

Exploring Environmental Impact:

Fireworks and Drone shows at Events

A study commissioned by **Celtic Fireworks Limited**, the UK's largest importer and wholesaler of professional fireworks and pyrotechnics, working with **UK SustainAbility**, a consultancy that supports businesses to understand their environmental impact and to target sustainability goals.

Abstract

To provide event organisers with environmental analysis to make informed decisions about the potential impact of fireworks for their events. With full analysis included in the report below, our main conclusions are -

- The largest share (at least 80%) of emissions from any type of event occur due to the travel and facilities/infrastructure used by attendees of those events
- When a full life-cycle analysis of drones and fireworks is performed side-by-side, the emissions outcomes are comparable in profile

Summary

As we move towards a more sustainable world, event organisers and attendees are increasingly concerned about the environmental effects of events. As an integral part of many events, fireworks can attract specific questions about their environmental impact, especially when compared to other types of media such as drones. This report helps to answer these questions and shares some of the work undertaken.

There is little disagreement that the inherent chemistry of fireworks means emissions are created when they are set off. However, as we demonstrate with this report, the emissions of the display itself are a small proportion of the overall event emissions, and even when the full emissions lifecycle are considered, firework emissions for a typical regional firework display are equivalent to the lifecycle emissions of just 1 cup of takeaway coffee per 10 attendees.

Drones are frequently suggested as a more environmentally friendly option, however when the entire lifecycle of a drone is taken into account, including the mining of the batteries, the charging of the drone and the end-of-life disposal needed, the overall environmental impact of drones is usually similar to a firework display and can be significantly larger if the drones have to be transported over long distances or are air-freighted to the display.

The firework industry is committed to working with its customers to continue reducing environmental impacts and is working hard on minimising some of the negative effects that fireworks can have – including implementation of new CE standards that will eliminate ejected plastic components in UK/EU firework production from 2024 onwards. In addition, Celtic Fireworks Limited are undertaking an elective program of plastic elimination across their product range by the end of 2025, as well as other sustainability initiatives such as supply chain



engagement, packaging changes and transport initiatives which are detailed on our website – [Celtic Fireworks Ltd.](#)

Event emissions – what should we be concerned about?

In order to assess the environmental impact of various events, we examined events of varying scales that may incorporate either a fireworks or drone show as part of their program.–

1. A wedding/private show (120 people, 25kg net explosive content or 30 drones)
2. A professional show such as the summer season fireworks at Bournemouth Pier (5,000 people, 75kg net explosive content or 150 drones)
3. A larger professional show such as the Plymouth Fireworks Championships (50,000 people, 475kg x 3 shows per night net explosive content or 300 drones)

We modelled the travel of attendees, the facilities (e.g. food trucks, lighting, toilets, traffic management) and the staff and equipment needed to host a safe event.

How much of these emissions are from the actual displays?

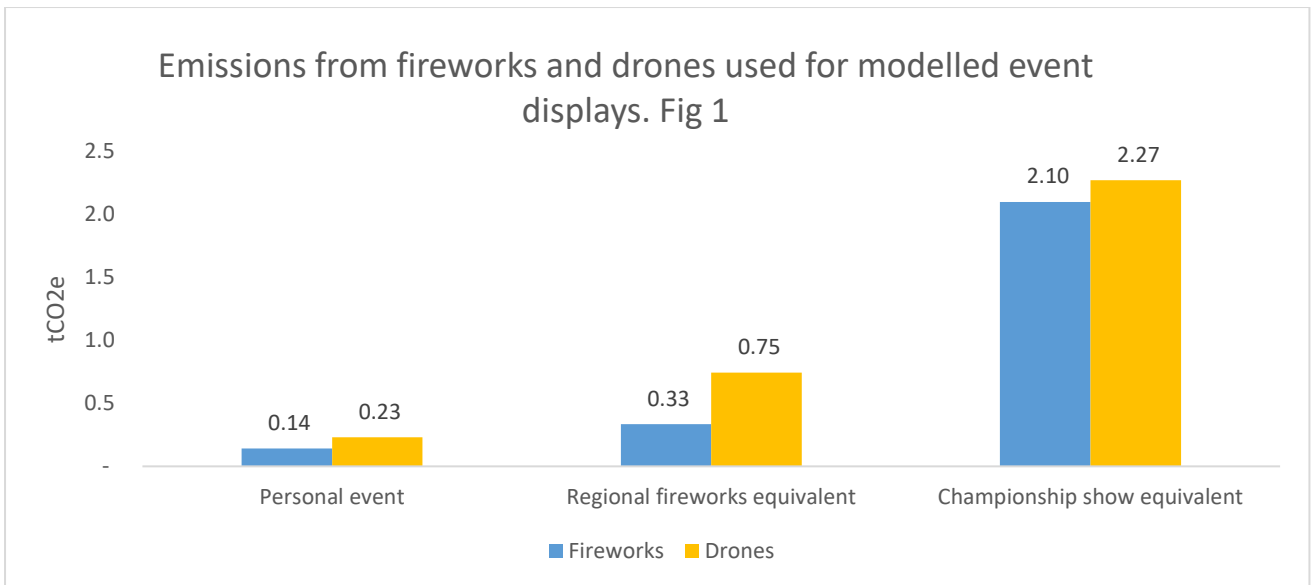
We analysed the size of show expected for each of these types of events including the complexity of the fireworks or drones and the duration of the displays.

In order to establish the environmental effects of firework and drone shows we conducted a full life cycle analysis (LCA) of each type – encompassing the mining of the minerals used in the powders or batteries through to the end-of-life disposal. Looking at the full LCA gives a comprehensive view of the full environmental impacts to be considered and allows a better indicator of where environmental effect reduction actions could be focussed (Federation (see bibliography)).

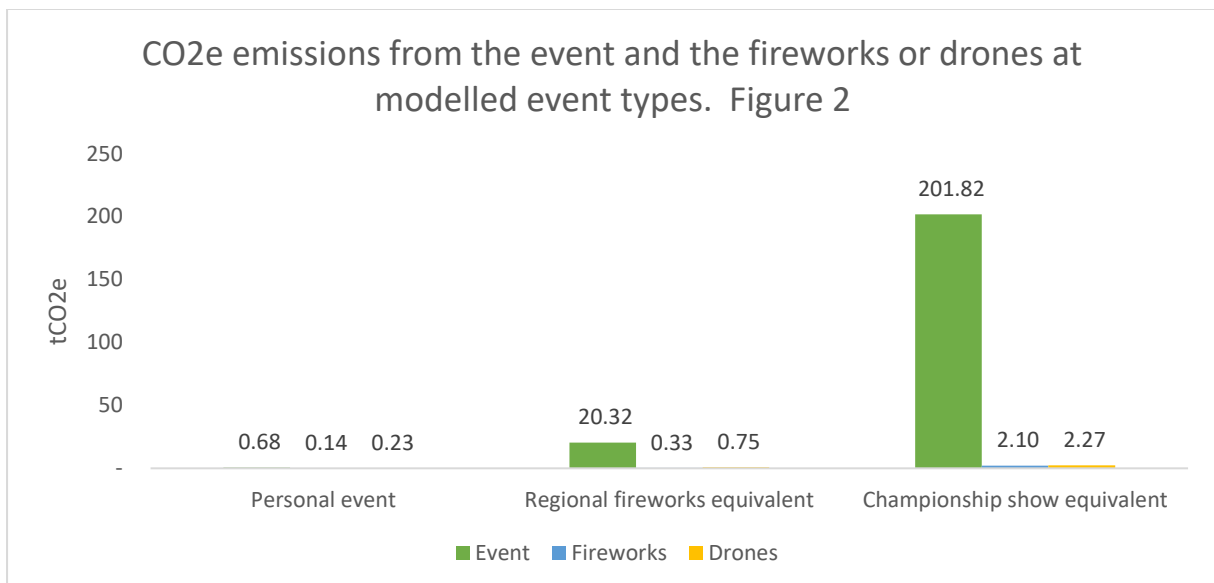
In studying firework events, we found that –

- A small/private event (e.g a wedding or party) with a firework display is responsible for 0.14 tonnes of CO₂e, equivalent to the emissions produced by around 18 of the attendees' travelling to and from the event.
- A regional firework display watched by approximately 5000 people emits 0.33 tonnes of CO₂e, comparable to 1 takeaway coffee for every 10 people watching the display.
- A single display at a national firework event such as the British Fireworks Championships in Plymouth – emits 2.10 tonnes of CO₂e or equivalent to just over one seat on a London to New York flight.





- Generally life-cycle emissions for drones were similar to or slightly larger than fireworks.
- We also found that in all scenarios the event itself (infrastructure, logistics, travel etc.) was usually responsible for at least 80% of the emissions created with the largest proportions being apportioned to spectator travel and generators for lighting/facilities – see figure 2.
- Emissions from just the fireworks or drones on the day of the event (vs measuring their whole lifecycle) are as little as 0.1-1% of the total event emissions.

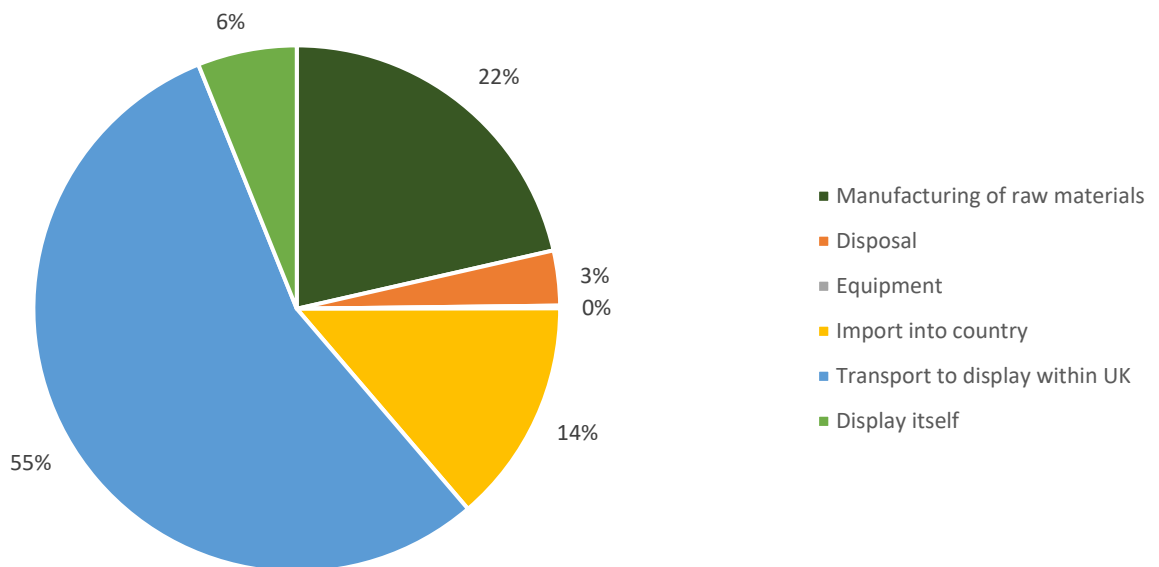


- The largest source of emissions across the lifecycle of fireworks is the transport of the fireworks into the country, and to the display itself – see figure 3. This principle applies to drones as well, and the environmental footprint can increase exponentially if the drones are air-freighted in for the display, a scenario that arises in large-scale events.



Firework emissions lifecycle breakdown - % emissions per lifestage

Figure 3



Other factors to consider – debris, pollution, cost and the “wow” factor

Beyond emissions, there are other environmental effects to consider such as the amount of waste and debris created by the different display types.

Fireworks can be manufactured with plastic and cardboard components, as well as plastic packaging to keep the product dry in transportation and in the field. Whilst these casings are recyclable and events often undertake efforts to collect and recycle this rubbish, firework debris is recognised as an area for continued focus by the industry and new regulations are thus being adopted – including new CE legislation to remove all ejected plastic units from fireworks from 2024 onwards.

Other emissions by fireworks have been studied previously and are generally considered to be negligible but do include some particulate matter, gasses, and soot. One recent study conducted after the London NYE fireworks concluded that there was no significant inhalation of the emitted chemicals and that most of the emissions are minor and easily absorbed by the seasonal atmosphere (GLA, 2016).

Whilst drones do not usually produce debris for each individual show they do have significant end-of-life waste to consider, such as recycling of the batteries and plastic casings of a drone that need to be addressed. As a relatively new technology there are not sufficient known studies to determine the rate of drone recycling, but if it is comparable to other light electrical goods in the UK we could expect a rate of just 31.2% (Edie, 2022). Furthermore, drones are often superseded before their actual end of life due to technology developments making older models obsolete, meaning serviceable drones are disposed of after a low number of uses.



Beyond environmental effects, drones and fireworks are sometimes cited as being interchangeable – however due to the high comparable cost of drone shows in relation to a similarly scaled firework display, they become harder to consider as a “like for like” swap. Indeed, some events such as the Galveston Island, USA, 4th of July show, that previously switched to drones have since switched back to fireworks due to missing the flexibility, impact and “wow” factor of fireworks (Chronicle, 2023).

Once we understand that the emissions of fireworks vs drones are both similar and negligible, it helps to underline that both forms of entertainment should coexist and can be used to complement each other, as demonstrated in numerous national and international events to date.

Looking to the future – firework industry working hard on environmental footprint

Whilst the results of this analysis show that fireworks and drones are broadly on a level with regards to carbon emissions, the firework industry, and specifically Celtic Fireworks Limited, is being proactive in addressing elements of their environmental footprint that can be of concern to the industry and the public.

As a part of this work, Celtic Fireworks Limited have engaged professional support to review their sustainability objectives, and to identify the risks and emissions throughout their supply chains. They are working on new materials and product improvements to meet a range of targets including reducing waste and eliminating plastic across their range by 2025.

As part of this work, it was found that the largest emissions come from the transport of the fireworks themselves, and thus not the display itself (see figure 3), and even though much has already been done in this area, Celtic Fireworks Limited are making it a priority to further engage their supply chain and make ongoing improvements as a primary objective.

In line with the world’s movement towards sustainability, these are complex, multi-year journeys that will evolve alongside event formats, legislation and the journey to net zero. Celtic Fireworks Limited look forward to continuing this learning and development alongside our customers and suppliers.



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Appendix – Methods

Event choices

To achieve our aims this report models the emissions and certain other environmental effects of three typical types of fireworks shows and compares them to similar scales of drone shows. Live music events were also considered but we decided not to include them as they are not a true like-for-like comparison for event organisers and have disproportionate carbon emissions. We have detailed our methods here -

These typical types of firework shows will be

4. A wedding show/personal show (120 people, 7 mins, 25kg net explosive content)
5. A smaller professional show such as the fireworks at Bournemouth Pier over the summer season (5000 people, 10 mins, 75kg net explosive content)
6. A large professional show such as the fireworks at Plymouth Fireworks Competition (50000 people, 10 mins, 475kg x 3 shows per night net explosive content)

Comparable drone shows will be (show length and attendee numbers kept consistent)

1. A 75 piece drone show for personal use
2. A 300 piece drone show set by professionals for a one-off event
3. A 600 piece drone show set by professionals at e.g. at Disney, often using 2 x fleets of 300 drones

Environmental notes

The environmental effects calculated will include – the seven direct greenhouse gasses under the Kyoto Protocol – Carbon Dioxide, Methane, Nitrous Oxide, Hydrofluorocarbons, Perfluorocarbons, Sulphur hexafluoride and Nitrogen trifluoride, using conversion factors for 100 year timescales from the IPCC's AR5 report (IPCCC, 2014). Materials will include any non-recyclable or non-reusable plastic, metal or paper as used as a part of a show. All measured as "CO₂e".

CO₂e stands for "carbon dioxide equivalent." It is a unit of measurement used to express the global warming potential (GWP) of various greenhouse gases in terms of the amount of carbon dioxide (CO₂) that would cause the same level of warming over a specified time period. Since different greenhouse gases have different warming potentials, CO₂e allows for the comparison and aggregation of emissions from various sources. For example, methane (CH₄) has a much higher GWP than carbon dioxide over a shorter time frame, so emitting a certain amount of methane would have a greater warming effect than emitting the same amount of carbon dioxide. By converting methane emissions into CO₂e, it becomes easier to assess the overall impact of greenhouse gas emissions and to develop strategies for reducing them.

In this report we are using life-cycle emissions or Life-Cycle Assessments. LCAs are a systematic and comprehensive method for evaluating the environmental impacts of a product throughout its entire lifecycle, from raw material extraction to disposal. It assesses various environmental



factors such as energy use, resource depletion, emissions of pollutants, and waste generation across all stages of the product's life, including manufacturing, transportation, use, and end-of-life disposal or recycling.

The fireworks industry is eliminating plastic from their products as a part of updated CE regulations – BS EN 15947 & BS EN 16261 – information and details regarding these can be found online.

Model assumptions –

There has been extensive work done by Carndu Ltd. that uses the stoichiometry of fireworks to determine the environmental outputs from a display – this was used as the inputs into the fireworks emissions. As fireworks are a use-once product this plus the emissions created in the manufacture and distribution of the fireworks denotes the LCA of the firework.

As to drones – as a relatively new technology they are evolving fast but there is much interest in their potential use as delivery mechanisms for online shopping and so the research on their environmental effects is apace.

To model the typical drones used in fireworks shows we based our numbers on the Intel Shooting Star drones.

Drones will, of course, lose some of their environmental effects as they are charged from the grid which is becoming greener and greener with the addition of renewables however, this is less than 1% of the attributable emissions.

The model sources all inputs next to where the inputs are indicated – these have been sense checked with industry experts and in best faith but as in all predictive models will have elements of uncertainty.

