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SUSTAINABLE DESIGN AND PRACTICE IN REPRODUCED SOUND

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1 INTRODUCTION

Large broadcasters are beginning to recognise the importance of environmental sustainability in their operations as part of their corporate responsibility. The albert+ standard developed by the BBC¹ and BAFTA² and Sky's 'The Bigger Picture'³ reports are evidence of this. There is evidence of pockets of development in environmental sustainability in the audio industries but the industry is yet to develop a coherent strategy in this area.

This paper reviews some of the current literature and practice in environmental sustainability in the audio-visual (and related) industries and considers how this can be applied to some of the challenges of live and installed sound with regards to reducing carbon footprints and operating in a more environmentally friendly and sustainable way. Recommendations are then made with respect to future working practices and future research required in this area.

2 BACKGROUND

2.1 Environmental Challenges in the Audio Industry

The professional audio industry faces very specific challenges with regards to sustainability and carbon footprint, particularly in the area of reproduced sound. High sound pressure levels require high power amplifiers which often require large amounts of energy input. High sound pressure levels also require bulky loudspeaker systems which require transportation with the associated emissions and carbon footprint. The materials used in the manufacture of audio systems are a complex mix of metals, wood, electronics and composites and need careful sourcing in order to ensure sustainability is maintained.

The industry is a very diverse one, with audio related activities taking place within the wider audio-visual creative industries and beyond. It is often the case that audio related activities have to take place under the environmental sustainability requirements of other industries and there is evidence of discussion and research into sustainable practice in the wider creative industries that include elements of audio. At the time of writing there is very little discussion specifically in the audio industry with regards to environmental sustainability and green practice. However, there are now well established sustainability agendas within the major UK broadcasters which are clearly visible on the public webpages of these organisations^{3,4,5,6,7}. There are many parallels between broadcast and the audio industries in terms of the types of activities that are carried out and, of course, audio is a fundamental part of the broadcast industry, with many audio engineers working within the broadcast industries. It is clear that there is much that can be taken from the broadcast industry with regards to sustainable practice.

2.2 Aims, Definitions and Scope

The main aim of this paper is to review a range of key research, policy and guidance documents with regards to environmental sustainability and consider how these can be applied to developing sustainability policy and practice in the audio industries. This paper is presented at the Reproduced Sound 2015 conference and therefore focuses on the installed sound reproduction and live sound production areas of the audio industry. The paper is intended to ignite discussion and debate within this community with a view to working towards the production of guidance documents specifically for audio engineers. The paper considers what these documents might look like and some of their key inclusions. This paper represents the author's early explorations of this subject area and the beginnings of a program of doctoral study. The identification of further work is therefore fundamental here.

Sustainability as discussed in this paper refers to environmental sustainability. The most significant aspect of this is carbon footprint but also includes waste management, materials choice and supply chain. Environmental sustainability is often referred to as being 'green'. Although there are many variations on the definition of carbon footprint Wiedmann and Minx⁸ have proposed the following succinct version:

*"The carbon footprint is a measure of the exclusive total amount of carbon dioxide emissions that is directly and indirectly caused by an activity or is accumulated over the life stages of a product."*⁸

In terms of reproduced sound we are considering the energy required to run a sound system specifically during its period of installation with any associated transport requirements as being direct emissions. Emissions involved in the manufacture and distribution of the audio equipment would be considered as indirect emissions. Full consideration of these emissions are beyond the scope of this paper and the paper assumes some knowledge of the energy requirements of installing and running an audio system.

3 SUSTAINABILITY GUIDANCE DOCUMENTS, RESEARCH AND POLICY

3.1 Julie's Bicycle

Early investigations into environmental sustainability in the music industry were carried out by the consultancy and thinktank organization Julie's Bicycle. In 2007 they conducted a greenhouse gas emissions survey of the UK music industry. Their key findings with regards to emissions were:

- *Live Performance – In the order of 75 million tickets are sold annually, 90% are venue-based and 8% are music festivals. There are ~2,200 venues in the UK regularly playing live music and almost 500 festivals annually. A music venue with a capacity of 2,000 people is likely to produce over 400 t CO₂e per year. A large music festival (more than 40,000 people) including audience transport will produce in the order of 2,000 t CO₂e.*
- *Live music performance sectors together with audience travel account for three-quarters (~75%) of the UK music industry's GHG emissions. Recorded music sectors account for a quarter (~25%) of GHG emissions.*⁹

The report recognised that 'it is clear that there is widespread support for coordinated industry actions on climate'⁹ and made several recommendations, including:

- *In the short term, it is proposed that reducing the industry's own carbon footprint should be the clear priority.*
- *In the medium term, the industry should identify its 'levers of influence' and use these to effect policy interventions and public education on climate*
- *The music industry is centrally influential in lifestyle choices and therefore has an opportunity to be an important leader in the transformation to a low carbon economy, as emissions are closely tied to decisions on lifestyle. As a service industry, it could and should be an exemplar in the UK and internationally for demonstrating how business works in partnership with its sub-contractors and customers to transform its products and services; to minimise the emissions generated; and to bring an amplified voice for changes in the energy infrastructure and for a drive towards a low carbon economy. The mobilisation of the industry's critical mass will be key to its becoming a climate leader.*⁹

Since this report, Julie's Bicycle have widened their scope beyond just the music industry and have been active producing a wide variety of guidance documents related to environmental sustainability in the creative industries which are available on their webpages. Their latest piece of survey work, 'Sustaining Creativity Survey: Actions and attitudes from the creative community: environmental sustainability 2014' provides an interesting snapshot of current attitudes and development and could be seen as a natural follow up to the 2007 emissions survey. The research presents the following headline trends:

- *High engagement across the sector, with strong affirmation of the importance of sustainability, and an emergent vision and desire to lead change. The strongest driver for engagement is the personal commitment of staff.*
- *Encouraging levels of action, with scope to further embed environmental sustainability into operations and communications of most organisations. Around half of organisations have also created work that concerns environmental sustainability, though very few consistently focus on this.*
- *For many, action leads to financial and/or reputational benefits, though environmental sustainability is yet to be perceived as a core business concern by executive and non-executive directors.*
- *Appetite to come together and take a lead through peer groupings, knowledge transfer and networking.*

- *Despite the high engagement level and the financial and reputational benefits of incorporating environmental sustainability, there remains a value-action gap (the gap between the values and attitudes of an individual/organisation, and the actions. This is true of the population as a whole.) Environmental sustainability is seen as a priority but actions do not match attitudes.*¹⁰

From these findings it appears that whilst there has been some promising developments in practice and a clear appetite for change, there remains a lack of action and the recommendations from 2007 have not really been followed up on.

Julie's Bicycle, in partnership with Arts Council England have developed a 'Creative Industry Green Certification' scheme that 'has been running for five years and has certified almost 200 organisations to date'¹¹. Partnered with an online carbon calculator 'Creative IG Tools' it 'provides a rigorous, independently assessed approach to the understanding, management and sustained reduction of your environmental impacts' allowing measurement of 'Energy, Water, Waste and recycling, Transport and travel and Production materials'. The calculator includes tools for 'Festivals and outdoor events', 'Venues and cultural buildings', 'Offices, Productions and Tours'¹¹. This certification, although not widely taken up by the industry is aligned with key international standards and is a valuable tool for creative businesses.

3.2 Albert

The BAFTA Albert Consortium members include all3media, BBC, Channel 4, Endemol, IMG, ITV, Kudos, NBC, Universal International Television, Sky, Shed Media, Twofour and UKTV'¹². Established in 2011 it is 'the leading think-tank on sustainability for film and television, working to raise the profile of sustainability in the industry, championing sustainable production techniques and freely providing the tools, guidance and direction needed to reduce the impact of moving-image media production on the environment'¹².

One of the key initiatives of the Albert consortium is the albert+ standard. Based on original research and development by the BBC, albert+ is a 'mark of sustainability which indicates that the programme has taken steps to manage and reduce its environmental impact during production'². Although Albert focuses on the production process for TV programmes there are many parallels with live music event production and considerations such as travel, energy use on location, waste disposal and equipment supply chain are all pertinent to live music events.

Albert provides a checklist for production companies to work to covering 'General' issues, 'In the office', 'On location', 'Transport', 'Sets, props and wardrobe', 'In the studio' and 'Post production and show launch'. Many of the issues in this checklist can easily be applied to reproduced sound projects and a selection of these are shown below:

General

- *Consider how to make the biggest cuts to the footprint Albert's predicted for your production*
- *Write a simple statement of intentions and goals*
- *Nominate a senior individual responsible for sustainability*
- *Tell all cast, crew and supply chain about the plan as soon as possible*

Travel

- *Use Albert to estimate your travel carbon footprint and commit to cutting to a minimum*
- *Devise a travel plan based around low-carbon vehicles, public transport usage and reduced mileage*
- *Request low-carbon vehicles from all suppliers*
- *Cut the number of vehicles needed by making sure each vehicle is full*

On Location

- *Ensure your work will not impact on wildlife or vegetation*

- *Devise a sustainable transport plan for getting cast and crew to the site*
- *Choose local accommodation providers where possible*
- *Keep meter readings of energy consumption on site*
- *Research generator efficiency and go with the best*
- *Keep generator use to a minimum*
- *Provide clearly-signed recycling points for all main materials*
- *Be aware of legal requirements under ISO 14001*²

Much of this advice is clear and straightforward and easy to implement for anyone working within the reproduced sound industry. This could easily be developed and adapted into a checklist for sound system design, installation and operation.

3.3 The Broadcasters

Being publically funded, corporate responsibility is high on the agenda at the BBC and the corporation has a strong sustainability policy called 'The Difference' that is highly visible on their webpages. The BBC is also one of the key early partners in the Albert project. The Difference focuses on five areas:

- *Get the basics right – reducing the impacts of the infrastructure we provide and operate, for example by investing in energy efficiency for our buildings and technology;*
- *Improve how we work – addressing our own behaviour, for example by reducing travel by increasing video conference use and using bespoke tools such as albert the carbon calculator for TV production to encourage good practice;*
- *Work with our suppliers – improving the sustainability of the products and services we procure;*
- *Lead the industry – embedding sustainability in the TV production process and working closely with partners in the broadcast industry;*
- *Engage our staff – encouraging and enabling sustainable behaviour by BBC staff across the organisation through training courses and awareness campaigns.*⁴

Sky's corporate responsibility agenda is titled 'The Bigger Picture'. This is a very wide ranging agenda of which environmental sustainability is only a small part but the corporation does have the following goals for 2020:

- *Halve our emissions relative to revenue*
- *Increase energy efficiency by an average of 20% across all buildings by setting energy performance targets*
- *Sky-owned sites to obtain 20% of their energy requirement from owned or controlled renewables*
- *Increase fleet fuel efficiency by 15%*
- *Reduce CO₂ emissions from travel by 20% per full time equivalent (FTE) employee*
- *Achieve zero waste to landfill at our main offices*⁷

Channel 4 also place their environmental policy within their corporate responsibility and as part of this have a commitment to 'energy, waste and water reduction targets'⁵. ITV have a dedicated corporate responsibility webpage outside of itv.com (itvresponsibility.com). Their priorities listed here are:

- *Limit our contribution to climate change by managing our energy use more effectively;*
- *Minimise waste by evaluating operations and ensuring they are as efficient as possible;*
- *Minimise emissions through the selection and use of transport and energy requirements;*
- *Actively promote recycling both internally and amongst customers and suppliers;*
- *Work with our key suppliers, customers and other stakeholders to develop and identify opportunities to improve environmental performance;*
- *Comply with all relevant environmental legislation, regulations and codes of practice;*

- *Identify KPI's, measure and monitor the key environmental data;*
- *Actively work towards the goal of a year on year reduction of energy and water consumption measured per employee.*⁶

3.4 BS ISO 20121:2012

This guidance document titled 'Event sustainability management systems — Requirements with guidance for use' was released in 2012 and was developed from BS 8901:2007, 'Specification for a sustainable event management system with guidance for use'¹³. BS 8901:2007 itself was developed as a result of the organising team for the London 2012 Olympics recognising the importance of sustainability as part of the event and a desire to formalise and share good practice in this area.

The document provides a very generic framework for event sustainability with a strong emphasis on documentation and tracking with clear and strong management of the whole event process from planning and procurement through to evaluation. There is, however, some useful guidance for the audio side of events, with energy efficiency of equipment, choice of renewable energy sources, transport and logistics and noise levels all being identified as key issues¹⁴.

Of particular interest are comments relating to supply chain management and good practice which is relevant to the relationships between event management and organization teams and those providing audio services. There is particular emphasis placed on developing a dialogue with suppliers.

*Supply chain management is the practice of improving the way a company finds the products or services it needs for its customers. A company's success is intertwined with the actions, practices and products of its suppliers. Best practice is to develop and refine sustainable procurement policies and maintain clear and open communication with suppliers.*¹⁴

The organization should select from appropriate approaches, tools and techniques to assess and manage sustainable procurement. These include the following:

- a) weighting/scoring systems: quantitative/qualitative ways of assessing the merits of proposed solutions applied to the KPIs;
- b) life cycle assessment and whole life costing: the real impacts of products and/or services based on a "cradle-to-cradle" approach, i.e. a holistic approach which assesses the environmental aspects and potential impacts associated with the manufacture, use and disposal of a product;
- c) the environmental purchasing hierarchy: "rethink, eliminate, reduce, re-use, recycle, dispose", an approach to minimizing natural resource impacts which is similar to the waste management hierarchy;
- d) supplier code of conduct, which can be employed by the contracting organization in order to ensure that their suppliers conform with the environmental, social and ethical elements of sustainable procurement,
- e) industry best practice: standards for sustainable development management for specific industry sectors/areas defined by the industry and representing the industry's assessment of appropriate performance levels;
- f) best value, defined by the UK government as "the optimum combination of whole life costs and benefits to meet the customer's requirement"^[14]; this approach enables sustainable development, including quality management, to be taken into account when service delivery options are being considered.

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3.5 BS EN ISO 14001:2015

'BS EN ISO 14001:2015, Environmental management systems — Requirements with guidance for use'¹⁷, has recently been rewritten and 'specifies the requirements for an environmental management system that an organization can use to enhance its environmental performance'. This

is a much more wide reaching document than BS ISO 20121:2012 and is intended to support the long term development of an organisations environmental sustainability policies. It focuses on leadership, management, policy and monitoring. It provides much useful guidance on how to run an organisation in an environmental sustainable way. It is a widely known international standard that has been in operation in various forms for 20 years. The British Standards Institution offer a certification route against BS EN ISO 14001:2015 for organisations. The document includes a really nice summary of key considerations for organisations.

When determining its environmental aspects, the organization can consider:

- a) emissions to air;
- b) releases to water;
- c) releases to land;
- d) use of raw materials and natural resources;
- e) use of energy;
- f) energy emitted (e.g. heat, radiation, vibration (noise), light);
- g) generation of waste and/or by-products;
- h) use of space.

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3.6 Professional Bodies

The Institute of Engineering and Technology IET have sustainability written into their rules of conduct for members which suggests that sustainability should be a part of all members daily professional practice.

9. Members shall take all reasonable steps to avoid waste of natural resources, damage to the environment, and damage or destruction of man-made products¹⁵.

The Institute of Acoustics (IOA) have a sustainability task force in place which are running workshops and seminars to progress discussion in the area. This has yet to result in any formal guidance but it is promising to see these discussions taking place. The IOA code of conduct includes a statement with regards to the environment, stating that members should not 'needlessly pollute the environment except when legally authorised to do so'¹⁶. At the time of writing there is no sustainability agenda or publications within the Audio Engineering Society.

4 AUDIO EQUIPMENT AND SUPPLY CHAIN

4.1 Audio Equipment

The audio industry is not always known for direct technical innovation and more often benefits from 'trickle down' from developments in other industries. Developments in materials science, digital signal processing and power electronics have all been extensively applied in interesting and novel ways in the audio industry. Examples of this include using composite materials in loudspeaker cones and employing DSP chips designed for medical and military use in an audio context.

Much of the development in the audio world, particularly with regards to amplifiers and loudspeakers, has been a quest for more power in lighter and more affordable packages. This can be seen in the progress of Class D amplification and the use of lightweight materials and powerful rare earth magnets in loudspeaker drivers. Amplifiers and loudspeakers are now more efficient than ever and it is possible to design and install audio systems that exhibit extremely low power consumption for a given output sound pressure level. It can also mean the use of less equipment

overall for a given task, reducing transport requirements. This is clearly a good thing for the carbon footprint of any installation or event. However, with increased power and efficiency comes the temptation to use larger and larger systems for a given purpose. Efficiency is only a gain for carbon footprint if it is used to reduce the power consumption requirements of any given system.

The move to digital processing systems has revolutionized working practices in the audio industry and an easy assumption to make would be that digital devices would be more efficient than analogue circuitry for a given task. However, this appear not to be the case. A quick survey of key manufacturers digital and analogue mixing desk products (figure 1) suggests that often the analogue options exhibit lower power requirements than the digital equivalents and that there is no real pattern in the size and weights of the two formats.

It would appear that currently, digital architecture is not necessarily improving the efficiency and green credentials of our audio systems. Digital systems run on a completely different electronic architecture to analogue systems (closer to that of a conventional computer) and the power requirements of the banks of ADC/DAC/DSP chips are often greater than that of discrete analogue componentry. There is also a tendency for manufacturers to try and incorporate as much processing as possible into a digital device which can increase power consumption.

There is more work to do here in terms of a wider survey into energy consumptions of audio equipment. With so many audio systems running on a DSP architecture, there is also much to learn from the area of 'green computing' with regards to lightweight and efficient processing options and how some of the latest research here can be incorporated into the audio world.

Make/Model	Format	Size	Weight	Power Consumption
Yamaha MG32	Analogue	1,027 x 169 x 565mm	19kg	86W
Yamaha TF1	Digital	510 x 225 x 599 mm	13.5kg	100W
Behringer EURODESK SX3242FX	Analogue	100 x 896 x 410 mm	11kg	50W
Behringer X32	Digital	900 x 528 x 200 mm	20.6kg	120W
Mackie 3204VLZ4	Analogue	269 x 584 x 1080 mm	20kg	65W
Mackie DL32R	Digital	224 x 538 x 533 mm	10.4kg	100W
Allen and Heath GL2400 32ch (with RPS PSU)	Analogue	560 x 150 x 1025mm	26.5kg	300W
Allen and Heath GLD80	Digital	730 x 577 x 159mm	16.5kg	95W
Soundcraft LX7ii 32ch	Analogue	503 x 164 x 1059mm	23kg	60W
Soundcraft Si Performer 3	Digital	940 x 536 x 170mm	21.5kg	300W

Figure 1 – Popular analogue and digital mixing console sizes, weights and power requirements

5 DISCUSSION

5.1 The Key Messages

Government policy and media discussion suggests that environmental sustainability will continue to be an important aspect for any business activity and will only become a more important issue over the coming years. The summary research presented in this paper indicates that many of the major broadcasters in the UK have recognised this and have clear policies in place to incorporate environmental sustainability into their everyday operations with clear and ambitious targets. There is much to learn from these approaches for audio based activities.

Despite clear progress in the wider creative and engineering industries, the reproduced sound industry more specifically has yet to develop any formal guidance and policy in this area. The Julie's Bicycle research suggests that there is an appetite for change here, mostly driven by the personal desires of the practitioners involved, yet the critical mass to create significant change is not yet in place. The research suggests that despite a positive attitude towards environmental sustainability within the industry, the work to back this up are not being put into action as widely as is required to make a real difference.

The reproduced sound industry is in a position where the equipment available to it is the most efficient and sophisticated it has ever been. The research, policy and guidance from other industries is progressing strongly and there are clear mandates from the professional bodies to incorporate environmental sustainability into everyday practice. The choices available to audio engineers in terms of renewable energy sources, equipment and transport give us the a wealth of opportunities to choose more sustainable options for our activities. there should be no reason why the reproduced sound industry cannot make significant developments in environmental sustainability in the coming years.

5.2 A 'Green Guidance Document' for the Audio Industry?

One aim of this paper is to consider what an environmental sustainability guidance document for audio engineers might look like and what it's key features might be. Most other guidance documents take the form of a series of statements or a checklist and this would seem to be the most sensible way to approach this.

5.2.1 General Considerations

There are several key features of all the policy and guidance presented in this paper and these are summarised below:

- Minimise transportation and use low emission vehicles and transport choices
- Use low emission or renewable energy sources
- Reduce overall energy use
- Recycle and minimise waste
- Consider the supply chain and use suppliers with strong sustainability policies
- Document and record sustainability activities
- Place the responsibility for sustainability on a senior member of the team
- Communicate your sustainability agenda strongly both within and outside of your organisation

5.2.2 Albert

The Albert standard provides a really strong base for audio events and installations. Many audio engineers who have worked within broadcast events may already be used to working within some of these constraints. Albert is seeing strong adoption in the broadcast industry and is backed by a wide range of significant organisations which should see it gain a strong base in the broadcast and

creative industries in the coming years. The Albert checklist issues as highlighted in the earlier section are all valid issues for audio engineers, however, there are many items on the full checklist that are not applicable and may cause confusion, such as wardrobe and set considerations. The Albert online carbon calculator is a useful tool for any event, installation or production. The structure of Albert is sensible and the breakdown of sections and the checklist nature could easily be adopted for audio. Albert is not a full solution for audio engineers but is useful guidance in general and the core messages are all applicable.

5.2.3 British Standards

BS ISO 20121:2012 is a very useful guide for one off events, but is most use when considered by event organisers rather than the engineers delivering the audio services. BS EN ISO 14001:2015 is very much focused on long term development of environmental policy within an organisation and most applicable to small to medium sized businesses with a management structure in place. Both are designed to be used as standalone general frameworks for either events or organisations but are short of detail and specifics to be of use to audio engineers.

5.2.4 Audio Specific Considerations

There are a few more specific issues for audio engineers to bear in mind when designing, commissioning, using and installing audio systems, in addition to the guidance from Albert, Creative IG Tools and BS ISO 20121:2012. These are:

- Choosing the most efficient and lightweight equipment for a given task
- Using sound systems in the most energy efficient way
- Careful choice of equipment supply chain to ensure renewable materials are used
- Engaging with supply chain manufacturers to encourage dialogue and development of sustainable policies

5.3 Further Work and Recommendations

One key aspect of this paper is to consider what a sustainability guidance document might look like and the next stage of research is clearly to develop this and put it into practice. However, this will require a period of research and discussion into how best to approach this and whether there is an appetite among the key organisations to support this.

There is currently a sustainability task force in place in the Institute of Acoustics which mainly focuses on sustainability in building and environmental acoustics. It would be great to see a sustainability policy developed for the Electroacoustics special interest group which could be used to influence further policy within the audio industry.

There is potential for a wider survey of new audio systems and their energy consumption and efficiency with a particular focus on the energy consumption of real world systems when commissioned for one-off events or as permanent installations. An interesting aspect of this would be to consider how audio engineers can use audio systems more efficiently and whether good practice can be developed here.

Audio engineers need to work more closely with manufacturers to ensure the environmental sustainability of the supply chain for any audio installation or event. An exercise to assess the sustainable credentials of various audio manufacturers would allow engineers to make a more informed choice when specifying and commissioning systems. This could involve some form of rating system or kite mark system.

6 CONCLUSIONS

It is clear that environmental sustainability as an agenda for audio companies and audio practitioners will continue to be an important part of their activities. There is a clear mandate to consider environmental sustainability written into the code of conduct for members of both the IOA and the IET. Whilst there have been some interesting research and discussion of environmental sustainability in audio this has yet to have a significant impact on policy and practice. Further work is required within special interest groups, and in general, to raise the profile of this important issue and to work towards policy and guidance for audio engineers and those engaged in audio related activities. Audio engineers have access to the most sophisticated, lightweight and efficient tools that have ever been available to them and the ability to make a real difference to practice within the industry.

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