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Will Cities Survive?

Carbon Neutral Music Venue:
A Sustainable Urban Development

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ABSTRACT: The viability of cities in the future will depend on whether they can offer facilities and opportunities for residents whilst maintaining a sufficiently low environmental impact. Cities encompass more than just buildings; they are complex organisms comprised of layers of social, economic, political, environmental and cultural systems. Taking this complexity into account will benefit attempts to implement reductions of CO2 emissions. An approach to this challenge is explored through a case study of a music venue with an integral community centre. A short review is provided defining carbon neutrality and examining current work towards reducing emissions in the music industry. The development of a methodology is described and results of modelling the venue's total CO2 emissions from Scope 1, 2 and 3 activities are given. Options for refurbishment and renewable energy systems are compared with emissions from the wider organisational activities of staff and audience travel, and proposals for emissions reductions are discussed. This work is being used to formulate a roadmap for the organisation to reach its goal of carbon neutrality. The approach described aims to provide a model for organisations seeking to reduce emissions, thereby allowing them to contribute more positively to the future of their cities.

KEYWORDS: Carbon emissions, energy use, refurbishment, sustainability

1. INTRODUCTION

Globally, business sectors are moving towards sustainability initiatives to help achieve the goals laid out in the Paris Climate Agreement, which are to keep the global temperature rise this century well below 2◦C above pre-industrial levels, with a further aim of reducing the temperature increase even further to 1.5◦C (United Nations, 2015). The arts and culture sector are recognising their own role and have begun addressing the need to develop more sustainable festivals and events, and for artists to make touring decisions based on emission reduction obligations (Cummings, 2014).

Traditionally, 'sustainability' has been described as balancing three pillars of longevity: financial, environmental and social (Brennan et al. 2019). Hawkes (2002) meanwhile cited culture as the 'Fourth Pillar of Sustainability', arguing that 'a society's values are the basis upon which all else is built. These values and the ways they are expressed are a society's culture.' Or, to put it another way: without integrating certain cultural norms into sustainability practice, the other three pillars of sustainability will fall. The founding constitution for UNESCO (UNESCO, 1945) explicitly mentions culture as one of the areas which has the potential to transform societies. This paper will start to explore the relationship between the music industry, communities, and the minimisation of carbon emissions.

2. BACKGROUND AND LITERATURE REVIEW

This section reviews literature and previous research concerning carbon emissions from the music industry overall, discusses carbon neutrality, and gives an overview on the methodology for calculating a baseline carbon footprint.

2.1 Carbon Emissions in the music industry

Increasingly, the arts and culture sector are recognising their own sizeable contribution to greenhouse gas (GHG) emissions and are addressing the need to develop more sustainable festivals and events (Cummings, 2014). Despite more recent awareness, Brennan et al. (2019) notes that an advertised interest in sustainability has been present in music festival culture since at least the 1960s, but actions typically do not reflect the rhetoric. For example, music festivals where rural land areas are transformed into music villages or cities have been found to be particularly damaging (Mair and Laing, 2012). Julie's Bicycle, a foremost environmental consultancy for the British music sector, estimated in 2007 that the UK music market resulted in emissions of 540,000 t CO2e (Bottrill et al. 2007).

Despite growing recognition of the need to minimise carbon emissions within the music and culture industries, serious attempts to calculate and control emissions are rare. Brennan et al. (2019) and Upham et al. (2009), provide bases for calculating the carbon footprint of either a single music event/festival or a tour. Although these examples are both for a one-off event, they can serve as a blueprint to defining the calculation for a permanent venue. As Brennan et al. (2019) notes, many calculations only take into account onsite emissions and do not consider indirect emissions, such as audience travel. This is a critical exclusion and could result in an underestimation of up to 75% of overall emissions (Bottrill et al. 2007). Another study by Bottrill et al. (2010) found that audience travel resulted in 43% of the overall emissions from the UK music market.

2.2. Carbon Neutrality: Description and problems

'Carbon neutrality' implies that all outgoing carbon emissions are balanced or neutralised by some method of carbon sequestration. Most often, organisations achieve this by purchasing external carbon offsets through carbon sequestration projects, such as reforestation schemes. These offset schemes often are misguided or fail (Strand 2011). For example, the band Coldplay claimed that production of a 2006 album achieved carbon neutrality by supporting a reforestation project, but it was found that only a fraction of the planted trees survived for even one year (Dhillon and Harnden 2006).

Although carbon offsets can be less expensive upfront than other solutions, there is a considerable risk that relying on carbon offsets 'justifies continued inaction and shifts the burden of emission reductions to other sectors and future generations' (Scott et al. 2016). Worse, offsets could even have an increasing effect whereby they lull buyers into a false sense that their carbon emissions are removed from the atmosphere, and they can therefore make no efforts to reduce emissions (Peeters et al. 2016).

A better path is thus to first aim for ultra-low emissions to reduce the reliance on carbon offsets, and then seek to fund local projects with high potential impact or internal emissions reduction schemes as an alternative to offsetting.

2.3 Calculating a baseline carbon footprint

Achieving reduced emissions or working towards zero emissions requires quantification of a baseline carbon footprint. Various guidelines, such as the GHG Protocol (2013) and WBCSD and WRI (2012), describe a methodology where emissions are typically categorised as Scope 1, Scope 2 and Scope 3, defined as;

- Scope 1: direct emissions that the venue is in control of such as those resulting from fuel burned on site (e.g., the units of gas used annually for heating and cooking).
- Scope 2: indirect emissions such as the electricity purchased to power the site;
- Scope 3: all other indirect emissions, which can cover all aspects related to the activities of the organisation or within the company's value chain.

Scope 3 emissions are often neglected or considered not within the company's direct operations (see for example Hertwich and Wood (2018); Patchell (2018); Thomas et al. (2020)). Increasingly however, the sizeable contribution of Scope 3 to the overall emissions is being recognised, and it is therefore considered essential to both estimate and reduce them as much as possible.

3. METHODOLOGY

The methodology described here is based on guidelines from GHG Protocol (2013), WBCSD and WRI (2012) and suggestions by Bottrill (2010) and will attempt to encompass the building operations (i.e., Scope 1 and 2) as well as explore the Scope 3 impact of transportation of building users. Guidelines and carbon conversion factors are available from Defra (2019), and are used to convert usage values to tonnes of emitted CO2 (t CO2e) using the following formula:

$$GHGe = \text{activity data} \times ECF \quad (1)$$

where GHGe = GHG emissions
ECF = emission conversion factor

3.1 Quantifying Scope 1 and 2 emissions

For Scopes 1 and 2 (in this case, gas and electricity) the methodology may be used both for scenarios where primary energy data is available and also where it is unavailable. For the former scenario, bills or meter values can be obtained to directly quantify electricity and gas usage. For the latter scenario, Building Performance Simulation (BPS) or a simplified method capable of calculating heat flows may be used. Ideally both BPS and primary energy data are available, with BPS used to explore potential refurbishment scenarios and metered data used to calibrate the simulation results.

BPS is used to determine heating and cooling loads of the building. There are also benchmarks for energy use (electricity and thermal) that can be used (e.g., CIBSE, 2008) but these will not allow retrofit options to be explored in any detail. However, they can enable quick estimations of emissions for comparison with emissions from other aspects of the building operation.

3.2 Quantifying Scope 3 emissions due to transportation

Although publications such as GHG Protocol (2013) provides some instruction to quantify Scope 3, there are 15 categories covering all upstream and downstream operations and it can be difficult or impossible to obtain accurate or acceptable data for each category. Navigating issues with data quality and inconsistencies are given by PCAF (2020), who assigned the following reliability scores for different types of data:

- Score 1 (highest): Audited emissions data or actual primary energy data.
- Score 2: Non-audited emissions data, or other primary data.
- Score 3: Averaged data that is peer/sub-sector specific.
- Score 4: Proxy data based on region of country.

Whilst a comprehensive analysis of Scope 3 should attempt to include data across all categories outlined by the GHG Protocol (2013), the present research will seek to focus only on the highest emitting activity, as described by Bottrill (2010): audience transport. Carbon emissions from materials used in the refurbishment could be relatively easily quantified as sufficient databases exist (e.g. Hammond and Jones, 2008), but are not addressed in this paper as low quantities of materials are being used in the refurbishment. Considering the reliability scores outlined by PCAF (2020), it is suggested that the following three methods could be used to obtain audience travel data:

1. Model audience transport habits based on estimated number of audience members and previous data collected on typical transportation methods used (Score 3/4);
2. Conduct surveys of audience members where survey responders are asked how far they travelled to the venue and by what means of transport (Score 2);
3. Utilise mobile phone data using transport apps to track exact travel distances and method of transport used for all consenting audience members (Score 1).

From the data of distance travelled and transport method used, the overall carbon emissions output can be calculated using equation 1. The same methodology is used to predict transport emissions of regular commuting staff as well as artists and performers traveling to an event.

4. FUTURE YARD CASE STUDY

Future Yard, an event and recording venue in the Wirral, United Kingdom, is an organisation with strong links to the cultural life of the city and surrounding areas. The following section illustrates the range of factors involved in the quantification of emissions for the Future Yard live music venue. The initial aim of the organisation was to explore aspects of how it could approach and integrate sustainability into its operations, and as a first step the goal of 'net-zero' emissions was considered (Future Yard, 2022).

4.1 Building and operation

Future Yard is housed in a Victorian brick building with a single storey extension. The building contains a concert hall, café and bar, offices and workspaces, and changing rooms. A basement will be converted to small practice studios, as will the large space above the concert hall. The walls of the main building are solid brick, and all roofs are currently uninsulated.

The organisation requested information on exactly how carbon emissions were generated from day to day in order to understand how to reduce emissions through the refurbishment, and to explore how changes to the buildings operation and its fabric could alter emissions levels under Scopes 1 and 2. Information was also required to facilitate decisions on which parts of the building to renovate first, and which could be left until a later date.

The building occupation varies greatly from day to day, for example on some evenings there are large audiences while on others there are small teaching classes. The café is open all day and evening as are some of the music practice rooms. There are greatly increased heat gains and ventilation rates when a concert is held in the main hall. The design of the services will therefore have a large influence on emissions and at this stage these were only considered in outline, for example use of existing gas boiler for heating and Mechanical Ventilation and Heat Recovery (MVHR).

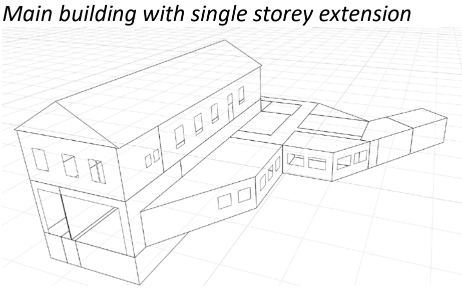
4.2 Scope 1 emissions: Refurbishment and building operations

Low carbon in-use strategies (e.g. GBC, 2019) often include the following stages or similar;

1. Reduce heating and cooling and other loads as far as practicable
2. Design efficient systems that provide optimum carbon performance
3. Supply the energy that is required in a form that minimises carbon emissions.

To date the work has focussed on Stage 1: reducing heating and cooling loads. If these loads are minimised the heating and cooling systems that are designed in Stage 2 will be smaller and more economical to install and run. Stage 3 involves a combination of choosing how heat will be generated (gas, electricity and/or environmental heat) as well as assessing whether electricity can be generated onsite using renewable energy technologies**.**

Figure 1:
Main building with single storey extension



As the building had been in partial and intermittent operation for only a few months utility bills were of limited use, so a BPS model was made using a comprehensive whole-building simulation tool (IES, 2022). Detailed occupancy profiles were used to assign plant operation, heat gains, and ventilation rates to each space. Other data, such as heating set points, were set using industry recommendations. Refurbishment options were considered, and after consideration of budgets and timescales for opening the venue, a number of these were modelled (table 1).

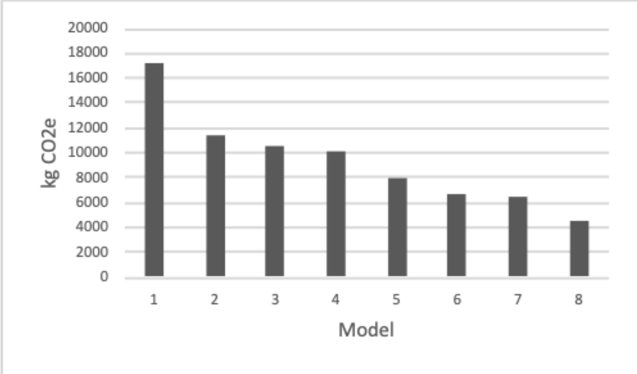
Table 1:
Renovation measures modelled

Model	Heating	Insulation (mm)		MVHR
		Roof	Wall	
1	All year	0	0	No
2	HSO	0	0	No
3	HSO	100	0	No
4	HSO	200	0	No
5	All year	0	0	Yes
6	HSO	200	0	Yes
7	HSO	200	50 (studios) [1]	Yes
8	HSO	200	100 (ext wall) [2]	Yes

HSO: Heating season only
[1] 50mm EPS to studio internal walls only
[2] 100mm EPS to external wall in heated area only

These scenarios test only the most basic strategies, in order to produce figures for comparing with other, non-building related, emissions. In the UK the roofs of the original uninsulated building would need to be insulated to satisfy building regulations, but it was thought useful to consider strategies separately (e.g. use of MVHR without insulating the building, and insulation of the building without MVHR) to enable the organisation to understand all the contributory factors of organisational emissions. A main aim of the modelling was therefore to provide the organisation with an understanding of context, with which to inform later decisions. Simulation results are presented in Figure 2.

Figure 2:
Annual heating emissions for the refurbishment options



For model descriptions, refer to Table 1

Models 1 and 2 show the emissions due to all year heating operation, and heating season only. Comparison of Model 2 with 3 and 4 shows the effect of 100mm and 200mm insulation respectively in the roof. The rather small improvements are due to the insulative value of thick plaster ceilings in the existing building.

Comparison of Models 2 and 6 show the effect of MVHR only (no insulation) which is large when compared to adding the insulation. Given that Building Regulations will require insulation to be added anyway, this result highlights to the client the potential significance of using heat recovery. Model 7 demonstrated that although sound insulation was needed in the practice studios it will have little effect on energy use as only one wall of each studio is an external wall, and half of the studios are in the basement where heat losses through the thick walls to the surrounding earth are relatively low. By contrast, Model 8 added 100mm insulation to the inner face of the external wall in all heated spaces, resulting in appreciable savings.

4.3 Scope 2 emissions: Electricity imported

Electricity consumption was estimated using benchmark figures, applying the relevent benchmark to the area of the building occupied by a particular use (CIBSE, 2008) and are shown in section 4.5 below. The benchmarks are pesimistic and actual electricity emissions would be lower as the hours of use of the concert hall are far less than the benchmark assumption, but the methodology will not permit an adjustment (ibid). A more accurate calculation of electricity consumption can be made when the plant is being designed and specified.

4.4 Scope 3 emissions: Travel

The planned number of concerts, educational classes, use of studios etc., and the anticipated staff, artist and audience numbers were used to calculate travel related emissions (table 2). The distances travelled are based on a knowledge of the audience and previous experience. The modes of transport were estimated based on data collected from a Liverpool Live Music Census (Padilla, 2018). Other indirect emissions are beyond the scope of the current paper but will be quantified in future work.

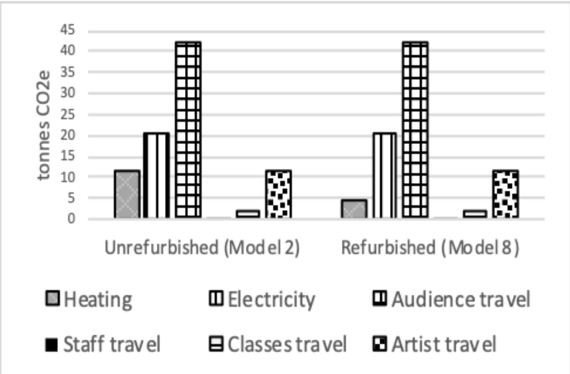
Table 2:
Scope 3 emissions from travel

Group	Annual emissions (kg CO2e)
Audience	42438
Staff	425
Classes	2121
Artist	11290

4.5 Comparison of scope 1, 2 and 3 emissions:

It is immediately clear that audience travel is the main emitter (figure 3). This result indicated clearly to the organisation that initiatives related to travel should be considered.

Figure 3:
Emissions for unrefurbished and refurbished building



4.5 Renewable energy options

The main building has a large south facing unobstructed pitched roof area and a flat roofed extension, both suitable for photovoltaic panels. The site is also suitable for air source heat pumps.

Table 3:
Emission savings from use of photovoltaics

Element	Area (m^2)	Power (Wp/m^2)	Energy (kWh.a)	Annual saving (kg CO2e)
Pitched roof (S)	140	180	25200	6441
Flat roof	280	126	35300	9018

A PV calculator indicates that the two roofs would generate 76% of the electricity requirements of the building and reduce emissions by 15459kg CO2e, further accentuating the dominance of travel related emissions (table 3). There is sufficient additional space above the yard at the rear of the building such that all the electricity required by the building could be generated. The use of some of this electricity to run air source heat pumps would lead to further reductions of gas heating related emissions. Although there is not a large requirement for hot water in the building, Solar Hot Water generation is also an option for this site and could be used to meet a significant proportion of the heating demand.

5. DISCUSSION

The results confirm earlier work that shows audience travel to be a major contributor of emissions for music and cultural venues. Future Yard are keen to consider how these emissions could be reduced, and as a socially active and creative organisation they also appreciate their relationship with their audience and musicians and are interested in whether this relationship can increase the effectiveness of any sustainability initiatives. Initial ideas related to transport include;

- Organise concerts to end earlier to allow audience to catch last bus or train
- Discuss with transport providers the provision of a late services
- Initiatives to reward people who do not drive, such as reduced cost tickets.

Schwanen et al. (2012) discuss the importance of habit change in impacting lower carbon transport and discusses the concept of embodied intelligence to affect the 'gradual change of actions from within'. It is here that the cultural sector and venues such as Future Yard could be an especially compelling messenger.

The building related emissions are less than Scope 3 emissions, and can be addressed through retrofit of building fabric, provision of efficient services, and energy generation using renewable energy technologies. If this work is done in a way that can be communicated, it could provide educational value and possibly influence the behaviour of the audience. Visible metering of energy generation and consumption is one such communication technique and could be effective in this case. Other initiatives can be envisaged such as allocating a percentage of the ticket price to pay for PV panels, or mounting air source heat pumps and PV panels where they are visible to visitors.

The results also raise the question of whether and how far an organisation should take responsibility for emissions related to their operations.

6. CONCLUSION

The methodology described is largely conventional in its modelling of emissions, but the inclusion of Scope 3 emissions prompts an initial exploration of relationships between the building, the organisation and the city and hence can focus attention on emissions reduction opportunities that might otherwise be missed. It is important to engage with the complexity of the interrelated technical, social, cultural and economic systems as these are the systems that make up the city and if dealt with separately will leave 'gaps' between them.

The case study illustrates that emissions calculations can be made using approximate and detailed calculation methods as are appropriate for the project under consideration.

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