# A Comparison of the Environmental Performance of Sports and Entertainment Venues for a Range of Percentage Capacities

for

## Countercoin Community Club Limited

## Project Number 6475B-072

18/12/2018

Author: Christopher Betteridge
Chris.Betteridge@stopford.co.uk
Issue A1
Document Number: R6475B-PM-0072

Funded by UK Government

European Union
European Regional Development Fund

The SEND project (no. 32R16P00706) is part-funded from the European Regional Development Fund (ERDF) as part of the European Structural and Investment Funds England Growth Programme 2014-2020 and the Department for Business, Energy and Industrial Strategy (BEIS).

Stopford Energy & Environment,
the trading name of Stopford Projects Ltd

VAT Registration Number: 388 107 726
Company Registration Number: 1630328

Enquiries:
Stopford Energy & Environment
Custom House
Merseyton Road
Ellesmere Port
Cheshire
CH65 3AD
United Kingdom

tel: +44 (0)151 357 7740
fax: +44 (0)151 345 8087
enquiries@stopford.co.uk

ISOQAR REGISTERED UKAS MANAGEMENT SYSTEMS 0026
Certificate Number 5021

## Keele University, SEND and the Business Gateway

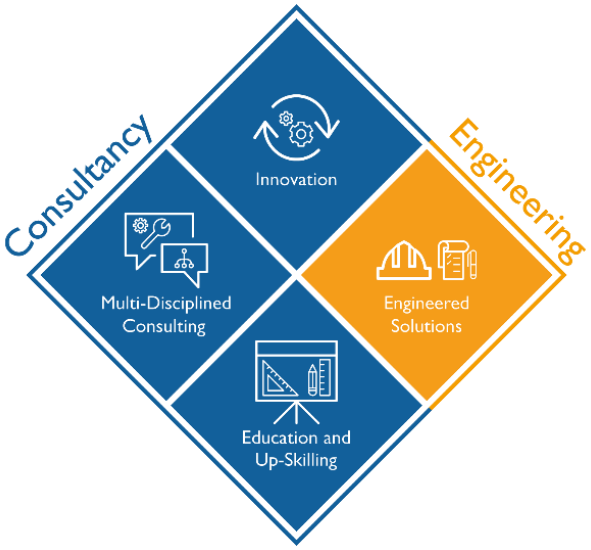
Keele University, a leader in energy, is developing Europe's largest smart energy network. The Smart Energy Network Demonstrator (SEND) will deliver power to houses, flats, office premises and University facilities across Keele's 600-acre campus. SEND will be an 'at scale' living laboratory where energy efficient technologies can be researched, developed and tested in a real-world environment.

The SEND project forms part of Keele University's Business Gateway, a single-entry route for businesses to access the extensive pool of knowledge, expertise and facilities offered by the University. For more information on the opportunities available, please visit www.keele.ac.uk/business

## Stopford Energy & Environment

Stopford is an international energy and environment consultancy providing innovative multi-disciplinary solutions to a global market from our North-West base. For over 35 years we have been serving the requirements of a multi-national client base from our team of industry leading experts.

As leaders in the energy and environment sector, we have developed complimentary consulting and engineering capabilities comprising innovation, multi-disciplined consultancy, engineered solutions, and education and up-skilling. We provide bespoke services to our clients throughout the lifecycle of projects from our sites in Ellesmere Port and Lancaster University. Key to our success is our alignment with leading academic institutions around the world, providing our staff access to the world class research and development facilities, technology and know-how.




With activities across Europe, USA, Middle East and Asia Pacific, Stopford is one of the fastest growing energy and environmental consultancies in the UK.

For more information about our services, please visit www.stopford.co.uk

## Contents


1 Scope of Work....2
2 Delivery....2
2.1 Quantifying Environmental Performance at Stadiums....2
2.2 Quantifying Environmental Performance at Arts and Entertainment Venues..4
2.3 The Environmental Impact of Empty Seats at Stadiums....5
2.4 The Environmental Impact of Empty Seats at Arts & Entertainment Venues...7
3 Conclusion....9
4 References....10
5 T&Cs....10


## Revision History

| Issue | Reviewed by (date) | Approved by (date) | Comments |
|---|---|---|---|
| A1 | B. Herbert (18/12/19) | B. Robertson (19/12/18) | |
| | | | |
| | | | |


Confidential © Stopford Energy & Environment

# 1 Scope of Work

Countercoin Community Club Limited (hereafter, Countercoin) is an organisation that is incentivising, recognising and rewarding community action and volunteering. Countercoin is achieving this by producing physical clay coins which can be earnt from undertaking volunteering activities. The coins can then be used by volunteers at Stoke & Newcastle entertainment venues (such as football clubs or at music venues) for discounted tickets.

To support Countercoin's marketing strategy the organisation is keen to quantify and assess the commercial and environmental benefits of venues operating at full capacity to help with marketing the scheme. Countercoin has therefore commissioned Stopford Energy and Environment (hereafter, SEE) to deliver an environmental and carbon savings assessment for various example venues.

The scope between the 2 companies was hence agreed as such:

- Research and define typical energy consumption values for stadiums and arts/entertainment venues. The focus will be on identifying energy used "per seat".
- By not filling a seat, the energy used is effectively wasted. A range of different scenarios will be investigated (i.e. for venues at 100% (full), 75%, 50%, 25% capacity), and the energy "wasted" displayed in marketable terms. These terms could include for example:
  - Km's driven in a car
  - Number of Incandescent Light bulbs replaced with LED's
  - Number of Trees planted

# 2 Delivery

## 2.1 Quantifying Environmental Performance at Stadiums

A study by Chilvers et al (2015) analysed the energy consumption of Wembley Stadium, the Aviva Stadium and a typical smaller stadium (Stadium A), to produce a gas and electricity usage per seat (Table 1). A thesis by Smulders (2012) conducted similar analyses for a number of stadiums in North West Europe. The results of which are also enclosed in Table 1.

*Table 1. A comparison of gas and electricity usage totals, and per seat, for Wembley stadium, the Aviva Stadium and a typical smaller stadium.*

| | Aviva | Wembley | Stadium A | Imtech Arena | Euroborg | Commerzbank | Allianz Arena |
|---|---|---|---|---|---|---|---|
| Capacity | 51,700 | 90,000 | 31,000 | 57,000 | 22,000 | 52,000 | 69,000 |
| Gas (MWh/yr) | 7,041 | 8,312 | N/A | 6,750 | 1,730 | 5,027 | 8,425 |
| Electricity (MWh/ yr) | 8,212 | 22,191 | 4,992 | 4700 | 2,098 | 5,506 | 13,228 |
| Gas (kWh/ [seat].yr) | 136.19 | 92.36 | N/A | 118.42 | 78.62 | 96.68 | 122.09 |
| Electric (kWh/ [seat].yr) | 158.85 | 246.57 | 161.02 | 82.46 | 95.35 | 105.89 | 191.71 |

By assembling the data in a chart and applying a trendline, an equation can be calculated to approximate the likely gas and electrical consumption for any size stadium in Europe (Figure 1 & Figure 2). The data and graphs can also be found in document R6475B-PM-0072A.

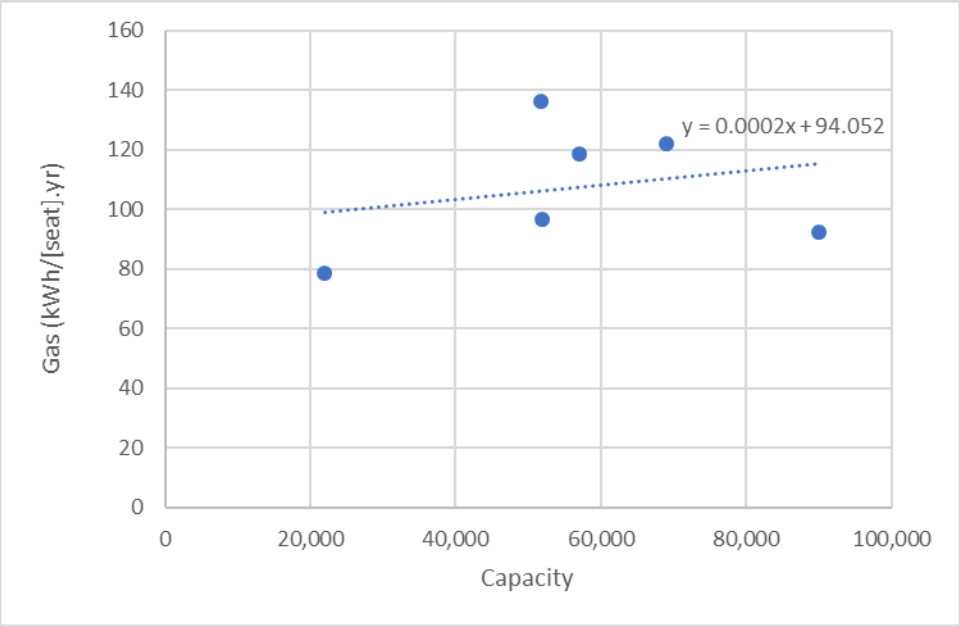



*Figure 1. Gas consumption per seat, per capacity stadium.*

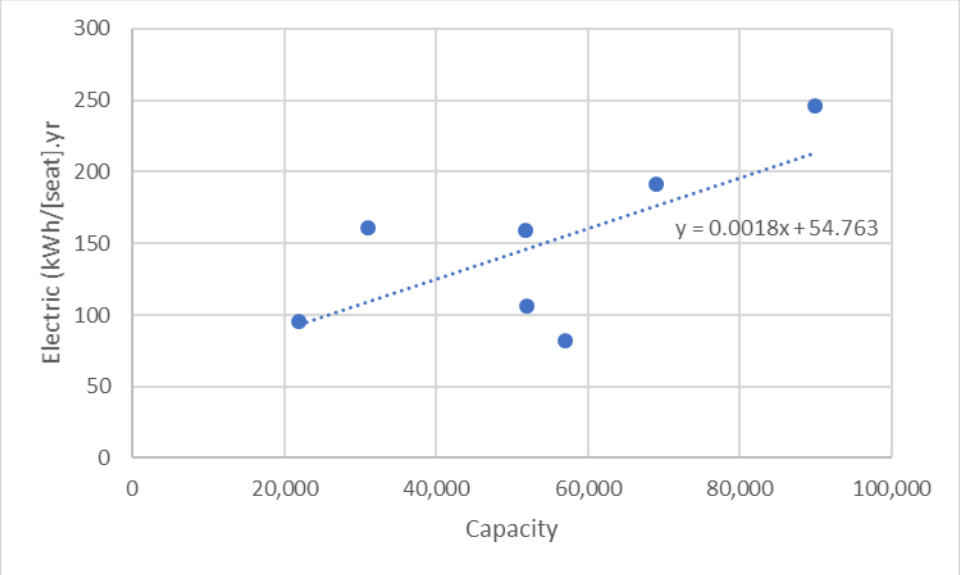



*Figure 2. Electricity consumption per seat, per capacity stadium.*

The trendline equation can then be used to estimate the gas and electricity consumption per seat for two of the premier stadiums in Staffordshire (Vale Park & Bet 365 stadium), stadiums for which Countercoin may seek to obtain tickets to support its scheme. The results are shown in Table 2.

*Table 2. Estimated gas and electricity consumption per seat for Vale Park and the Bet 365 Stadium.*

| | Vale Park (estimated values) | Bet 365 Stadium (estimated values) |
|---|---|---|
| Capacity | 19,052 | 30,089 |
| Gas (kWh/ [seat].yr) | 97.86 | 100.07 |
| Electric (kWh/ [seat].yr) | 89.06 | 108.92 |

An analysis of how much energy is "wasted" by underfilling the stadiums will take place in section 2.3.

## 2.2 Quantifying Environmental Performance at Arts and Entertainment Venues

Julie's Bicycle is an organisation which has become a renowned authority on climate change action for arts, culture and creative organisations. In 2012 they produced a benchmarking report (Julie's Bicycle, 2012) detailing typical energy consumptions for performance art venues and rehearsal spaces, classed

as entertainment halls, with the support of the Chartered Institute of Building Services Engineers (CIBSE). This report took into account the data from 100 performing arts venues (theatres, venues and rehearsal spaces) to produce annual electricity and gas values per seat. The results are presented in Table 3 below.

*Table 3. A summary of the annual energy use per $m^2$ and per seat at entertainment halls.*

| | kWh/m2 | kWh/seat |
|---|---|---|
| Electricity | 110 | 420 |
| Gas | 140 | 520 |

The data shows that the energy used per seat is approximately 20% higher in the case of gas when compared to electricity. The energy consumption when compared to typical values for stadiums is approximately 4-5 times as much per seat. This is likely due to economies of scale.

## 2.3 The Environmental Impact of Empty Seats at Stadiums

With an energy value per stadium seat quantified, analysis can be undertaken into how much gas and electricity is effectively "wasted" by a venue operating at sub-capacity. Wasted energy scenarios representing 100%, 75%, 50%, and 25% of stadium capacity will be presented for Vale Park (capacity 19,052), and for the Bet 365 Stadium (capacity 30,089). By using the annual electricity and gas "per seat" values stated in Table 2, the total amount of energy lost can be calculated. The energy lost will also be converted to environmental factors such as kilograms of $CO_2e$, number of trees planted, incandescent light bulbs changed to LED's, and km's driven in a petrol car. The data used in the tables can also be found in document R6475B-PM-0072A.

### 2.3.1 Vale Park

The results of the scenario analysis for Vale Park are presented in Table 4. When operating at 75% capacity, over a year this results in the wasting of circa 187,816 kg $CO_2e$. This equates to driving 1,292,339 km or growing 4,816 trees for 10 years. Operating at only 50% capacity results in the wasting of 375,631 kg $CO_2e$, which equates to 2,584,678 km driven or 9,632 trees planted. Using only a quarter of the venue results in the wasting of 563,447 kg $CO_2e$, equating to 3,877,017 km driven or the mass of carbon sequestered by planting 14,447 trees.

*Table 4. A comparison of various % capacity scenarios for Vale Park Stadium.*

| Venue % Full | 100% | 75% | 50% | 25% | |
|---|---|---|---|---|---|
| No. of Seats Empty | 0 | 4763 | 9526 | 14289 | |
| Annual Electricity not Utilised (kWh/seat) | 89.06 | 89.06 | 89.06 | 89.06 | |
| Annual Gas not Utilised (kWh/seat) | 97.86 | 97.86 | 97.86 | 97.86 | |
| Total Annual Electricity not Utilised (kWh) | 0 | 424,192 | 848,385 | 1,272,578 | |
| Total Annual Gas not Utilised (kWh) | 0 | 466,107 | 932,214 | 1,398,322 | |
| Annual Energy not Used Equivalent to Greenhouse Gas Emissions | 0 | 187,816 | 375,631 | 563,447 | |
| Annual Energy not Utilised Equivalent to Driving | 0 | 1,292,339 | 2,584,678 | 3,877,017 | Kilometers in a Car |
| Annual Energy not Utilised Equivalent to Replacing | 0 | 6,261 | 12,521 | 18,782 | Incandescent Light Bulbs with LED's |
| Annual Energy not Utilised Equivalent to | 0 | 4,816 | 9,632 | 14,447 | Sapling Trees Grown For 10 Years |

### 2.3.2 Bet 365 Stadium

The results of the scenario analysis for the Bet 365 Stadium are presented in Table 5. When operating at 75% capacity, over a year this results in the wasting of circa 341,312 kg $CO_2e$. This equates to driving 2,348,530 km or growing 8752 trees for 10 years. Operating at only 50% capacity results in the wasting of 682,669 kg $CO_2e$, which equates to 4,697,373 km driven or 17,504 trees planted. Using only a quarter of the venue results in the wasting of 1,023,981 kg $CO_2e$, equating to 7,045,904 km driven or the mass of carbon sequestered by planting 26,256 trees.


Confidential © Stopford Energy & Environment

*Table 5. A comparison of various % capacity scenarios for Bet 365 Stadium.*

| Venue % Full | 100% | 75% | 50% | 25% | |
|---|---|---|---|---|---|
| No. of Seats Empty | 0 | 7,522 | 15,045 | 22,567 | |
| Annual Electricity not Utilised (kWh/seat) | 108.92 | 108.92 | 108.92 | 108.92 | |
| Annual Gas not Utilised (kWh/seat) | 100.07 | 100.07 | 100.07 | 100.07 | |
| Total Annual Electricity not Utilised (kWh) | 0 | 819,296 | 1,638,701 | 2,457,998 | |
| Total Annual Gas not Utilised (kWh) | 0 | 752,726 | 1,505,553 | 2,258,280 | |
| Annual Energy not Used Equivalent to Greenhouse Gas Emissions | 0 | 341,312 | 682,669 | 1,023,981 | |
| Annual Energy not Utilised Equivalent to Driving | 0 | 2,348,530 | 4,697,373 | 7,045,904 | Kilometers in a Car |
| Annual Energy not Utilised Equivalent to Replacing | 0 | 11,377 | 22,756 | 34,133 | Incandescent Light Bulbs with LED's |
| Annual Energy not Utilised Equivalent to | 0 | 8,752 | 17,504 | 26,256 | Sapling Trees Grown For 10 Years |

## 2.4 The Environmental Impact of Empty Seats at Arts & Entertainment Venues

With a value per seat quantified, analysis can be undertaken into how much gas and electricity is effectively "wasted" by a venue operating at sub-capacity. Scenarios of 100%, 75%, 50%, and 25% capacity will be compared for a small venue of 200 seats, and for a large venue of 2,000 seats. By using the annual electricity and gas usage "per seat", as presented in Table 3, the total amount of energy lost can be calculated. Similar to the stadium analyses, the energy lost will also be converted to environmental factors such as kilograms of $CO_2e$, number of trees planted, incandescent light bulbs changed to LED's, and km's driven in a petrol car. The data used in the tables can also be found in document R6475B-PM-0072A.

### 2.4.1 200 Seat Venue

The results of the scenario analysis for a 200-seat venue are presented in Table 6. When operating at 75% capacity over a year, this results in the wasting of circa 10,000 kg $CO_2e$. This equates to driving 67,000 km or growing 250 trees for 10 years. Operating at only 50% capacity results in the wasting of

20,000 kg CO2e, which equates to 134,000 km driven or 500 trees planted. Using only a quarter of the venue results in the wasting of 30,000 kg $CO_2e$, equating to 200,000 km driven or the mass of carbon sequestered by planting 750 trees.

*Table 6. The results of the % capacity scenario analysis for a 200-seat venue.*

| Venue % Full | 100% | 75% | 50% | 25% | |
|---|---|---|---|---|---|
| No. of Seats Empty | 0 | 50 | 100 | 150 | |
| Annual Electricity not Utilised (kWh/seat) | 420 | 420 | 420 | 420 | |
| Annual Gas not Utilised (kWh/seat) | 520 | 520 | 520 | 520 | |
| Total Annual Electricity not Utilised (kWh) | 0 | 21,000 | 42,000 | 63,000 | |
| Total Annual Gas not Utilised (kWh) | 0 | 26,000 | 52,000 | 78,000 | |
| Annual Energy not Used Equivalent to Greenhouse Gas Emissions ($kgCO_2e$) | 0 | 9,723 | 19,446 | 29,169 | |
| Annual Energy not Utilised Equivalent to Driving | 0 | 66,903 | 133,807 | 200,710 | Kilometres in a Car |
| Annual Energy not Utilised Equivalent to Replacing | 0 | 324 | 648 | 972 | Incandescent Light Bulbs with LED's |
| Annual Energy not Utilised Equivalent to | 0 | 249 | 499 | 748 | Sapling Trees Grown For 10 Years |

### 2.4.2 2000 Seat Venue

The result of the scenario analysis for a 2,000-seat venue is presented in Table 7 . When operating at 75% capacity over a year, this results in the wasting of circa 100,000 kg $CO_2e$. This equates to driving 670,000 km or growing 2,500 trees for 10 years. Operating at only 50% capacity results in the wasting of 200,000 kg CO2e, which equates to 1,340,000 km driven or 5,000 trees planted. Using only a quarter of the venue results in the wasting of 300,000 kg $CO_2e$, equating to 2,000,000 km driven or the mass of carbon sequestered by planting 7,500 trees.

*Table 7. The results of the % capacity scenario analysis for a 2000 seat venue.*

| Venue % Full | 100% | 75% | 50% | 25% | |
|---|---|---|---|---|---|
| No. of Seats Empty | 0 | 500 | 1000 | 1500 | |
| Annual Electricity not Utilised (kWh/seat) | 420 | 420 | 420 | 420 | |
| Annual Gas not Utilised (kWh/seat) | 520 | 520 | 520 | 520 | |
| Total Annual Electricity not Utilised (kWh) | 0 | 210,000 | 420,000 | 630,000 | |
| Total Annual Gas not Utilised (kWh) | 0 | 260,000 | 520,000 | 780,000 | |
| Annual Energy not Used Equivalent to Greenhouse Gas Emissions ($kgCO_2e$) | 0 | 97,231 | 194,461 | 291,692 | |
| Annual Energy not Utilised Equivalent to Driving | 0 | 669,033 | 1,338,065 | 2,007,098 | Kilometres in a Car |
| Annual Energy not Utilised Equivalent to Replacing | 0 | 3,241 | 6,482 | 9,723 | Incandescent Light Bulbs with LED's |
| Annual Energy not Utilised Equivalent to | 0 | 2,493 | 4,986 | 7,479 | Sapling Trees Grown For 10 Years |

# 3 Conclusion

It has been found that underfilling capacity at stadiums and arts and entertainment venues results in considerable use of energy unnecessarily. In the case of typical sports stadiums this value is in the order of 100 kWh per seat per annum for gas and 100 kWh per seat per annum for electricity. For arts and entertainment venues, these figures rise to 520 kWh and 420 kWh respectively, although the size of these type of venues tend to be typically far smaller than stadiums. A comparison of the 4 venues analysed in this report in terms of greenhouse gas (GHG) emissions “wasted” is displayed in Figure 3.


Confidential © Stopford Energy & Environment

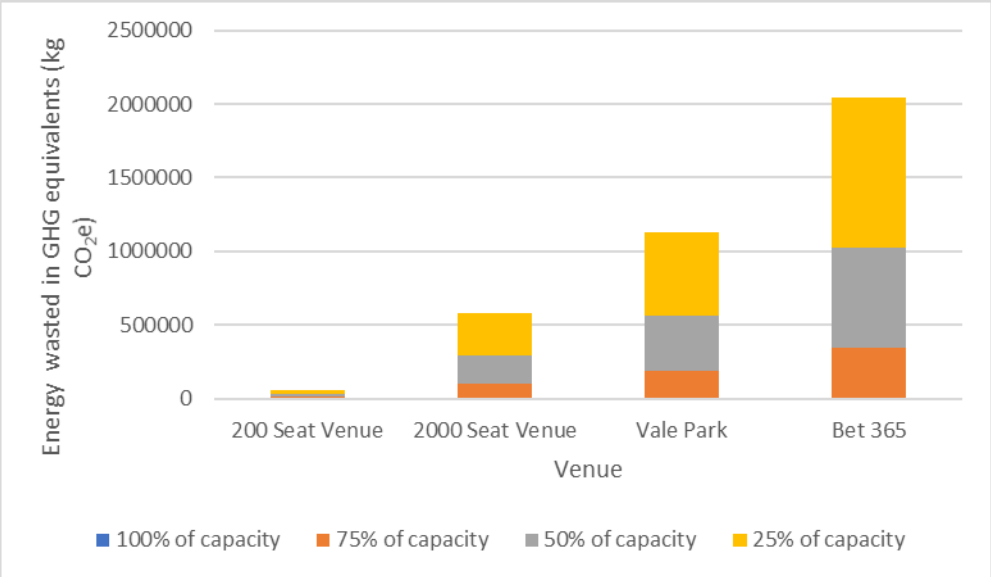



*Figure 3. A direct comparison of the 4 venues analysed in the report in terms of GHG emissions wasted.*

There therefore exists a real opportunity for Countercoin to employ its scheme to increase the energy efficiencies of venues in Staffordshire through filling up empty seats.

# 4 References

Chilvers, S., Chaer, I., and Ford, A.J. (2015). Environmental impact and energy management of sports stadia. Paper presented at CIB Joint International Symposium: Going North for Sustainability, LSBU, London, 23 November 2015 - 25 November 2015. London South Bank University.

Julie's Bicycle (2012). Tender – Arts Council Invitation to Tender. NPO Online Environmental Resource. Reference no. Arts-Council-England-2011-013. OJEU Reference: 11/S 209-340730/EN

UK Government (2018). UK Government Greenhouse Gas Conversion Factors for Company Reporting. Produced by BEIS and DEFRA. Expiry date:31/07/2019. Factor Set: Standard Set. Version: 1.01.

# 5 T&Cs

Terms and conditions are as per the 'Smart Energy Network Demonstrator (SEND) Supply Chain Development Project Proposal and Beneficiary Agreement' form, signed by authorised people on behalf of Keele University, Stopford Energy & Environment and the Beneficiary prior to undertaking the project.

# A Comparison of the Environmental Performance of Sports and Entertainment Venues for a Range of Percentage Capacities

for

Countercoin Community Club Limited

18/12/2018

Project 6475B-072

Document Number: R6475B-PM-0072

Stopford Projects Ltd
Custom House
Merseyton Road
Ellesmere Port
Cheshire
CH65 3AD
United Kingdom

+44 (0) 151 357 7740
+44 (0)151 345 8087