

Building acoustics professionals are far from being the only members of a design team interested in carbon and planet friendly engineering. Therefore, one of the first and most significant steps a practitioner can take is to remove obstacles to the delivery of sustainable design. We should think pragmatically beyond regulatory compliance and avoid over-estimation. To achieve this it is important to recognise the occurrence of sustainable design, and that acoustics can often create conflicts to it (e.g. noise ingress verses natural ventilation strategies or lightweight structures and sound insulation).

Consultants and manufacturers should seek to understand from their clients and collaborators the sustainability aims and goals when starting a project and (where these are made available) should consider these when providing proposals and design advice. In the absence of project-specific sustainability aspirations, the default should be to provide design with a view to reducing carbon at all available opportunities and encourage sustainable practices such as re-use and recycling (noting that this is a duty under the IOA's professional code of conduct) whilst maintaining acoustic design integrity.

Acoustic consultants and professionals should work collaboratively with other disciplines to promote sustainability, including reducing waste, embodied carbon, operational energy use, improve health and wellbeing of its future users, revive biodiversity etc.

Worked Example:

An acoustic consultant carries out a noise survey for a small commercial building that includes cellular offices, which is to meet British Council for Offices (BCO) guidance. They build a 3D computer noise model and calculate noise intrusion using appropriate calculation methods. The building physicist and mechanical engineer on the scheme are proposing a ventilation strategy comprising open windows, however the acoustic consultant's calculations indicate that with windows fully open this may generate internal ambient noise levels of NR42 $L_{eq,T}$, *i.e. +2 dB in excess of the relaxed natural ventilation recommendations in the BCO guidance. The consultant reasons that a 2 dB variation in noise levels is imperceptible to most people and that this only occurs in very limited locations. They discuss this with the client and design team and agree this is a reasonable compromise to facilitate natural ventilation. By taking this pragmatic approach the consultant is able to avoid the need for mechanical ventilation or large acoustic louvres, therefore dramatically reducing the embodied and operational carbon in the scheme (assuming the energy sources are not 100% renewable).*

Over-specification & Reduction of Materials

Traditionally, engineering consultancy designs-in some margin of safety in the design work associated with a project. This is often driven by the desire for comfort that best endeavours have been used to meet the target acoustic performance, with potential insurance claims in mind. The climate crisis and the need to focus significantly on the quantity of embodied carbon in design work brings this approach into question, and the Building Acoustics Group’s stance is that specifications should aim to provide the appropriate level of acoustic performance, balanced against the minimum quantity of material required to see this achieved in practice. Safety margin should therefore be minimised to avoid over specification that leads to more material use that is needed.

In a bid to reduce embodied carbon, specifications should generally be made whilst aiming to minimise the quantities of materials required as far as possible, providing this does not generate any health and safety concerns or serious risks of claims against the practitioner.

It should be noted that in some instances, this may mean that commissioning test results show minor deviations from agreed design targets (historically, specifications have often added large performance factor margins to allow for in-situ tolerance to mitigate this risk). Typically, these deviations from strict compliance are likely to generate differences in end-user perception that will be imperceptible and are considered negligible in the context of the over-riding climate and carbon aspirations.

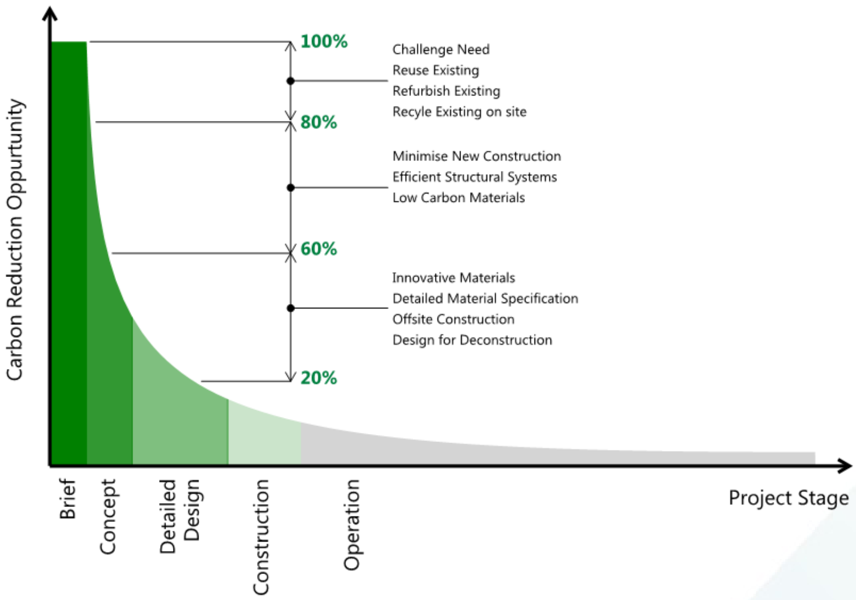
This strategy is reasonable provided it is agreed with the client from the beginning. Invariably this is popular with clients as it results in specifying less material in designs which not only boosts environmental credentials, but also reduces costs to both procure and install.

It is critical to note that the potential impact on carbon reduction of challenging a brief or suggesting deviations from typical design approaches may have a disproportionately positive effect when it is done earlier in the process. So – for example challenging the ventilation strategy in a noisy climate, considering how to make a CLT structure work for instance, or suggesting how an existing building can be adapted to be re-used/re-purposed will have a significantly greater impact on the total building carbon burden, compared to selecting a lower carbon building material during the detailed material specification stage.

It must be acknowledged that not every project will engage with acoustics professionals at every design stage – and so early interventions are not always possible for everyone. This is unproblematic – with the onus on the acoustician to influence what they are able to – if this is a moderate impact in a later design stage through material selection, then the maximum level of influence has still been exerted.

The use of concrete is a particular challenge in buildings because of carbon release during its production. A roadmap exists for net zero concrete but relies on carbon capture to deal with most of its negative impact. It may be possible to avoid use of concrete with alternative structural elements like timber, but these are lighter weight and are likely to require special acoustic design input to make sure sound and vibration energy transfer is addressed adequately.

The graphic below illustrates the point around reducing embodied carbon by influencing the design early in the process.



Source: Buro Happold, 2023

Worked Example:

A consultant is working on a higher education scheme where the aspiration is to provide an in-situ sound reduction value of ≥D_w 45 dB between adjacent research office spaces. In their designs, the consultant normally applies an 8 dB correction between the laboratory-tested R_w values received from manufacturers, and the site-tested D_w value aspired for on site. In the 20,000m^2 office development there is 7,000m^2 of partitioning required. The consultant examines manufacturers data and finds a double-plasterboard build up which is rated at R_w 53 dB and would therefore be ideal. However, they also discover a construction rated at R_w 49 dB. Upon calculating the required in-situ correction for some typical room sizes, the consultant believes that the single board build-up will likely result in a borderline test result at the commissioning phase. The consultant communicates this to their client and the development proceeds with the single-boarded solution Commissioning shows the average in-situ performance to be $D_{nT,w}$ 45 dB – with the range of performance being D_w 43-47 dB. The end users occupy the building and are satisfied with the acoustic separation between spaces. Typical plasterboard has a value of approximate 3 kgCO2eq per m^2, and the consultant has therefore saved 21,000kg of CO2e on their scheme.

Ask Manufacturers for EPDs

An Environmental Product Declaration is a document that quantifiably demonstrates the environmental impacts of a product. An EPD is generated based on data obtained through Life Cycle Assessment (LCA). An LCA is performed using a peer-reviewed Product Category Rules document (PCR) in line with EN 15804 (the European Standard for the generation of EPD for construction products), ISO 14025, and other related international standards.

By choosing products with EPDs (and by preferentially opting to specify products with, for example, low kgCO2eq values) acoustics professionals can report this information on the materials they are specifying and in turn influence the manufacturing industry. Both by encouraging established and emerging products within the industry to gain accreditation of their products, which allows calculation of the impact of design decisions; and by providing commercial motivation for innovation around reducing carbon in products.

It should be noted that EPDs are not, without context, the final word on sustainable products or processes, and there may be aspects for which EPDs cannot be obtained but are nonetheless extremely sustainable choices – an obvious example being the use of recycled sheep wool as sound absorption or as insulation. An EPD calculation is not currently sophisticated enough to separate the breeding of sheep for meat (a very high carbon-generating activity) from the obtaining of the (essentially waste) wool for use in this way. Therefore whilst an EPD might suggest that this product has poor eco-credentials, even a cursory inspection of the detail reveals this not to be true.

An appreciation of the contents of an EPD is beneficial but not critical to the success of engaging with sustainable design, the simple act of asking for an EPD can set in motion many positive environmental outcomes.

Consider Design / Layout Alternatives

Providing that acoustics professionals are engaged at a sufficiently early stage in the design, many carbon-costly options could be designed-out, rather than engineered-in by a traditional approach to acoustic design. Common examples include careful examination of orientations and layouts – avoiding problematic adjacencies where noise pollution increases the protection needed or where spaces which generate high levels of noise or vibration are situated next to areas with a low tolerance to intrusive noise and so need greater levels of acoustic protection and hence material.

The Importance of Considering Context

It is important to consider the context in which the building is being created. The impacts of design decisions, especially when these may generate outcomes that deviate (however marginally) from full compliance with the client expectations or relevant guidance document's aspirations. In setting appropriate design targets all interested parties and stakeholders should be involved in discussions and fully briefed on the implications of any deviations and resulting sustainable design benefits before any such decisions are made.

Sector and market are also relevant – it may be more acceptable (for example) for an international client developing a speculative office scheme in a region without mandatory guidance documents to deviate from original design targets which may apply in other regions, than for a commercial developer who is seeking to prove compliance with Building Regulations Part E in the UK, where local Building Control attitudes towards minor variations may allow some variation. Getting the premise for the design right for the intended use and context before it becomes locked into the process may result in a wide range of benefits

Whilst reduction of material typically generates reductions in cost as well as carbon, it is vital that this is seen as an additional benefit, and that reduction in carbon is not used as a convenient justification for developments to avoid aspiring to meet good acoustic design standards.

Any movement from baseline regulatory or code-compliance must not cause or create the potential for harm to a user's health or wellbeing, so variations should be limited to those likely to not be perceptibly different from the design target.

Special Areas of Focus

The following topic areas are the key elements in sustainable building design for acousticians to provide special focus on influencing, as they are likely to result in the largest benefits to sustainable development delivery in practice. For each topic, there is a definition of the topic area, alongside a list of key considerations, specific to the acoustic design of buildings. Whilst this is not exhaustive it is intended to cover the main things to consider.

Embodied Carbon

Embodied carbon is perhaps the most significant element of design in tackling the Climate Crisis, where acousticians have direct influence. This is especially whilst the energy grid remains carbonised.

Embodied carbon (CO2e) means all the CO2 emitted in producing materials. It's estimated from the energy used to extract and transport raw materials as well as emissions from manufacturing processes. The embodied carbon of a building also includes all the emissions from the construction materials, the building process, all the fixtures and fittings inside as well as from deconstructing and disposing of it at the end of its lifetime[5]. Low CO2e values provide more sustainable design options in the pursuit of delivering net zero buildings.

The following rules of thumb are relevant to how an acoustic design can minimise embodied carbon:

- Using less material almost always generates lower project-level CO2e values
- Locally sourced materials typically have inherently lower embodied carbon than imported materials because of the miles transported (assuming same material type);
- In partitioning, it is typically better to use timber studwork (which provides a home for sequestered carbon) than metal studwork, even if the timber is much more massive
- In partitioning, it may be typically better to use lightweight build-ups (but with alternatives to gypsum boards and mineral fibre insulation with studwork, ideally timber) rather than masonry blockwork; but the lifetime impacts should be considered
- In floor build-ups, use of a timber build-up is typically much lower in CO2e than a concrete build-up (and better still than a concrete-steel hybrid construction)
- In specifying room acoustic treatments, it is typically better to have an exposed soffit (which may additionally help with thermal mass and reduce operational carbon cooling demands) with discrete absorbing units (e.g. mineral fibre rafts or baffles) than a full suspended ceiling (which has significantly more metal and hence CO2e in the grid, hangers, supports etc.)

[5] https://www.ucl.ac.uk/engineering-exchange/sites/engineering-exchange/files/fact-sheet-embodied-carbon-social-housing.pdf

- Room acoustic treatments consisting of a simple, raw material product (e.g. rockwool, provided it is created using 100% renewable energy) perhaps faced with a timber finish (perforated plywood, timber battens etc.) is significantly preferable to a system which is framed or supported by metalwork (e.g. wall panels in a metal frame, perforated metal ceiling tiles etc.). Even better may be a bio-absorbing product such as hemp.
- Controlling dynamics and vibrations by stiffening intermediate floors which are exposed to dynamic live loads is a carbon-expensive strategy. Increasing the natural frequency of a floor slab by (for example) halving the centres of supporting primary structure, or increasing the depth of downstand beams could double the CO_2e of that element. Re-locating vibration-sensitive areas within a building onto ground-bearing slabs is significantly preferable, or recognising that the design life of the building will not be suitable for that use.

Project Example

A new Opera House development included 3no. large performance spaces within it, horizontally adjacent on plan. Each space was intended to house theatrical and musical performances, which included amplified music. The Stage 1 design envisaged by the client's brief-setting team included 3 huge structurally-isolated box-in-box constructions for each of the auditoria, requiring double-lines of structure for the internal (isolated) box floor/sides/lid and the external (primary structural) equivalents. Early on in the Concept Design stage, the acoustic engineer challenged this assumption and proposed a simpler solution – the division of the primary structure connecting the three spaces by way of isolation joints which run through the slabs, walls and roof of the building on demarcation lines between the auditoria. All of the boxes for the auditoria were then designed as single-skin elements. Some statistical energy analysis modelling was done which suggested that there would be limitations on the ability of this design to control the highest-amplitude, lowest-frequency structure-borne sound transmissions, but that by accepting a marginal operational concession (essentially that amplified 'rock and pop' performances in one space would not be scheduled simultaneously with quiet theatrical performances in the adjacent one) the client would save not only hundreds of thousands of pounds of cost, but an estimated >200,000 of CO_2e.

Operational Carbon

Next in order of significance for priorities for focus are the effects of operational carbon.

The amount of GHC carbon equivalents emitted during the operational or in-use phase of a building. This includes the use, management, and maintenance of a product or structure[6]. Lower levels of carbon used whilst the project is operating imply more sustainable design, and in aspiring for net zero this residual must be reduced to an absolute minimum and responsibly off-set.

Acousticians have a direct influence on the systems employed to service a building, which consume energy and so result in the release of GHG Carbon equivalents. The following rules of thumb are relevant to the effects of an acoustic design on operational carbon:

- Where the energy requirements can be met by locally generated 100% renewable energy (i.e. wind turbine / Solar PV) the operational energy can be considered net carbon zero, or potentially may provide a surplus to the grid. This is the best way to address carbon emissions and the acoustician removing conflicts that may exist for this approach is very helpful work, although the other impacts need to be considered, such as rare metals in battery etc. Note: A net carbon zero building can be achieved where the embodied energy and operation energy over its lifetime can be offset in this way.
- Natural ventilation is typically a lower-carbon solution than employing mechanical ventilation (assuming the grids currently energy mix), unless the energy lost through the windows creates a net loss greater than a renewable energy driven mechanical system for example.
- Mixed mode ventilation (a system that permits both natural and mechanical means of ventilation based on external seasonal conditions – e.g. natural ventilation when external temperatures provide free cooling or noise conditions permit). This is typically a lower carbon solution than a permanent mechanical ventilation solution (unless it is 100% renewable energy drive) even if there is marginally more embodied carbon required to install a binary system (i.e. natural vents/louvres combined with air handling plant)
- Exposed thermal mass, solar shading and other means of passive cooling are typically lower carbon emission solutions than the inclusion of mechanical cooling systems (unless supplied by 100% renewable energy
- There can be conflicts between embodied and operational carbon considerations. For example, opting for an exposed concrete slab (in preference to a timber build up) increases CO2e, but may reduce the operational carbon burden by providing passive cooling if it is left exposed, providing thermal mass, and the reverse is true. A simple heuristic is to remember that the climate Crisis is now – and that CO2e is ‘upfront carbon’, spent “now” and should generally be prioritised to minimise . Future generations and technology might find a way to provide cooling to the development in a more efficient and sustainable manner, but the CO2e “spent” in manufacturing and installing the concrete slab is “fixed” and contributing to the Climate Crisis now.

[6] https://spot.ul.com/blog/embodied-vs-operational-carbon

Project Example

An out-of-town residential development fronting onto a busy A-road achieved planning approval and had an accompanying noise assessment and TM59 dynamic thermal modelling report. The noise assessment utilised noise survey data to demonstrate that the site was suitable for residential use but reported that the noise exposure would constrain the use of an open window approach to remove excess heat on the most exposed façades. The dynamic thermal modelling report assumed all windows were to be closed and proposed excess heat is removed via a large mechanical ventilation heat recovery unit for every apartment. Post-planning, the acoustic consultant was able to develop a noise model of the site, supported by measurement validation to refine the prediction of a lesser noise exposure to some facades, and define an outside to inside level difference requirement for less-exposed bedrooms ranging between 5 and 15 dB. The dynamic thermal modelling was updated for the Building Regulations application, incorporating low g-value glazing on the façades less-exposed to noise, adopting a window open sufficiently to achieve the outside to inside level difference defined by the acoustic consultant. Consequently some apartments were able to avoid the need to install large mechanical ventilation heat recovery units, thus reducing the operational carbon significantly. Post occupancy evaluation confirmed that good comfort levels were maintained.

Circular Economy (Reduce, Re-use, Recycle)

An economic system based on reducing waste and the reuse and regeneration of materials or products, especially as a means of continuing production in a sustainable or environmentally friendly way[7]. Minimising waste is critical to this process also.

Acousticians can have a large influence on what materials or products are used in buildings to achieve the acoustic design targets, The aspiration should be to rethink the materials used, restore and replenish the planets resources, wherever possible. The following rules of thumb are relevant to circular economy and acoustic design within it:

- Reduce the materials needed (favouring light-weight structures that trap carbon for new-builds)
- Re-using an existing building, material or product is almost invariably a lower embodied carbon solution than procurement of new items
- Recycled content in materials reduces the resource drain on the planet.
- Recycling materials or products at the end of their lifecycle in the building may define which manufacturers should be recommended for consideration when specifying.
- Single materials are typically easier to re-use or recycle than products consisting of multiple elements (e.g. favouring a system comprising a separate resilient layer under / behind a timber batten or board rather than a bonded composite product)
- Less processed materials are typically easier to recycle than more heavily processed ones (e.g. sound absorbing products made from rock or mineral fibre are more readily recyclable than those made from melamine foams)
- It is better to design and build in 'layers' which can be removed individually, rather than composites (e.g. it may increase the circular economy potential if a soffit is mechanically fixed with a sound-absorbing board which can later be removed and re-used/recycled, rather than sprayed with an acoustic plaster which cannot)
- Timber boards or some of the main recycled alternatives are typically easier to re-use/recycle than gypsum based products. Magnesium Oxide board for instance sequesters carbon over its lifecycle.
- Reducing use of single use plastics in packaging of products or in products is an area to consider when specifying products.
- Materials passports and engaging with emerging detail within Building Information Modelling can significantly increase the chances of material reuse at the end of a building or fit out life (typically anywhere between 5 to 60 years)

[7] Definitions from Oxford Languages

Project Example

A scheme involved the re-modelling of a large floor plate in an office tower. The current insurance company occupiers were leaving, and the space was instead being let to a prestigious UK university for their School of Management. The space had an existing Cat B fit-out – a mixture of open plan, cellular offices, and meeting spaces. A condition survey of the existing fit out was undertaken, as well as a pre-refurbishment audit, to assess retained elements of the fabric such as core walls, raised floor and mechanical services, as well as to explore opportunities to reuse existing architectural elements and building services. Despite the significant physical differences between the School of Management design and the previous office fit out, considerable success was achieved in reusing elements from the previous fit out – for example:

Glazing: 64.7 linear metres of full-height laminated glazing (195m^2) was salvaged, surveyed and reused in new internal glass partitions.

Doors: 49 out of 53 pre-existing 3m-high walnut veneered timber door leaves were reused in the new fit-out. This equates to 67% of the timber doors in the project.

Ceilings: 771 sq. metres of metal acoustic ceiling tiles and diffuser grilles were salvaged, equating to just over 30% of the total ceiling area.

In some cases, the surveys included acoustic measurement of the existing elements which were aspired to be re-used (e.g. glazed partitions), and in others it was a case of examining the specification and simply using existing manufacturer's data in new calculations (e.g. metal ceiling tile systems). Whilst some elements required a moderate level of refurbishment (e.g. the application of new acoustic perimeter seals to doorsets) it is plain to see that the saving on CO2e compared to replacement with new was significant. This project is an example of an alternative approach, where a brave attitude towards risk is balanced by diligent design and engagement to fully support the most sustainable solutions practicably achievable. Pre-completion commissioning showed that all retained or re-used elements met acoustic targets, with no or minimal differences observed between the retained and new elements.

Health & Wellbeing and Social Value

By default, acousticians usually promote healthy spaces through applying good acoustic design, which have positive effects on health and wellbeing but what does sustainable wellbeing actually mean?

Sustainable wellbeing is achieved when improvements to individual wellbeing are correlated with improving the wellbeing of other members of society and the natural environment[8].

Soundscape is an emerging field, which involves taking a user-centric approach with participatory processes to determine sonic priorities, and the co-creation of solutions. Rather than focussing on benchmark criteria for unoccupied buildings, a soundscape approach starts from the human experience of sound in a particular context. Experience of sound is heavily influenced by non-acoustic factors, which can be categorised as personal, tangible, and psychosocial factors. For aviation noise, for example, one third of the variance in annoyance can be attributed to acoustic factors. This means that two-thirds of the annoyance reaction is determined by non-acoustic factors. So far, documented non-acoustic factors can account for one third of the overall annoyance response. So non-acoustic factors must be taken seriously if the goal is to achieve good acoustic outcomes.

What constitutes “good acoustics” for one person is different to the requirements of another person: a soundscape approach reveals the differences and range of experience that different people have in the same environment. This information can inform the design such that it enables a range of options for occupants, or the level of control necessary to achieve sufficient or good conditions.

As a soundscape process is necessarily participatory, it is naturally inclusive. When end-users are involved in the design process, where that is possible and appropriate, there is a wide range of evidence demonstrating that this can lead to improved environmental satisfaction in the new building. Conversely, if users feel that they are mis-informed about the extent of input they may be able to have in the new design, this can lead to disappointment with a corresponding degradation of environmental satisfaction. Therefore there are risks associated with taking a participatory approach, but it can add social value.

[8] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7579264

Project Example

A soundscape approach was used with the participants of a co-housing group, developing 25 dwellings and shared facilities. Soundwalks across the site during the daytime, evening and weekends revealed the different sensitivities of the different members and helped them think about sound in the new homes. Participants' experience of the acoustic environment did not correlate with the measurements in dBA: on one side of the development the traffic was intermittent and passing close by, whereas on the other side, traffic was constant but at a much greater distance. The difference in response compared with measured dBA levels also changed between daytime and night-time periods. This information could lead to the design of traffic noise mitigation differently from the current reliance of dBA to inform suitability. Opportunities to enhance natural sounds were emphasised, by using planning to encourage birds into the courtyard, and reducing openings to the courtyard to keep traffic noise out. The most suitable external amenity area to create a calm, relaxing space could be determined effectively based on the participants' perceived affective quality, which was different from the area with the lowest average dBA levels.

The following rules of thumb are relevant to the acoustic design when considering an occupant's wellbeing and the societal value of the built environment:

- Linked with the provision of natural ventilation – it is generally considered to improve wellbeing of a building's occupants or users if they have access to control of the provision of natural ventilation – even if opting to operate their space in a natural ventilation condition increases internal ambient noise levels at times
- Having a connection to the outdoors and nature is typically considered to improve wellbeing – even if the choice to operate the space in this way increases internal ambient noise levels, providing these can be maintained to achieve reasonable occupancy conditions, for the intended use of the space;
- In workplaces, educational establishments, healthcare settings and more – research typically suggests that more appropriate acoustic environments (note – not necessarily "quieter", but rather fitted to the purpose of use and neurological preferences of the user) lead to less stress, better outcomes, improved productivity etc. The influence of non-acoustic factors means that other things like conscious choice is as important as the absolute levels of acoustic control, when considering comfort and wellbeing.
- High levels of sound insulation (either intentionally or as a consequence of high thermal insulation and airtightness) may result in internal places being very quiet, or filtering out mid the high frequency sound, isolating users and disconnecting them.
- Access to amenity space that provides relative quiet and a quality soundscape provides respite and connection to nature and is also helpful to human restoration and an improved sense of wellbeing and happiness.

- Factors that affect the inclusivity of the diverse range of users should be considered in such a way that promotes the ability for end-user to control acoustic conditions sufficiently to support their health and wellbeing.

Project Example

A traditional office space was proposed to be refurbished to create a multi-use activity-based workplace. A study was undertaken into the use of the space to consider user satisfaction. Acoustic treatments were installed alongside a new layout and furniture. A repeat survey was undertaken in the office, and it was found that the acoustic conditions had not changed, but user satisfaction had got worse. From a detailed review of usage of the office, it was determined that occupants had less control over their environment in the new configuration. The environmental conditions were altered to provide more control over when people can access the spaces, and the lighting and temperature was altered to provide controllable features. A further satisfaction survey was carried out and this confirmed an improvement in acoustic satisfaction, despite no change to the acoustic environment.

Design for Manufacture and Assembly / Modern Methods of Construction

The energy demand of a building can be reduced through adopting Modern Methods of Construction (MMC) and Design for Manufacture (DfMA).

DfMA and MMC are both processes intended to streamline construction, particularly through offsite and modularised manufacturing.

The following pointers/rules of thumb are relevant to how the acoustic design can influence whether DfMA / MMC is viable:

- Schemes constructed through DfMA or MMC are typically more sustainable on the basis that:
    - Tolerances in factories are typically finer than on site, reducing offcuts and waste
    - Material transport and procurement at scale means that factory-construction is typically less carbon intensive, even if final panellised products require transport to site
    - The deconstructability of DfMA or MMC is typically higher, increasing circular economy potential
- The DfMA and MMC approach runs neatly with cost. If a solution costs less, then this typically means that less labour and/or material is required, which reduces the carbon burden in terms of CO2e and/or transportation.
- The acoustic brief may lend itself to adopting DfMA or MMC, e.g. because it calls for repetitive performance requirements/constructions
- Off-site validation acoustics testing may be available, but where they are not this should be validated in any event on site.
- By spending a little more time understanding the needs of the project to set criteria that can be easily achieved with modular systems, we can enable DfMA on a site that may ordinarily demand extensive construction using traditional methods.

Project Example

A new healthcare laboratory was being designed, comprising working process lines separated by partitions with doors, and a corridor between the laboratory lines where no door existed. The original brief proposed compliance with all NHS standards, including HTM 08-01. The standard sound insulation requirement based on HTM 08-01 indicated a need for minimum R_w 44 dB partitions. The concept scheme was originally developed based on traditional construction method. However, early contractor engagement at schematic design resulted in the decision to opt for prefabricated modular systems. The supplier of the modular system was only able to achieve R_w 40 dB with the standard construction. A review of the proposed use of the laboratories with the end-user team determined that privacy was not an important factor. However, noise within some rooms as a result of the proposed equipment was predicted to be high and, therefore, a moderate level of noise control between rooms was still necessary. To reduce the effect of equipment, acoustic wall panels were installed, reducing reverberant sound. By taking the time to understand the end-user use in detail, the acoustic requirements could be catered specifically for the proposed use, enabling the use of a lesser performing modular system. This consequently provided spaces fit for purpose and using a construction method that significantly reduced construction time and embodied carbon.

Day-to-Day Implementation

This guidance is provided to enable acoustic designers to easily implement sustainable practices in their day-to-day approaches and is a first step in providing guidance which will evolve as the current state of knowledge advances.

To assist practitioners with grasping the opportunity to advance the delivery of sustainability at pace, the Building Acoustics Group has assembled a checklist of key elements for consideration in a design. This checklist is provided on the following pages.

It is intended that designers include copies of the checklist in reports and on file, as evidence / demonstration that they have proactively taken measures to consider and promote sustainable building acoustic designs.

Abbreviations & Terminology

Terms used in this document are defined or briefly explained below:

Sustainability – This is typically the term used to represent the following for a building:

- Carbon Net Zero over its lifecycle
- Net Zero harm to the environment
- Restorative for biodiversity
- Do best with least resources that have eco-credentials
- Collaborate to deliver interdependence
- Whole system and holistic design
- Use UN SDG's as a framework to do better than
- Re-think, restore, replenish

Global Greenhouse Gas Emissions from Built Environment – This is the combination of Construction/ Demolition, maintenance, operational (heating, cooling, lighting), materials (inc. embodied carbon) and its demolition.

Whole-Life Carbon Assessment – The process of calculating the emissions from the construction, maintenance, and demolition of a building, and from the energy used in its day-to-day operation.

Net Zero Carbon - The term net zero means achieving a balance between the carbon emitted into the atmosphere, and the carbon removed from it. This balance – or net zero – will happen when the amount of carbon we add to the atmosphere is no more than the amount removed[9].

Embodied Energy - The accumulative energy spent for a product's total life cycle, from raw mining to disposal, and it is incorporated in the material itself[10].

Renewable Energy - Renewable energy comes from sources that will not be used up in our lifetimes, such as the sun and wind.[11]

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[9] https://energysavingtrust.org.uk/what-is-net-zero-and-how-can-we-get-there/

[10] N. Lushnikova, L. Dvorkin, in Sustainability of Construction Materials (Second Edition), 2016

[11] https://education.nationalgeographic.org/resource/renewable-energy/