



Acoustics for a sustainable future

Richard Grove
Inhabit
80 Canterbury Grove
London
SE270PA

ABSTRACT

Sustainability is now at the core of everything we are doing in our daily and professional lives. The need to consider sustainability is now, more than ever, a critical element of our approach to design, engineering and construction. The wide ranging terminology and acronyms associated with sustainability, sometimes abstract concepts around Health and Wellbeing, and passing reference that is made in wider standards and guidance, can be difficult to resolve with technical acoustic performance in practice. Much of an acoustician's work is centered on the acoustic performance of a building or environment, however concepts of embodied carbon, operational carbon, and health and wellbeing have required that acousticians consider their input beyond the technical acoustic performance of spaces or materials. This paper provides a review of the current UN Sustainable Development Goals and how these relate to an acousticians input to building design, providing information around the concepts of Life Cycle Analysis, Whole Life Carbon, as well as the consequential effects of a balanced approach to positive health and wellbeing, in an effort to provide a framework of acoustic solutions which consider environmental and social sustainability.

1. INTRODUCTION

The climate emergency and the concept of sustainability are now widely, if not wholly, considered as one of the leading drivers in our day-to-day decision making. The World Business Council's Brundtland report defines sustainability as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" [1], leading to the further definition by the same body of the fundamental pillars of Sustainable Development of "economic prosperity, environmental quality, and social equity". The United Nations Sustainable Development Goals (SDGs), adopted by 193 countries in 2015, cover seventeen discrete but inextricably linked development challenges and now form the 2030 Agenda for Sustainable Development, established to address fundamental Sustainable needs of the world's population and in summary to provide a "blueprint to achieve a better and more sustainable future for all" [2]. The 2030 agenda provides a plan of actions, defining the discrete areas of People, Planet, Prosperity, Peace, and Partnership, and comprise 169 targets aimed at stimulating action in areas of critical importance for humanity and the planet.



SUSTAINABLE DEVELOPMENT GOALS



Figure 1: United Nations Sustainable Development Goals [3]

The UN SDGs do not reference sound or noise in any of the 17 Sustainable Development Goals, and as such do not draw specific attention to the need to consider sound as part of Sustainable Development. Whilst not directly referenced, this author argues that the sound environment is implied in all of the UN Sustainable Development Goals, often cutting across one or more of these goals.

Historically, sound and noise have largely been considered as public health issues, traditionally referred to as a pollutant which causes nuisance and a negative impact on human health [4]. As such, standards and guidance tend to drive towards the suppression, reduction, and mitigation of noise levels used as a means to easily assess compliance. A recent movement acknowledges the qualitative elements of sound and the potential for the positive impact sound can have on our daily lives has taken shape in the form of soundscape research and an increasing drive towards evidence based design [5]. Such a shift in the reputation of sound amongst designers has been accompanied by research into the psychological and physiological effects of sound in the realms of human health and diversity across aural, visual and neural diversity. No better is this represented than in designing for education, which includes specific criteria for students with Special Educational Needs [6].

Our understanding of sound in the design community is beginning to respond to the fundamental human experience of sound and how we interact with our environments, evolving from sound as a marker related to our base responses of fight or flight to sound as a component of our overall experience in our environments alongside our other senses.

Methods have been developed for calculating and predicting the optimal sound environment, resulting in recommendations for incorporating manufactured materials into our built environment which assist in shaping environments for our use and enjoyment. Calculated predictions are typically based upon criteria contained in standards and guidance are referenced in certification schemes which promote and guide sustainable design, and as such encourage the inclusion of materials throughout the built environment [7]. In doing so acoustic design can often respond predominantly to the need for compliance in order to obtain certification, leading sometimes to specifications which err on the



side of caution, commonly by recommending more material than may be necessary. This tension between compliance for certification and the optimum user experience can lead to design decisions that, with further consideration to the wider needs of Sustainable Development, may be better balanced and therefore reduce the need for acoustic materials.

When considering the concept of material quantity and purpose in a building, it is important to be mindful of the contribution that these materials have to the fundamental pillars of Sustainability Development. The use of materials will inevitably have an impact upon the environment through carbon emissions as a result of the process of extraction, manufacture, delivery, installation and disposal. Economic considerations are more complex, commonly relating to productivity as a result of optimal acoustic environments [8]. However it may be argued that the process of producing, delivering and installing this material also provides economic prosperity to the many who work with within the supply chain. The social impacts of acoustic interventions are amongst the most well understood, in that sound relates directly to our experience of spaces, how we access and communicate within our environment, and consequentially how we create healthy societies [9].

In considering acoustics and its contribution to the design of the built environment, this ongoing research is motivated by a strong belief that acousticians can provide advice that represents a true contribution to the fundamental aims of Sustainable Development by considering to the environments that are designed alongside the impact these designs have on the environmental, social, and economic aims of the UN Sustainable Development Goals. In doing so this research aims to question whether acousticians should frame their design advice in a way which is has meaningful impact on the Un Sustainable Development Goals.

2. METHOD

2.1. General approach

The approach to developing this paper are wholly qualitative, utilising Content Analysis and Theme Analysis methods. In order to provide a focussed area for initial study publications and information made available by the United Nations (UN) and the Royal Institute of British Architects (RIBA) have been focussed upon. These institutions produce vast quantities of information and as such specific documents have been focussed upon from these sources to build an initial view on the subject of acoustics and sustainability, acknowledging that further research and corroboration would be necessary to develop this view.

The key acoustic design considerations of sound insulation for acoustic privacy, room acoustics for communication and comfort, acoustic design for building services and natural ventilation, and acoustic design for external environments, have been reflected upon when reviewing information sources to develop areas.

Finally, and for ease of understanding the far reaching implications of the UN SDGs, these have been grouped in line with the three pillars of sustainable development based upon their apparent interdependency [10].



Figure 2: SDGs categorised against pillars of Sustainable Development

3. OUTCOMES

The outcomes of the review have been presented in the context of the UN SDGs grouped within each pillar of Sustainable Development, presenting opportunities for acoustic design to be considered in broader terms than traditional acoustic performance in order to contribute to the achievement of the UN SDGs.

3.1. Environmental Sustainability

The construction of the built environment, for which good acoustic design is an integral part, accounts for 36% of global final energy consumption and 37% of CO₂ emissions overall, with act of constructing our built environment accounting for 6% of energy related and 10% of emissions related CO₂ [11]. These emissions relate to the Whole Life Carbon of a given building, from inception to delivery, and including all carbon emissions across embodied and operational carbon. Many factors influence the Whole Life Carbon of a building, including the materials and systems selections incorporating raw materials and methods of manufacture, where materials and systems are procured and delivered from, and how these are implemented in to the design of buildings.

Figure 2. Buildings and construction's share of global final energy and energy-related CO₂ emissions, 2020

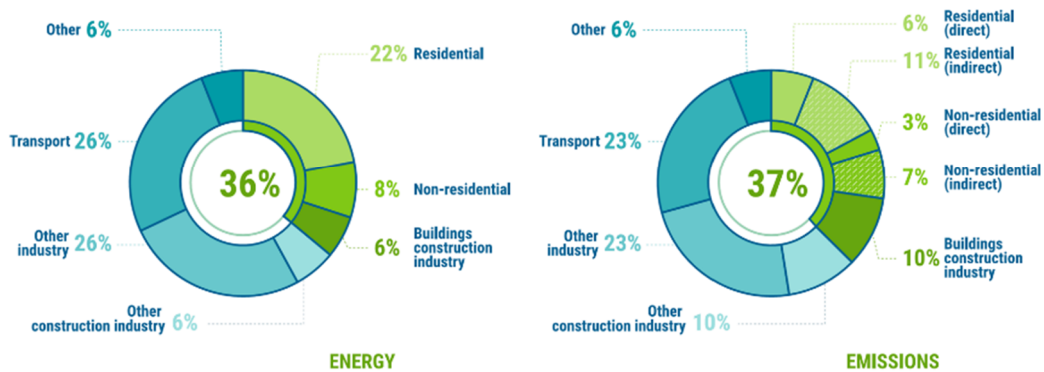


Figure 3: Buildings and construction share of global final energy-related CO₂ emissions, 2020

This approach has given rise to an increased need for designers to consider the end of a building's life cycle, placing the emphasis on reducing CO₂ impacts as a result of building disposal and giving rise to an increasing need for adaptive reuse of buildings as well as consideration to reincorporating materials back into the supply chain through recycle or reuse, known as the Circular Economy [12]. The Royal Institute of Chartered Surveyors (RICS) published the Whole life Carbon assessment for the built environment professional statement in 2017, becoming mandatory and regulated in May 2018. This shift highlights the need for the acoustician to understand the approach to carbon accounting and impacts of the materials they specify, as well as how materials can be reintroduced into the supply chain in order to offset the carbon impacts of their initial manufacture. Operational carbon impacts are most directly associated with building ventilation, which have been well addressed and are therefore not looked at with any degree of depth in this paper. Acousticians have long argued for locating non-noise sensitive rooms on facades, and more recently have engaged in the concepts of air flow and overheating through recent building regulations related to overheating [13].

Designers in the built environment have a fundamental responsibility to the creation of future environments, and as such have great deal of influence over the how the built environment addresses the issues raised in the UN SDGs. In 2019, the Royal Institute of British Architects published the Sustainable Outcomes Guide [14], defining core sustainable outcomes which correspond to the UN SDGs and align with the RIBA Plan-of-Work. References to acoustics and noise in this document are limited and as expected are predominantly provided under the heading of Good Health and Wellbeing, specifically stating "Design spaces with good acoustic comfort". An additional, if not brief, reference is made under the head of Net-Zero Operational Carbon, specifically "Windows, daylighting, ventilation, solar and acoustic control". As such, it would be reasonable for the reader to conclude that acoustic design considerations should only address the sound environment which is being design for, omitting necessary considerations for the quantity and type of materials specified and their impact on the UN SDGs of Climate Action (SDG 13) by considering the broader impact of criteria which is more focused on the optimal user need rather than compliance with so-called optimal metrics. For example, considering room acoustic design as optimal across a large space would drive the need for vast quantities of material, whereas focused approaches which consider specific needs of different areas can assist in targeting acoustic materials and allowing the space to reflect its volume and materiality. This approach may also assist in echo-mapping for the visually impaired, whereby an impression of the space is built through the connection of the visual and aural cortex [15].



Finally, materials procurement will increasingly play an important role in the acoustician's considerations. By seeking out solutions which have the least logistical environmental can assist in improving the quality of), Life Below Water (SDG 14) [16] and Life On Land (SDG 15), at least until cleaner fuels and lower noise vehicles are developed for these purposes.

3.2. Social Sustainability

Acoustics for Good Health and Wellbeing (SDG3) appears to have become the natural home for acoustic design, and referenced as such in many Sustainability Certification standards. Areas such as acoustic privacy and room acoustics can shape behaviour [17] and provide accessible spaces, resulting in positive contributions in the development of Sustainable Communities (SDG 10), which in turn can create just societies (SDG 16). Fundamental to this is Quality Education (SDG 4) for which Building Regulations in the UK [18] reinforce through the need to provide quality acoustic environments. In short and educated society with good communication environments has a better chance of achieving sustainable social structures, assisting in Gender Equality (SDG 5), as well as Decent Work and Economic Growth (SDG 8) leading to Reduced Poverty (SDG 1) and one hopes Zero Hunger (SDG 2). Finally, much of the aforementioned impacts on the environment, which consequentially have an impact on societal health, are associated with the development of technologies to provide Affordable and Clean Energy (SDG 7), both across the manufacture of acoustic materials and the method by which buildings are ventilated. Intelligent design, reducing the need for acoustic attenuation, will have a consequential impact on our use of energy, cutting across responsible Consumption and Production discussed further under the heading of Economic Sustainability.

3.3. Economic

The economic impacts of good acoustic design have typically been associated with productivity and the acoustic environment, with the theory that designing workplaces will lead to Decent Work and Economic Growth (SDG 8), largely by designing out distraction to promote concentration [19]. The recent global pandemic, forcing many to work from home, has created a paradigm shift and forced the design community to redefine the working environment, and many companies to realign their values associated with productivity, although the bottom line appears to remain the primary metric by which success is measured. Much of this shift has been towards providing a variety of working environments, which further promotes the idea of spaces for collaboration and concentration by focusing acoustic materials in certain areas and reducing them in others (see Environmental Sustainability). This reduction in acoustic materials may give rise to the consequential impacts on the supply chain and those whose livelihoods are dependent on the manufacture, supply, transport, and installation of materials [20]. The logical consequence of reduced material will require manufacturers, and the designers who specify them, to engage in Innovation (SDG 9), and perhaps rethink the distribution network and means by which they reintroduce their materials into the supply chain at the point of disposal, thereby demonstrating Responsible Consumption and Production (SDG 12). This can also go some way to reducing inequalities (SDG 10) through the creation of local thriving economies associated with materials manufacture and supply to service the needs of the built environment.



4. CONCLUSIONS

The interaction of the UN Sustainable Development Goals and Acoustic design is broad and multifaceted. In studying the available literature, and considering the vastness of the subject, it is acknowledged that this study acts as an introduction with more research required.

Firstly, the interdependency of the UN SDGs remains a continual area of study, with the European Union's report on Monitoring report on progress towards the SDGs in an EU context [21] highlighting the highly complicated nature in which consequences of actions towards an SDG outcomes impact different one another. In developing the view contained in this paper, this concept is further reinforced by considering the area of economic sustainability and its highly complex interaction between supply and demand of acoustic materials. Considering that Economic Prosperity underpins large parts of our societal function, designers are driven towards considering this as a primary measure of success.

However, and given the urgent need to address the climate challenge, it should also be incumbent on the acoustic designer to measure the value of acoustic materials they specify by both their contribution to the health and wellbeing of the user and their contribution to the environment. Turning our attention to the UN SDGs Outcomes Map contained in the RIBA Sustainable Outcomes Guide, it may be argued that acoustic design has a broader influence than may be considered by architects, and by considering the influence across the SDGs can carry greater weight in the user experience and consequential achievement of the SDGs. In addition, by making architectural considerations more prevalent in the acoustician's thinking, it is possible to positively and directly impact the Whole Life Carbon of a building and consequential environmental acoustic impacts by simply reducing the need for extracting, processing, delivering, installing and disposing of the unnecessary materials, as well as focusing the approach to one which encourages the reuse of materials as part of the circular economy.

The SDGs provide a framework in which to contextualize a wide variety of industries, against which these industries can develop approaches which seek to contribute to the solution. Acoustics is no different, and should no longer be solely considered as a means to improve health and wellbeing or as method by which we can eradicate noise pollution. Rather the frameworks provided by the likes of RIBA, and the UN itself, along with the knowledge that acoustic interventions can have far reaching positive impacts should be used to develop approaches and arguments for alternative approaches to acoustic design, and for challenge compliance based design to create evidence based recommendations.

In attempting to develop a framework for acoustician's to consider in their day-to-day work, it is apparent that the achievement of SDGs and how acoustic design impacts these is a wide ranging and complex issue worthy of more research and development. Framing acoustic design in this way however alters the narrative from something which is often considered as necessary for compliance, or even a luxury item which can be engineered out, to something which is necessary for a sustainable future.

Finally, it is acknowledged that the work contained is limited by the breadth of the source material that has been analysed. In progressing the thinking, a broader range of literature should be reviewed. In addition, it is intended that numerical analysis of the actual carbon and financial impacts, both of which are measurable, of designing to standards and guidance should be developed to develop evidence basis on which acousticians can advise upon the most sustainable approach to design interventions which meet the aims of improving our socio-cultural interactions whilst being cognisant of the environmental and economic impacts of our decisions.



5. REFERENCES

1. United Nations Secretary-General, World Commission on Environment and Development, "Report of the World Commission on Environment and Development," United Nations (1987)
2. United Nations, "Transforming Our World: The 2030 Agenda for Sustainable Development" (2015).
3. <https://sdgs.un.org/goals> accessed 12 April 2022
4. World Health Organisation Environmental Noise Guidelines for the European Region 2018
5. William J. Davies, Mags D. Adams, Neil S. Bruce, Rebecca Cain, Angus Carlyle, Peter Cusack, Deborah A. Hall, Ken I. Hume, Amy Irwin, Paul Jennings, Melissa Marselle, Christopher J. Plack, John Poxon, Perception of soundscapes: An interdisciplinary approach, Applied Acoustics, Volume 74, Issue 2, 2013
6. Building Bulletin 93 (BB93): acoustic design of schools - performance standards (2014)
7. SD5078: BREEAM New Construction Technical Manual (2018)
8. Kenneth P. Roy, Open office acoustics and productivity, The Journal of the Acoustical Society of America 104, 1785 (1998)
9. Aletta, Francesco, and Jian Kang. "Promoting Healthy and Supportive Acoustic Environments: Going beyond the Quietness." International journal of environmental research and public health vol. 16,24 4988. 8 Dec. 2019
10. J. Rockström and P. Sukhdev, "How Food Connects All the SDGs," Stockholm Resilience Centre (2016), <https://www.stockholmresilience.org/research/research-news/2016-06-14-how-food-connects-all-the-sdgs.html> (accessed 15 April 2022)
11. United Nations Environment Programme (2021). 2021 Global Status Report for Buildings and Construction: Towards a Zero-emission, Efficient and Resilient Buildings and Construction Sector. Nairobi
12. MacArthur, E., 2013. Towards the circular economy. Journal of Industrial Ecology, 2(1), pp.23-44.
13. Harvie-Clark, J. et al. (2019) 'Assessing noise with provisions for ventilation and overheating in dwellings', Building Services Engineering Research and Technology, 40(3), pp. 263–273
14. RIBA Sustainable Outcomes Guide 2019 <https://www.architecture.com/knowledge-and-resources/resources-landing-page/sustainable-outcomes-guide> accessed 20 December 2021
15. Retinotopic-like maps of spatial sound in primary 'visual' cortex of blind human echolocators Liam J. Norman and Lore Thaler Proceedings of the Royal Society B: Biological Sciences Volume 286, Issue 1912, 2019
16. Erbe Christine, Marley Sarah A., Schoeman Renée P., Smith Joshua N., Trigg Leah E., Embling Clare Beth The Effects of Ship Noise on Marine Mammals - A Review, Frontiers in Marine Science, Vol. 6 (2019)
17. Giyoung Park & Gary W. Evans (2016) Environmental stressors, urban design and planning: implications for human behaviour and health, Journal of Urban Design, 21:4, 453-470, DOI: 10.1080/13574809.2016.1194189
18. Approved Document E: resistance to the passage of sound 2003 (updated 2015)
19. Haapakangasa A, Hongistoa V., Distraction distance and perceived disturbance by noise—An analysis of 21 open-plan office, The Journal of the Acoustical Society of America 141, 127 (2017)
20. UK Acoustics Network Sound Economics Report (2019)
21. Sustainable development in the European Union Monitoring report on progress towards the SDGs in an EU context (2021)