# REDUCING ELECTRICITY RELATED GREENHOUSE GAS EMISSIONS AT MUSIC FESTIVALS

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## SUMMARY

There is great potential to reduce electricity related greenhouse gas emissions from UK music festivals. To help quantify this, electricity consumption data was monitored minute by minute, for over 70 different electrical power systems at over 18 music festivals in the UK from 2009 to 2012. These power systems supplied electricity for stages (lighting, audio and video), traders (groups of traders and individual bars) and site infrastructure (production areas, performers' tour buses and camp site lighting). The data was then analysed to produce typical consumption profiles of electricity use at music festivals. This analysis showed that there are opportunities to reduce electricity related greenhouse gas emissions at music festivals by reducing the demand for electricity, using electricity more efficiently and generating electricity with renewable energy. This can be summarised as (i) switching equipment off when not in use; (ii) specifying more energy efficient equipment (including more efficient generators); (iii) sizing generators more effectively; and (iv) substituting electricity provided by diesel to that provided by biofuels or solar photovoltaic.

## ELECTRICITY CONSUMPTION AT MUSIC FESTIVALS

Electricity consumption data was measured for 73 different activities at 18 festival events at 7 different festivals between 2009 and 2012. Based on these measurements, the total electricity consumption of a festival can be roughly broken down by thirds, in terms of stage related electricity consumption (audio, video, and lighting); trader related activity (food traders, non-food traders, bar) and site infrastructure (production areas, performers tour buses, festival lighting etc). These are expressed graphically below.

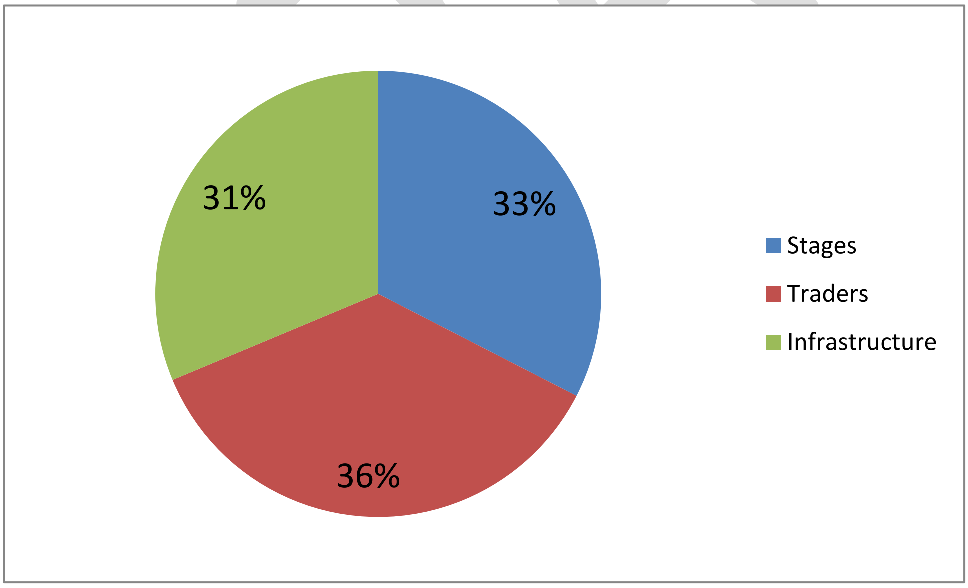


**Figure 1. Typical breakdown of electricity consumption by Stages, Traders and Infrastructure**

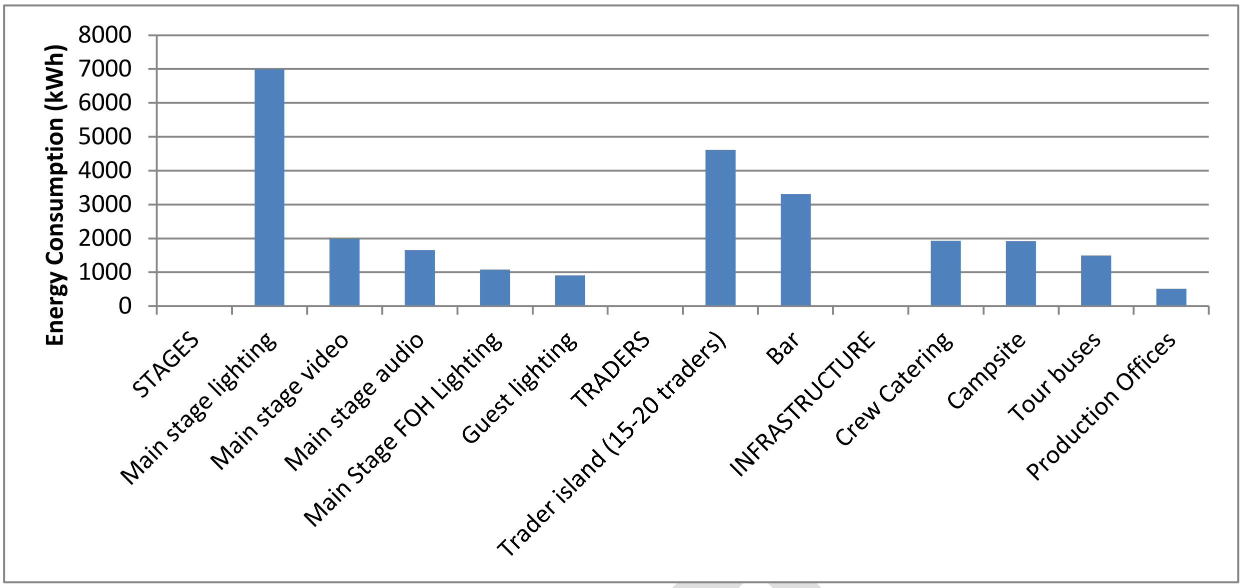


**Figure 2 . Typical consumption by activity**

The typical total electricity consumption by activity is shown in Figure 2. Each of these columns refers to one individual system on site, and not the entire demand for these systems across the whole site. FOH lighting refers to Front Of House lighting, used for safety lighting. Table 1 shows, for each activity, the typical maximum electrical demand (kVA) and the typical electricity consumption (kWh) over a festival event.

| | Total kWh | Max kVA |
|---|---|---|
| **STAGES** | | |
| Main stage lighting | 6,990 | 1,185 |
| Main stage video | 1,999 | 344 |
| Main stage audio | 1,657 | 229 |
| Main Stage FOH Lighting | 1,078 | 163 |
| Guest lighting | 908 | 589 |
| **TRADERS** | | |
| Trader island (15-20 traders) | 4,614 | 480 |
| Bar | 3,313 | 367 |
| **INFRASTRUCTURE** | | |
| Crew Catering | 1,933 | 382 |
| Campsite | 1,916 | 222 |
| Tour buses | 1,498 | 485 |
| Production Offices | 511 | 69 |

**Table 1. Typical maximum demand and consumption**

This shows that the maximum demand is highest for stage lighting at over twice the demand of the next largest (traders). Stage lighting is also the largest absolute energy consumer over the duration of festival, but only 50% higher than groups of traders. This is because lighting is used for a relatively short period of time throughout an entire festival, whereas electricity is used for traders throughout the Festival. It also shows that performers' tour buses are a significant load.

The following graphs show typical minute by minute consumption over a weekend festival. Figure 3 shows the consumption of stages (lighting, audio and video) and Figure 4 shows traders and infrastructure (groups of traders, bars, performers' tour buses and camp site lighting).

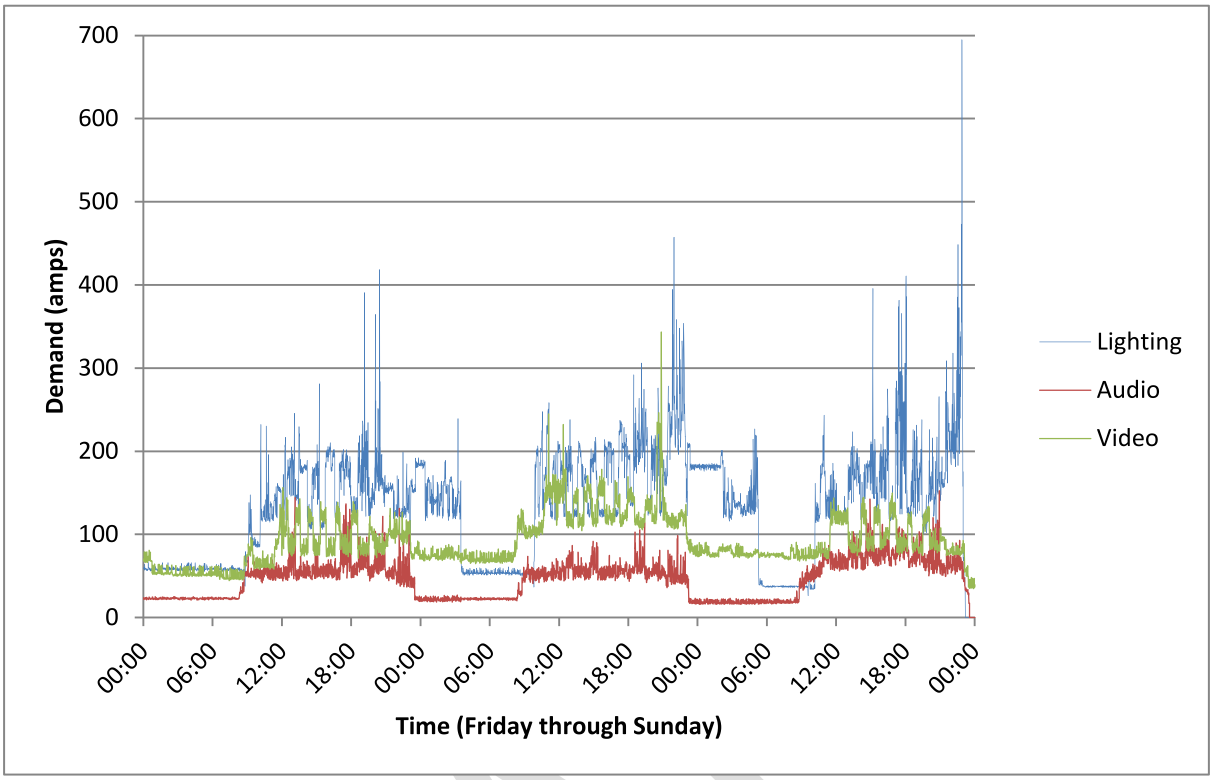


**Figure 3. Typical consumption profile for electricity use on stages**

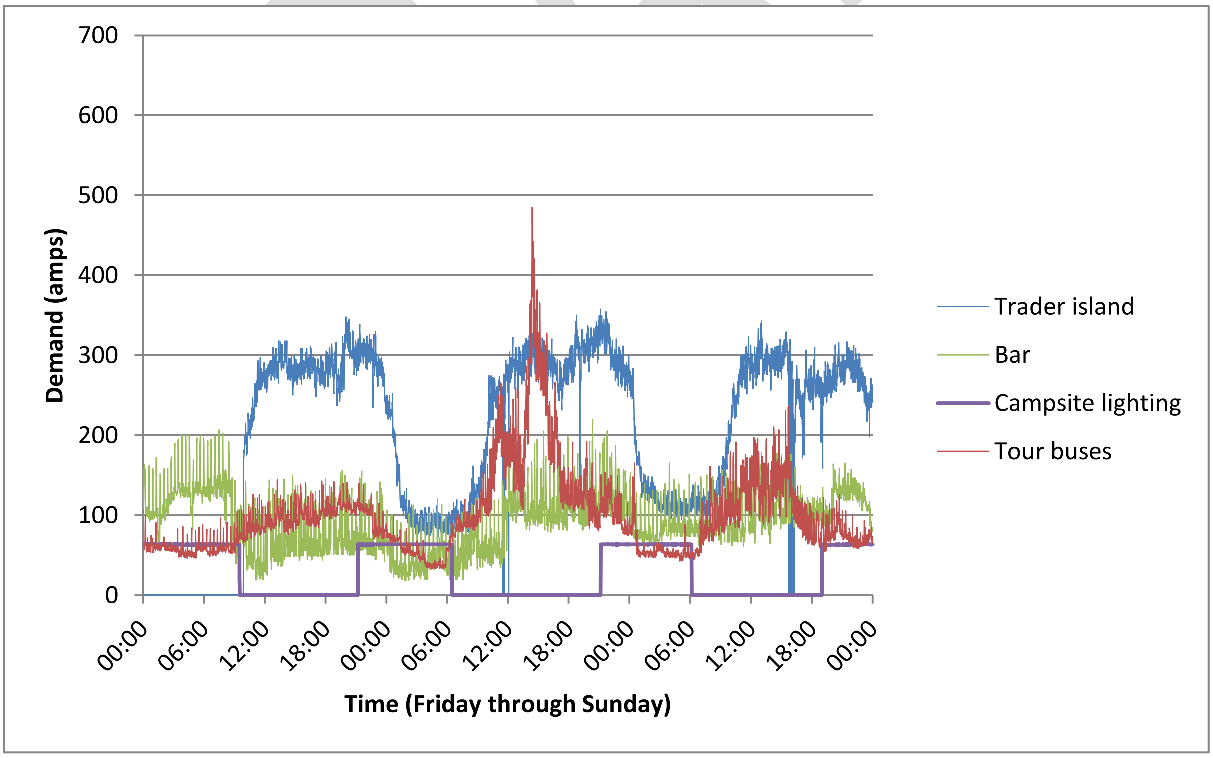


**Figure 4. Example consumption profile for electricity use for traders, bars, campsite lighting and tour buses**

**POTENTIAL EMISSION REDUCTIONS**

Analysis of the minute by minute data was carried out to identify potential greenhouse gas emissions reductions in terms of when equipment can be switched off, the potential to specify more efficient equipment, the potential to reduce the size of generators and, finally, the opportunities for using renewable energy.

**Switching off equipment when not in use.** The electricity consumption of the different activities at different time periods were compared with other time periods. Analysis showed that, for some periods, equipment was left on when it could have been switched off. An estimate of the potential savings is shown in the following table.

| | GHG reduction due to reduced overnight load | | | |
|---|---|---|---|---|
| | **Lighting** | **Video** | **Audio** | **Bars** |
| Percentage | 3 - 11% | 10 - 15% | 1 - 9% | 4 - 9% |
| Example of savings (kWh) | 199 | 245 | 121 | 140 |
| Example of savings (kg $CO_2$e) | 200 | 246 | 122 | 141 |

**Table 2. Potential emissions reduction from switching of equipment when not in use.**

**Specifying more energy efficient equipment.** Electricity consumption data for specific activities was calculated for the entire duration of the Festival. The potential electricity savings by replacing this equipment with more energy efficiency equipment was then calculated based on this actual consumption. Examples of more efficient equipment include Class D amplifiers, LED lighting (for stages, campsite, bars, traders, etc), more efficient refrigeration and more energy efficient beer dispensing equipment. Generators are much less energy efficient at low loading. The analysis of the data showed that many generators were operating at relatively low loads. The following table highlights the potential savings based on the data measured.

| System | Example system total demand | Reduction with new equipment (includes assumptions) | Estimated saving | |
|---|---|---|---|---|
| | kWh | | kWh | kg $CO_2$e |
| Lighting | 6,990 | 54% | 3,215 | 3,230 |
| Audio | 1,657 | 43% | 944 | 949 |

**Table 3. Potential emissions reduction from specifying more energy efficient equipment**

**Sizing generators.** One of the key issues highlighted by the monitoring was the relatively poor sizing of generators. Many were significantly oversized. More accurate sizing of generators can significantly reduce fuel consumption and reduce the costs of supply in the generators, since smaller units can be provided. Figure 5 shows the loading on 8 generators, with the maximum demand (top of the vertical line), the minimum demand (bottom of the vertical line) and the typical operating range (the column).

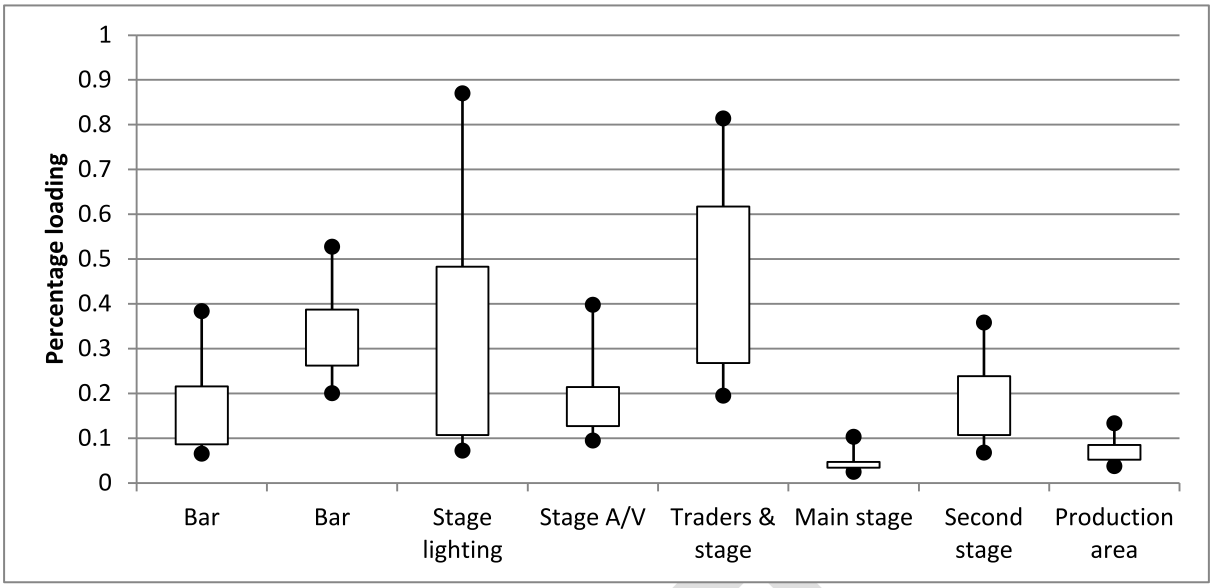


**Figure 5. Generator loading, showing minimum and maximum demand, as well as the typical range of demand on the generator.**

Had each of the generators above been seized in accordance with the recorded demand, the following savings could have been achieved.

| | Reduction through using smaller generators | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Bar | Bar | Stage lighting | Stage A/V | Traders & stage | Main stage | Second stage | Production area |
| Percent | 25% | 15% | 17% | 54% | 3% | 80% | 44% | 62% |
| GHG (tonnes $CO_2$e) | 0.66 | 0.49 | 1.75 | 5.33 | 0.12 | 12.51 | 3.23 | 1.41 |

**Table 4. Potential emissions reduction from sizing generators more accurately**

In addition to sizing the generators more effectively, replacing these generators with variable speed drive generators (that have greater efficiencies at low load) could improve the overall energy efficiency of the electricity generation.

**Substituting fuel.** From the data, it was possible to identify those loads suitable for photovoltaic generated electricity with battery backup. Those electricity profiles which were not "peaky" and which had a relatively stable, low consumption would be suitable to be powered with photovoltaic panels. This analysis also identified those overnight electricity uses that were relatively small. Such small and constant loads could be met by battery storage rather than having generators operate throughout the night period. This was typically a trader load. There are several examples of individual traders who already use their own power supplies in order to avoid the cost of hiring power at the event. The analysis of the day time and night profiles identified that groups of traders could have their power supply met by solar photovoltaic electricity and battery storage.

| | **GHG reduction due to reduced overnight load** | |
|---|---|---|
| | **Traders** | **Bars** |
| Percentage | 12% | 13% |
| Example of savings (kWh) | 267 | 158 |
| Example of savings (kg $CO_2$e) | 268 | 159 |

**Table 5. Potential emissions reduction from using photovoltaic electricity (with battery storage) for smaller traders and smaller bars.**

## ESTIMATE OF POTENTIAL SAVINGS

The potential savings can be broken down into demand related savings (switching off and specifying more energy efficient equipment) and supply related savings (sizing generators and substituting fuel). However, it is not possible to simply add up all the individual savings in order to obtain an overall value. The individual savings effect each other. For example if more energy efficient equipment is specified, then the saving achieved from switching that equipment off will be reduced, since it is now more efficient. Similarly if correctly sized generators are used, then the savings from installing variable speed drive generators will be reduced since the generator is now working more efficiently because it is more accurately sized.

| | | GHG savings (tonnes $CO_2$e) / festival size | | |
|---|---|---|---|---|
| | **Potential savings** | **Small** | **Medium** | **Large** |
| Demand (Switching off and specifying energy efficient) | 49% - 60% | 8.8 - 10.8 | 64.7 - 79.2 | 102.9 - 126.0 |
| Supply (Sizing generators and substituting fuel) | 15% - 67% | 2.7 - 12.1 | 19.8 - 88.4 | 31.5 - 140.7 |

**Table 6. Estimate of potential savings**

## CONCLUSIONS

The analysis of all different electricity uses at different festivals over a four-year period has identified significant opportunities for reducing electricity related greenhouse gas emissions. The main potential reductions are related to the generators. However, before we discuss energy supply we first need to address reducing energy demand. The analysis showed that energy demand can be reduced by switching equipment off when it is not in use and specifying more efficient equipment. This reduced energy demand can then be met by a reduced energy supply. More effective sizing of generators and the use of variable speed drive generators can improve the efficiency of this energy supply. Up until now, sizing of generators has been relatively difficult, since the actual minute by minute electricity consumption for different activities was not generally known. However, we now have a series of typical electricity load profiles that can help improve the sizing. Secondly, many generators work at part load for a significant duration of their operation. Using variable speed drive generators would improve the efficiency and reduce emissions. Renewable energy can also be introduced once the typical demand profiles are known. A reduced number of variable speed drive generators can then be fuelled by biodiesel and some smaller generators, with relatively constant load could be met by solar photovoltaic panels and battery storage. In addition some smaller generators could incorporate battery storage and switch off at night, with the relatively low night load being met by the batteries.

However, further reductions are possible, by combining the consumption monitoring with control. Monitoring the electricity consumption of all generators at a festival provides minute by minute details of the load on each generator. Adding a control function to this will allow previously identified unessential loads to be temporarily switched off when demand for essential loads is high. In this way, generators can be operated at maximum efficiency, with some battery storage, to minimise greenhouse gas emissions. There is now the opportunity to implement such a music festival "smart grid".

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