**The carbon impact of a UK safari park – application of the GHG Protocol using measured energy data.**

Stephen Finnegana\*, Steve Sharplesa, Tom Johnstona, Matt Fultonb

a University of Liverpool, School of Architecture, Liverpool, UK.

E-mail: s.finnegan@liverpool.ac.uk

b University of Liverpool, Global Eco Innovatory, Liverpool, UK.

\* Corresponding Author

**Abstract**

Determining the carbon impact of commercial developments is an essential starting point in understanding a company’s carbon footprint. It is also integral to the development of a strategy to reduce that impact in a cost effective manner. There are numerous industry standard carbon calculation methodologies. This paper focuses on the application of one such method, the Greenhouse Gas (GHG) Protocol, and applied it to the unusual example of a UK safari park. The safari park management wanted to understand the park’s impact on the environment as part of a long-term plan to reduce that impact by identifying realistic carbon reduction solutions. Actual monitored energy data for a twelve-month period were available as part of the analysis. The results of this paper show that the application of the GHG Protocol, in reality, and especially for a non-standard situation, is difficult. Effective performance monitoring is essential to enable transparent recording of data, from which a carbon footprint can be calculated. The methodologies for calculation are relatively straightforward but depend upon available information. Identification of the carbon impact of the development is the relatively easier task - the real challenge is reducing this impact to near zero in a cost effective manner.

**Keywords**: carbon; sustainability; ISO standards; GHG protocol; PAS2050; Life Cycle Assessment (LCA); carbon accounting; zero carbon.

**1. Introduction**

The need to consider the carbon impact of the built environment is growing in inportance and significance. One particular sector under review in this paper, is that of tourism. The impact of which has been highlighted by the United Nations World Tourism Organisation (UNWTO) who state that global tourism contributes to around 5% of the world’s carbon[[1]](#footnote-1) emissions [1], with further work by [2], [3], [4], [5] and [6] also highlighting the impact of tourism more generally. More detailed analysis realting to the quantification and analysis has been conducted by [7], [8], [9], [10], [11] and [12] with further research highlighting mitigation options to reduce the carbon imnpact of tourism, conducted by [13], [14], [15], [16] and [17]. Measuring the carbon impact of tourism can be achieved through the use of the globally accepted Greenhouse Gas (GHG) Protocol Corporate Accounting and Reporting Standard [18], referred to hereafter as the ‘GHG Protocol’. This protocol established a framework to measure and manage GHG emissions, of which carbon is the most significant contributor. In this paper the carbon impact of tourism, using the GHG protocol, for a UK safari park, is considered. This is based on an extensive twelve-month energy data monitoring exercise. The UK safari park considered is a zoological park and tourist attraction in Merseyside, England, which opened in 1971 and is currently home to many different animals including giraffes, elephants, tigers and baboons. In addition, there is a theme park, education centre, restaurant and shop. There are a number of other safari parks, theme parks and zoos that have also considered, or wish to consider their impact on the environment, and their resultant carbon impact including for example [19], [20], [21], [22] and [23] . These types of development can have a relatively high carbon impact due to their size, scale and visitor numbers. There is a debate over whether or not a safari park, theme park or zoo should be held accountable for the impact from their visitors. For example, Disney’s extensive plans to create a zero carbon park in Florida have recently been badged as greenwash [21], having minimal impact, given that the carbon emissions from European visitors to the park are equivalent to that of 83 million people in Ethiopia. To date, no safari park, zoo or theme park has successfully found a cost effective methodology to carbon neutrality [24], with most organisations opting for a specific technology to advertise their green credentials. For example, Greenwood Forest Park [22] has a 150kW solar PV system and claim to be the UK’s first solar-powered theme park. Lightwater Valley in Yorkshire have installed a biomass heating system fueled by wood pellets to create energy [25]. Legoland Florida provided all of its power for one day from renewable energy and has plans for large scale solar PV arrays [26], while the Lower Zambezi National Park in Zambia has made the claim to becoming the world’s first carbon neutral national park [27].

Considering the total carbon impact of any development is essential and ensures that the development can continue to operate in a responsible fashion, protect against current and future environmental regulation and operate in a more cost effective manner. Choosing a single or range of sustainable energy technologies can be beneficial but should not be the starting point. All options (managerial, operational and technical) should be considered and the real starting point is, in fact, to measure accurately a baseline carbon footprint. On completion, the organisation will then have a clearer picture of the carbon intensive areas that require targeted action. A number of UK zoos have taken this approach and measured their carbon impact with varying levels of success. For example, Bristol Zoo developed their own software tool to measure on site direct and indirect carbon emission, as reported in their 2010 Environmental Sustainability Strategy [28], whereas Whipsnade and Edinburgh Zoos took a different approach and decided to implement ISO14001 [29]. This international ISO methodology uses the GHG Protocol. Which provides a number of different accounting methods at the city [30], [31], [32], corporate [33], policy [35], project and product [36] levels . It also provides a framework upon which the total impact of a development can be measured and, most importantly for the topic of this paper, for safari parks, zoos and theme parks it provides guidance on how to consider the impact of visitors. The GHG protocol excludes visitors from the calculations due to the fact that these activities cannot be directly controlled by the organisation and should be considered by the individual responsible for their actions. For this paper a corporate level assessment, as discussed in [33], has been used. This approach excludes the carbon contributions from other activities outside the boundary of the development, including visitors.

Although the GHG protocol standard provides an overarching framework for calculation, the reality is that every safari park and, indeed, other mixed use development, is different, requiring specific bespoke carbon reporting techniques that are still evolving [36], [37], [38], [39], [40], [41], [42]. A review of the most common methods has been undertaken by [43] and [38]. Application of the GHG Protocol in theory is simple and relates to energy use i.e. measure the total amount of energy used by the safari park and convert that energy into carbon. Once this value is known it is then becomes possible to identify the problematic carbon intensive areas of operation. Potential cost effective solutions to reduce that impact to zero can then be explored. The ultimate aim of most safari parks, and indeed any other public and private sector development, is to create and maintain a position of sustainability. As a starting point they all need to calculate their carbon footprint, which is a term that reflects the amount of carbon emitted throughout the life of a particular activity, industry, service or product [44], [45], [46]. Alongside the universally accepted GHG Protocol method, there are other ISO methodologies that can be used to calculate the carbon footprint of any development with [47] [48], [49] and [50] providing good examples.

This paper examines the baseline carbon reporting stages of the GHG protocol as applied to a UK safari park. It does not present a fully compliant and verified report, as some elements of the protocol are missing, such as future years’ assessments and verification. Calculation of the carbon impact is the first stage in gathering the necessary data and outlining processes that can then be used to consider the next steps of carbon reduction and ultimate aim of carbon neutrality. Detailing the methodology and presenting the results of this study will prove invaluable for others who may wish to carry out a similar assessment and are confused by the terminology, process and terminology.

The originality in this research is in the application of the GHG protocol to a UK safari park, its explanation and presentation of methodology and its presentation of results from real world measured energy data.

**2. Methodology**

The aforementioned GHG Protocol is considered by to be the most widely used in the reporting of carbon at all corporate levels [33]. The protocol works with industry to provide a robust methodology to enable the effective calculation of carbon for business. It enables calculation through either corporate-level, project-level or product-level and in this paper a corporate-level control approach has been chosen. This assessment type typically requires a multistage investigation which have been reduced to the following three stages:

* *Stage 1*: *Scope* – clearly defining what is in and out of scope and defining system boundaries;
* *Stage 2*: *Current energy use* – the collection of activity data to calculate the direct and indirect energy use,
* *Stage 3:* *Conversion to carbon* – using the appropriate conversion factors to convert energy use figures into carbon.

It is not the intention to carry out a fully compliant and verified model, but rather to use key stages of the GHG Protocol to assist in the calculation of carbon for the safari park.

2.1 Stage 1 - Scope

At this stage it is necessary to consider the total impact of the organisation, the setting of operational boundaries and the stages that are in and out of scope. Life Cycle Assessment (LCA) is commonly used to assess the whole life impacts of any process or material and ISO 14040 [51] and ISO14044 [52] have been used to assist in defining the scope for the safari park. Specific examples of the use of LCA using the ISO standards can be found in [53] and [54]. In this paper the methodology for the scope has been to consider the operational use of the safari park. The embodied carbon impact has not been considered as there is no requirement to do so. This would include the carbon emissions due to the extraction of materials, construction of all buildings and ultimate disposal and/or re-use. The GHG Protocol has considered how this operational use can be calculated by creating emission categories under Scope 1, 2 and 3.

* *Scope 1*: All direct carbon. Inclusive of fuels combusted and owned transport;
* *Scope 2*: Indirect carbon emissions from consumption of purchased electricity, heat or steam;
* *Scope 3*: Other indirect carbon emissions, such as the extraction and production of purchased materials and fuels, transport-related activities in vehicles not owned or controlled by the reporting entity, electricity-related activities not covered in Scope 2, outsourced activities, waste disposal.

In accordance with the GHG Protocol, it is reasonable and equitable to generally consider *scopes 1 and 2* onlywhen reporting operational carbon emissions. This is a controversial point but one that is supported by work undertaken by Forum for the Future [55]. Other activities that fall into *scope 3* cannot be directly controlled by the organisation but can possibly be influenced i.e. procurement and waste. Moreover, if scope 3 emissions are included in the assessment, there is a danger of ‘double counting’ [56], [57] i.e. indirectly including another company’s emissions.

The full scope of the safari park can be seen in Figure 1. This has been created to show the total impact and influence of the development in its entirety. The safari park has a series of *scope 3* transport related inputs and output activities. They can be seen at the top and bottom of the figure and include animals, guests, staff, facilities management etc. Due to the existence of the safari park there is an indirect demand for all of these external services and each will arrive and leave the site using various forms of transport. Although these energy flows are outside of the *scope 1* and *scope 2* system boundary, they do have an indirect carbon impact. For example, animals will arrive into the safari park on an infrequent basis via aircraft, train, boat and/or HGV from outside of the UK. In addition, animals will be transferred from the safari park to other UK and overseas locations. These inputs and outputs are difficult to control and, according to the GHG protocol, are outside the scope of corporate assessment. A user may wish to include *scope 3* emissions in their assessment but this is not required for ISO 14001 accreditation or for other corporate carbon accounting standards such as the UK GHG reporting regulations [58].

Figure 1: Transportation inputs and outputs of the safari park



2.2 Stage 2 - Current Energy Use

For any development, the current operational energy use can be calculated by measuring the amount of energy used. This may or may not prove to be difficult depending upon the existing monitoring and reporting systems in place. In this study it has been necessary to gather 12 months of measured energy data from January 2016 to December 2016. These data were reported in volumes and energy units - in particular, litres of LPG and red diesel used and energy (kWh) of electricity consumed. It has been necessary to convert all of these values into the common format of kWh using appropriate UK energy conversion factors.

In the majority of UK domestic and commercial buildings, electricity is used for power and natural gas is used for heating. In the case of this safari park, electricity is used for power and Liquified Petroleum Gas (LPG) is used for heating. It is typical at this Stage 2 to conduct an energy audit [59], [60] of the site from which the energy and, therefore, carbon output can be derived. For the safari park, a simple energy audit was conducted and the calculation methodology consisted of the following:

* a separation of the site into four distinct activity areas: (a) safari park, (b) guest services, (c) offices and (d) owned transport;
* a review of the use of electricity and LPG for each area;
* a review of the data collection procedures;
* identification of anomalies and discrepancies in the data collected;
* changes in operation of the safari park and therefore energy use over the 2016 period;
* calculation of energy use through actual or proxy measures,
* the introduction of any energy saving measures.

In order to calculate the current energy use of the safari park, a simple multiplication of the scope 1 and 2 energy use in each of four activity areas mentioned above was necessary, see Equations 1 through to 4.

 $x= a+b+c+d$ (1)

where **x** is the total indirect and direct scope 1 and 2 energy use[[2]](#footnote-2) (kWh) by the safari park in 2016 from electricity and LPG respectively, where **a** is the total energy use from the safari park; **b** is the total energy use from guest services; **c** is the total energy use from the offices and **d** is the total energy use (kWh) from owned transport. Each activity area a, b and c was then sub-divided by each individual activity as follows. Transportation (d) is a single activity:

$a=a\_{1}+a\_{2}+a\_{3}+a\_{4}$(2)

 $b=b\_{1}+b\_{2}$ (3)

 $c=c\_{1}+c\_{2}$ (4)

where **a** is the total energy use (kWh) in 2016 from the safari park, which consists of: **a1** the energy use of the giraffe/elephant house, **a2** the energy use of the antelope house, **a3** the energy use of the electric gates, **a4** the energy use of the rhino house, **b** is the total energy use (kWh) in 2016 from guest services, which consisted of **b1**, the energy use of the amusement park and **b2**, the energy use of the restaurant/shop, **c** is the total energy use (kWh) in 2016 from the offices which consists of **c1**, the energy use of the animal house and **c2**, the energy use of the staff office.

2.3 Stage 3 – Conversion to carbon

On completion of stage 2, the methodology for stage 3 is straightforward, and consists of the conversion of the energy data to carbon using an approved technique. The Defra/DECC conversion factors for company reporting, Defra [61], are commonly used for this conversion and is the method adopted in this study. These conversion factors are approved for use in the GHG Protocol and for numerous other methods of company reporting. The formulae for calculation are as follows:

 $y= d+e+f+g$ (5)

where **y** is the total carbon (kg) output from scope 1 and 2 by the safari park in 2016 from electricity and LPG respectively, **d** is the total carbon output in 2016 from the safari park, **e** is the total carbon output from guest services, **f** is the total carbon output from the offices and **g** is the total carbon output from transport. Each activity area is then sub-divided and multiplied by the corresponding conversion factors, see Equations 6-9.

 $d=(a\_{1}\*z)+(a\_{2}\*z)+(a\_{3}\*z)+(a\_{4}\*z)$(6)

 $e=(b\_{1}\*z)+(b\_{2}\*z)$ (7)

 $f=(c\_{1}\*z) +(c\_{2}\*z)$ (8)

 $g=(d\*z) $ (9)

where **d** is the total carbon output (kg) in 2016 from the safari park which consists of **a1** the energy use of the giraffe/elephant house, **a2** the energy use of the antelope house, **a3** the energy use of the electric gates, **a4** the energy use of the rhino house (park fam yard) and **z** is the emission factor for conversion of energy (kWh) to carbon (kg), **e** is the total carbon output (kg) in 2016 from guest services which consists of **b1** the energy use of the amusement park and **b2** the energy use of the restaurant and **z** is the emission factor for conversion of energy (kWh) to carbon (kg), **f** is the total carbon output (kg) in 2016 from the offices which consists of **c1** the energy use of the animal office and **c2** the energy use of the staff office and **z** is the emission factor for conversion of energy (kWh) to carbon (kg), **g** is the total carbon output (kg) in 2016 from transport which consists of **d** the energy use of vehicles owned by the safari park and **z** is the emission factor for conversion of energy (kWh) to carbon (kg).

**3. Results**

3.1 Stage 1 – Scope

In accordance with the GHG Protocol, it is reasonable and equitable to generally consider *scopes 1 and 2* onlywhen reporting operational carbon emissions. Other activities that fall into scope 3 cannot be directly controlled by the organisation but can possibly be influenced i.e. procurement, waste. Therefore only scopes 1 and 2 are considered in this study. Moreover, if scope 3 emissions are included in the assessment, there is a danger of ‘double counting’ [56], [57] i.e. indirectly including another company’s emissions. The omission of scope 3 emissions by the GHG protocol is important because generally this is the single largest component of most organisations’ carbon footprint.

3.2 Stage 2 – Current Energy Use

The safari park currently uses Liquified Petroleum Gas (LPG) (scope 1) and electricity (scope 2) to power and heat a variety of buildings and activities in the following areas:

* Safari park (a) – giraffe house (a1), antelope house (a2), electric gates (a3), rhino house (a4), elephant house (a4).
* Guest Services (b) – amusement park (b1), restaurant yard (b1)
* Offices (c) – picnic site (c1), staff offices (c2)
* Transport (d) – owned transport

Further details are provided in Table 1, which shows a breakdown of the individual energy usage (kWh) from each activity across the safari park in 2016. Scope 1 and 2 energy use for the safari park in 2016 has been calculated using Equations 1-5 as outlined in the methodology. Further details on data collection are presented below.

Table 1: Energy use (kWh) by activity

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Activity Area** | **Individual Contribution** | **ID** | **Scope 1** | **Scope 2** | **Total** | **%** |
| Safari park | Giraffe/Elephant House | a1 | 581,256 | 86,080 | **665,336** | 33% |
|  | Antelope House | a2 | 0 | 16,711 | **16,711** | 1% |
|  | Electric Gates | a3 | 0 | 20,695 | **20,695** | 1% |
|  | Rhino House | a4 | 102,845 | 77,537 | **180,382** | 9% |
| Guest Services | Amusement Park | b1 | 0 | 242,192 | **242,192** | 12% |
|  | Restaurant Yard | b2 | 179,973 | 263,001 | **442,974** | 22% |
| Offices | Animal Office  | c1 | 0 | 45,338 | **43,338** | 2% |
|  | Staff Offices | c2 | 34,203 | 23,737 | **57,940** | 3% |
| Transport | Own use transport | d | 337,940 | 0 | **337,940** | 17% |
|  | **Total** |  | **1,236,216** | **771,291** | **2,007,507** | 100% |
| % |  |  | 62% | 38% | 100% |  |

Scope 1 is the single largest contributor to energy use in the safari park, totalling 1,236,216 kWh in 2016. The vast majority of this is for the giraffe and elephant houses, representing 33% of the total, see Figure 2. The second highest contributor is that of the restaurant yard, representing 22% of the total energy use. Figure 2 also shows the percentage contributions from other activities within the safari park.

 Figure 2: Percentage contribution from each activity

*Scope 1 – LPG and own transport use.*

The total scope 1 energy use for 2016 was recorded as 1,236,216kWh. LPG used in the safari park and, in particular, the giraffe/elephant and rhino houses, represents 684,101kWh (55% of the total for scope 1), see Figure 3. Guest services contributed to 15% of the total for scope 1 through the contribution of 38,635kWh of the restaurant yard and own use transport (85,059 kWh) also made a significant contribution representing 27% of the total. In 2016 the safari park owned 22 vehicles, of which 17 were categorised as Light Goods Vehicles (LGVs). Annual mileage and fuel use was recorded for 17 off road vehicles. These vehicles used red diesel and were categorised as such through a SORN declaration [62], with data missing for the remaining five on the road vehicles. In order to calculate fuel use an estimated mileage was given for these five on the road vehicles and, in total, all owned vehicles used approximately 30,000 litres of red diesel, equivalent to 337,940 kWh.

Figure 3: Scope 1 energy use in 2016

LPG is delivered to the site by road tankers and then stored in on-site tankers. It is then used in the safari park for two main purposes, the first is to heat the giraffe/elephant and rhino houses. Heating of these buildings is provided through hot air fan blowers. They directly combust LPG, mix the heat with fresh air and passes it through the building, ensuring adequate heating and sufficient ventilation. Secondly, the LPG is used in wet heating systems in the office and restaurant. In these buildings, the LPG-fired boilers heat water, which in turn provides central heating through radiators and hot water through taps. The amount of LPG used is monitored and recorded on a monthly basis via automated monitors back to the LPG provider, recording quantities consumed and current tank levels.

*Scope 2 – Electricity use*.

Electricity is used on site for power and lighting of all facilities. The largest consumer of electricity was guest services which is dominated by the contribution from the restaurant (263,001 kWh) and the amusement park (242,192 kWh), see Table 1 and Figure 4, which shows the total electricity consumption across the site. In 2016 the park used 771,291kWh of electricity, inclusive of a contribution from solar PV panels. There are 8 meter points across the site to monitor electricity on a half-hourly basis for all the main buildings. Each week the electricity consumption (kWh) is recorded via manual reading of individual meters.

Figure 4: Scope 2 energy use in 2016

The vast majority of electricity is derived from a grid connected system with additional electricity also generated via a 60kWp Hyundai solar photovoltaic (PV) system [63] fitted to the roofs of the bat house, sea lion house, antelope house and education building. In 2016 the system created approximately 51,000 kWh of electricity. Ideally, each building across the site should be sub-metered and a review of the general benefits has been discussed by [64]. Unfortunately, the safari park does not sub-meter their buildings and as a result it is not possible to identify individual contributions or split consumption from power and lighting. This is problematic for the safari park as, in order to reduce energy use and carbon emissions, they need to have an accurate account of existing use.

*Scopes 1 and 2 – Total energy use*.

The total combined scope 1 and scope 2 energy use for 2016 can be seen in Figure 5. The contribution from the safari park (a) and guest services (b) dominate the table, with offices (c) having the smallest overall energy use. The scope 1 LPG and own transport energy use represents 62% of the total energy use on site of which own use transport represents 17% of the total. If LPG were to be replaced by a less carbon intensive fuel then the safari park would benefit significantly from an overall reduction in carbon. Furthermore, the scope 2 contribution from the indirect use of electricity is dominant in guest services (b) and in particular the amusement and restaurant yard which collectively represent 25% of the total energy use. Using less electricity, identifying the key area of consumption and sourcing from a less carbon intensive source would also be of great benefit to the safari park.

Figure 5: Scope 1 and 2 energy use by activity for 2016



With an understanding of the total energy use in scope 1 and 2 it is now possible to convert these energy values into carbon and present the carbon footprint of the site.

3.3 Stage 3 – Conversion to carbon

In 2016 the total energy use for the site was 2.007,507 kWh of which 62% was derived from scope 1 and 38% from scope 2, see Table 1. Conversion of LPG, diesel and electricity to CO2e values follows the 2016 Defra/DECC Conversion Factors for Company Reporting [61] using equations 6 to 9 and the following conversion factors[[3]](#footnote-3). The total carbon from all activities from scopes 1 and 2 is presented in Table 2 and Figure 6. The total carbon output from scope 1 and 2 for 2016 was 596,741 kg, of which 49% is derived from scope 1 and 51% from scope 2. The carbon impact can be further disaggregated to show the contributions from all activities across scopes 1 and 2 in Figure 6. The safari park (a) emitted a total of 224,986 kg of carbon (38% of total) and the contribution from guest services was 248,523kg (42% of the total).

Table 2: Total carbon output (kg) from each activity

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Activity Area** | **Individual Contribution** | **ID** | **Scope 1** | **Scope 2** | **Total** | **%** |
| Safari park | Giraffe/Elephant House | a1 | 133,689 | 34,473 | **168,162** | 20% |
|  | Antelope House | a2 | 0 | 6,852 | **6,852** | 15% |
|  | Electric Gates | a3 | 0 | 8,485 | **8,485** | 1% |
|  | Rhino House | a4 | 23,654 | 17,834 | **41,488** | 1% |
| Guest Services | Amusement Park | b1 | 0 | 99,299 | **99,299** | 4% |
|  | Restaurant Yard | b2 | 41,394 | 107,830 | **149,224** | 22% |
| Offices | Animal House | c1 | 0 | 17,769 | **17,769** | 9% |
|  | Ticket Office | c2 | 7,867 | 9,732 | **17,599** | 13% |
| Transport | Own use transport | d | 87,864 | 0 | **87,864** | 3% |
|  | **Total** |  | 294,468 | 302,273 | **596,741** | 100% |
| % |  |  | 49% | 51% |  |  |

Figure 6: carbon output from all activities



In Figure 5 the most dominant energy use is the safari park itself and, in particular, the use of LPG to heat the giraffe/elephant and rhino houses. In Figure 6, guest services becomes the highest carbon contributor with 42% of the total. This figure may seem at odds with energy consumption data; however, it serves to highlight the carbon intensity and impact of LPG in comparison to grid connect electricity. For every kWh of LPG and electricity used in 2016 approximately 4.3kg and 2.4kg of carbon respectively are released. Grid connected electricity has almost half the carbon impact of LPG. The kWh of LPG used in 2016 was almost double that of electricity and when the carbon conversion factors are applied this gives a false impression that electricity is worse than LPG when in fact it is the opposite. If the carbon emissions factor of LPG was similar to electricity then Figure 6 would be dominated by the safari park with a carbon value of over 350,000 kg.

To put these numbers into perspective, the total scope 1 and 2 carbon output for the safari park was approximately 567t (tonnes). In a paper by [65] two 85 room hotels situated in Dorset (UK) were assessed using the GHG Protocol. Their total annual CO2e emissions from energy use alone was calculated as 335t (Hotel 1) and 178t (Hotel 2) respectively. The majority of emissions from Hotel 1 (86%) and Hotel 2 (65%) were derived from indirect electricity use. A further study [66] highlighted in a book by [67] cited that the construction of a new 2-bedroom cottage with two reception rooms and a kitchen in Scotland would emit approximately 80t of carbon. One of the most significant UK studies into the carbon footprint of buildings was undertaken by [68] in 2011, where data for 40,000 public buildings has been published. A comparison to numerous buildings in the North West of England becomes possible, with St Georges Hall emitting 1,267t and the Liverpool Arena and Conference Centre emitting 3,466t of carbon respectively.

**4. Limitations**

There are a number of limitations and areas of improvement identified in this study.

1. The exclusion of scope 3 emissions, although approved by the GHG protocol, is a significant contributor to the total carbon emissions output and should be considered in future work;
2. As the site is not sub-metered it is not possible to identify accurately the contributions from individual and separate elements. Improvements in this area would assist the safari park in targeting improvements;
3. The amusement park is powered by electricity and it is not currently possible to identify accurately the individual contributions from each ride through different loading patterns and cycles,
4. Calculation of the fuel use (diesel) for vehicles, by vehicle type, is approximate and ideally some form of accurate measure of fuel consumption is needed.
5. Reporting energy and resultant carbon emissions is, at present, not automated with the safari park reliant on manual forms of data collection and analysis. An automated system would prove invaluable.

**5. Discussion and Conclusion**

This study has applied the baseline GHG Protocol Corporate Accounting and Reporting Standard to the calculation of carbon emissions for a UK safari park during the calendar year 2016. Some elements of the standard are missing, such as future years’ assessments and verification, which have not considered for this paper. The next steps for the safari park are to consider future use and how to apply the GHG Protocol standards. In addition, there is a need for an assessment of the potential options for carbon reduction, with a full business case outline. The safari park is in a state of transition, with new attractions and buildings planned over the next 3 years. By 2020, it is anticipated that the elephant house will be remodelled and additional catering/retail facilities will be built. Both of these are planned to be powered by renewables. It is anticipated that due to these new developments and increased visitor numbers that the demand on heating energy and electrical power is estimated to increase by 20%+ by 2020, based on a 2015 baseline.

With the limitations considered and improvements made the next step is to consider a plan to reduce the carbon impact. The simplest method would be to follow the approach taken by the Lower Zambezi National Park in Zambia, who have made the claim to becoming the world’s first carbon neutral national park [27]. In short, they generate no carbon emissions from their operation and their partners. This is achieved through a form of offsetting via the use of so called Verified Carbon Units (VCUs) [69]. The national park began by calculating emissions using a simplified approach to the one described in this paper, then investigated costs effective measures to reduce this impact. Finally, any remaining emissions were offset. Offsetting is one simple method to achieve zero carbon status and one that has been widely adopted throughout the world. At a country level, the Clean Development Mechanism (CDM) [70] allows individual countries to offset their carbon through Certified Emission Reductions (CER). At a company level, individuals are able to offset through initiatives such as Climatecare [71] which are used by a number of companies such as Jaguar Land Rover [72]. In addition to Certified Emission Reductions (CER), there are Verified Emissions Reductions (VER) and Non-Verified Emission Reductions (NVER) as discussed by [73]. It is the authors’ opinion that offsetting is not the way forward and should only be considered as a last resort. An improved method is to accurately calculate the carbon output in the current and future year, research all possible energy reduction measures, shortlist to a selection of feasible options, identify the business case and source internal and/or external funding and implement the measures. On completion of all of these stages offsetting could then be considered.

**6. References**

|  |  |
| --- | --- |
| [1]  | UNWTO, “Climate Change and Tourism,” United Nations World Tourism Organisation, [Online]. Available: http://sdt.unwto.org/content/faq-climate-change-and-tourism. [Accessed 28th February 2018]. |
| [2]  | Y. Sun, “A framework to account for the tourism carbon footprint at island destinations,” *Tourism Management,* vol. 45, pp. 16-27, 2014.  |
| [3]  | J. Wang and Y. Wang, “Greenhouse gas emissions of amusement parks in Taiwan,” *Renewable Sustainable Energy Review,* vol. 74, pp. 581-589, 2017.  |
| [4]  | L. Dwyer, P. Forsyth and R. Spurr, “Estimating the carbon footprint of Australian tourism,” *Journal of Sustainable Tourism,* vol. 3, pp. 355-376, 2010.  |
| [5]  | S. Perch-Nielson, A. Sesartic and M. Stucki, “The greenhouse gas intensity of the tourism sector: the case of Switzerland,” *Environmenal Science and Policy,* vol. 13, pp. 131-140, 2010.  |
| [6]  | P. Wu and P. Shi, “An estimation of energy consumption and CO2 emissions in tourism sector of China,” *Journal of Geography Science,* vol. 4, pp. 733-745, 2011.  |
| [7]  | S. Becken, C. Frampton and D. Simmons, “Energy consumption patterns in the accommodation sector: the New Zealand case,” *Ecology Economics,* vol. 3, pp. 371-386, 2001.  |
| [8]  | S. Becken, D. Simmons and C. Frampton, “Energy use associated with different travel choices,” *Tourism Management,* vol. 3, pp. 167-277, 2003.  |
| [9]  | S. Becken, “Analyzing international tourist flows to estimate energy use associated with air travel,” *Journal of Sustainable Tourism,* vol. 2, pp. 114-131, 2002.  |
| [10]  | S. Becken, “A review of tourism and climate change as an evolving knowledge domain,” *Tourism Management Perspective,* vol. 6, pp. 53-62, 2013.  |
| [11]  | S. Becken and D. Simmons, “Understanding energy consumption patterns of tourist attractions and activities in New Zealand,” *Touism Management,* vol. 4, pp. 343-354, 2002.  |
| [12]  | S. Becken and M. Patterson, “Measuring national carbon dioxide emissions from tourism as a key step towards achieving sustainable tourism,” *Journal of Sustainabel Tourism,* vol. 4, pp. 323-338, 2006.  |
| [13]  | S. Gossling , “Carbon neutral destinations: a conceptual analysis,” *Journal of Sustainable Tourism,* vol. 1, pp. 17-37, 2009.  |
| [14]  | S. Gossling, J. Broderick and P. Upham, “Voluntary carbon offsetting schemes for aviation: efficiency, credibility and sustainable tourism,” *Journal of Sustainable Tourism,* vol. 3, pp. 223-248, 2007.  |
| [15]  | C. Jones, “Scenarios for greenhouse gas emissions reduction from tourism: an extended tourism satellite account approach in a regional setting,” *Journal of Sustainabel Tourism,* vol. 1, pp. 1-15, 2012.  |
| [16]  | I. Smith and C. Rodger, “Carbon emission offsets for aviation-generated emissions due to international travel to and from New Zealand,” *Energy Policy,* vol. 9, pp. 3438-3447, 2009.  |
| [17]  | K. Mearns, “Climate change and tourism: some industry responses to mitigate tourism’s contribution to climate change,” *African Journal of Hospitality, Tourism and Leisure,* vol. 5, no. 2, 2016.  |
| [18]  | WRI, “Greenhouse Gas Protocol: Policy and Action Standard,” World Resources Institute, Washington, 2014. |
| [19]  | E. Digital, “Carbon neutral safari reserve recognised for its sustainability efforts,” Energy Digital, 2016 December 2016. [Online]. Available: http://www.energydigital.com/sustainability/carbon-neutral-safari-reserve-recognised-its-sustainability-efforts. [Accessed 28th February 2018]. |
| [20]  | M. Chadha, “Victorian Zoos Are The First Carbon-Neutral Zoos In The World,” Clean Technica, 11th April 2013. [Online]. Available: https://cleantechnica.com/2013/04/11/victorian-zoos-are-the-first-carbon-neutral-zoos-in-the-world/. [Accessed 28th February 2018]. |
| [21]  | Guardian, “Greenwash: Disney's green intentions are pure fantasy,” 19 March 2009. [Online]. Available: https://www.theguardian.com/environment/2009/mar/19/disney-greenwash-fred-pearce. [Accessed 24 June 2017]. |
| [22]  | Edie, “Wales welcomes UK's first solar-powered theme park,” 21 September 2015. [Online]. Available: https://www.edie.net/news/6/New-solar-investment-used-to-create-the-first-renewable-theme-park/. [Accessed 18 June 2017]. |
| [23]  | B. Wire, “BioCarbon Partners Announces World’s First Carbon Neutral National Park From Operations In Lower Zambezi, Zambia,” Business Wire, 6 January 2016. [Online]. Available: http://www.businesswire.com/news/home/20160106005854/en/BioCarbon-Partners-Announces-World%E2%80%99s-Carbon-Neutral-National. [Accessed 18 April 2017]. |
| [24]  | E. S. Trust, “A rollercoaster ride to sustainability,” Energy Saving Trust, [Online]. Available: http://www.energysavingtrust.org.uk/blog/rollercoaster-ride-sustainability. [Accessed 24 June 2017]. |
| [25]  | Y. Press, “Theme park on track to make energy saving of £130,000 a year,” 4 September 2015. [Online]. Available: http://www.yorkpress.co.uk/business/news/13646257.Theme\_park\_on\_track\_to\_make\_energy\_saving\_of\_\_\_130\_000\_a\_year/?ref=mac. [Accessed 24 June 2017]. |
| [26]  | A. Magazine, “Legoland Florida announces parking lot solar energy project Legoland Florida solar energy,” 23 April 2016. [Online]. Available: http://attractionsmagazine.com/legoland-florida-announces-parking-lot-solar-energy-project/. [Accessed 23 June 2017]. |
| [27]  | S. active, “Zambia: Luambe National Park now the Worlds most carbon neutral,” 5th December 2017. [Online]. Available: https://sustainabilityactive.com/2017/12/zambia-luambe-national-park-now-worlds-carbon-neutral/. [Accessed 28th February 2018]. |
| [28]  | B. Zoo, “Environmental Sustainability Strategy,” Bristol, Cliftom amd West of England Zoological Society Ltd, Bristol, 2010. |
| [29]  | ISO, “(ISO), International Organization of Standardisation,” [Online]. Available: http://www.iso.org/iso/home.htm. [Accessed 2 March 2017]. |
| [30]  | K. Dahal and J. Neimela, “Cities’ Greenhouse Gas Accounting Methods: A Study of Helsinki, Stockholm, and Copenhagen,” *Climate,* vol. 5, no. 2, p. 31, 2017.  |
| [31]  | S. Schultz, J. Dickinson, S. Hammer, M. Lynch, J. Corfee-Morlot and O. Wyman, “Global Protocol for Community-scale Greenhouse Gas Emissions Inventories - Version 2.0,” 2014. [Online]. Available: http://www.ghgprotocol.org/files/ghgp/GPC . [Accessed 1 March 2017]. |
| [32]  | British Standards Institute, “PAS 2070: 2013. Specification for the Assessment of Greenhouse Gas Emissions of a City,” British Standards Institute, London, 2013. |
| [33]  | B. Watt and I. Burtins , “Getting to Zero: Defining Corporate Carbon Neutrality,” Clean Air Cool Planet and Forum for the Future, Portsmouth, NH, 2008. |
| [34]  | F. f. t. Future, “Getting to zero: Defining Corporate Carbon Neutrality,” 2008. [Online]. Available: https://www.forumforthefuture.org/sites/default/files/project/downloads/getting-zerouk-versionjune-2008.pdf. [Accessed 1 june 2017]. |
| [35]  | M. Brander, “Comparative analysis of attributional corporate greenhouse gas accounting, consequential life cycle assessment, and project/policy level accounting: A bioenergy case study,” *Journal of Cleaner Production,* 2017.  |
| [36]  | I. 14046, “Specification with Guidance at the Project Level for Quantification, Monitoring and Reporting of Greenhouse Gas Emission Reductions or Removal Enhancements,” ISO, 2006. |
| [37]  | G. Sinden, “The contribution of PAS 2050 to the evolution of international greenhouse gas emission standards,” *The International Journal of Life Cycle Assessment,* vol. 14, no. 3, pp. 195-203, 2009.  |
| [38]  | D. Pandey, M. Agrawal and J. Pandey, “Carbon footprint: current methods of estimation,” *Environmental Monitoring and Assessment,* vol. 178, no. 1, pp. 135-160, 2011.  |
| [39]  | B. Weidema, M. Thrane, P. Christensen, J. Schmidt and S. Lokke, “Carbon Footprint: A Catalyst for Life Cycle Assessment?,” *Journal of Industrial Ecology,* vol. 12, no. 1, pp. 3-6, 2008.  |
| [40]  | E. Giama, Life Cycle Versus Carbon Footprint Analysis for Construction Materials, Springer, 2015.  |
| [41]  | N. Pelletier, K. Allacker, R. Pant and S. Manfredi, “The European Commission Organisation Environmental Footprint method: comparison with other methods, and rationales for key requirements,” *International Journal of Life Cycle Assessment,* vol. 19, pp. 387-404, 2013.  |
| [42]  | G. Hammond, “Time to give due weight to the carbon footprint issue,” *Nature,* vol. 445, no. 7125, pp. 256-256, 2007.  |
| [43]  | T. Liu, Q. Wang and B. Su, “A review of carbon labeling: Standards, implementation, and impact,” *Renewable and Sustainable Energy Reviews,* vol. 53, pp. 68-79, 2016.  |
| [44]  | T. Boukherroub, Y. Bouchery, C. Corbett, J. Fransoo and T. Tan, “Carbon Footprinting in Supply Chains,” in *Sustainable Supply Chains*, vol. 4, Springer, pp. 43-64. |
| [45]  | C. Peng, “Calculation of a building's life cycle carbon emissions based on Ecotect and building information modeling,” *Journal of Cleaner Production ,* vol. 112, no. 1, pp. 435-465, 2016.  |
| [46]  | T. Wiedmann and J. Minx, “A definition of ‘carbon footprint’,” *Ecol Econ Res Trends,* vol. 1, pp. 1-11, 2008.  |
| [47]  | R. Anderson, C. Christensen and S. Horowitz, “Analysis of Residential System Strategies Targeting Least-cost Solutions Leading to Net Zero Energy Homes,” in *ASHRAE Conference, National Renewable Energy Laboratory*, Quebec City, 2006.  |
| [48]  | T. Moore, “The Costs and Benefits of Zero Emission Housing: Modelling of Single Detached Houses in Melbourne,” RMIT University, Melbourne, 2010. |
| [49]  | M. Leckner and R. Zmeureanu, “Life cycle cost and energy analysis of a Net Zero Energy House with solar combisystem,” *Applied Energy,* vol. 88, pp. 232-241, 2011.  |
| [50]  | T. Häkkinen and K. Belloni, “Barriers and drivers for sustainable buildings,” *Building Research & Information,* vol. 39, no. 3, pp. 239-255, 2011.  |
| [51]  | I. 14040, “International Organization of Standardization (ISO 14040:2006) Environmental management. Life Cycle Assessment Principles and Framework,” [Online]. Available: http://www.iso.org/iso/catalogue\_detail?csnumber=37456. [Accessed 3 March 2017]. |
| [52]  | I. 14044, “International Organization of Standardization (ISO 14044:2006) Environmental management. Life Cycle Assessment Requirements and guidelines,” [Online]. Available: http://www.iso.org/iso/home/store/catalogue\_tc/catalogue\_detail.htm?csnumber=38498. [Accessed 2 March 2017]. |
| [53]  | C. Karlsson, S. Miliutenko, A. Björklund and U. Mö, “Life cycle assessment in road infrastructure planning using spatial geological data,” KTH Royal Institute of Technology, Stockholm, 2016. |
| [54]  | Z. Sajid, F. Khan and Y. Zhang, “Process simulation and life cycle analysis of biodiesel production,” *Renewable Energy,* vol. 85, pp. 945-952, 2016.  |
| [55]  | Forum for the future, “Getting to zero: Defining Corporate Carbon Neutrality,” 2008. [Online]. Available: https://www.forumforthefuture.org/sites/default/files/project/downloads/getting-zerouk-versionjune-2008.pdf. [Accessed 23 May 2016]. |
| [56]  | F. Caro, C. Corbett, T. Tan and R. Zuidwijk, “Double Counting in Supply Chain Carbon Footprinting,” *Manufacturing and Service Operations Management,* vol. 15, no. 4, pp. 545-558, 2013.  |
| [57]  | M. Lenzon, “Double-Counting in Life Cycle Calculations,” *Journal of Industrial Ecology,* vol. 12, no. 4, pp. 583-599, 2008.  |
| [58]  | DEFRA, “Environmental Reporting Guidelines: Including mandatory greenhouse gas emissions reporting guidance,” DEFRA, London, 2013. |
| [59]  | M. Krarti, Energy Audit of Building Systems: An Engineering Approach, Second Edition, Florida: CRC Press, 2011.  |
| [60]  | S. Halbhavi, V. Datar , S. Kulkarni and P. Terani, “Energy Auditing: A Walk through Survey of Library Building of Institute to Reduce the Lighting Cost,” *International Journal of InnovativeResearch in Electrical, Electronics, Instrumentation and Control Engineering,* vol. 3, 2015.  |
| [61]  | Defra/DECC, “Guidelines to Defra/DECC's GHG Conversion Factors for Company Reporting,” 2016. [Online]. Available: https://www.gov.uk/government/collections/government-conversion-factors-for-company-reporting. [Accessed 23 May 2016]. |
| [62]  | Gov.uk, “Register your vehicle as off the road (SORN),” Gov.uk, 2 April 2017. [Online]. Available: https://www.gov.uk/make-a-sorn. [Accessed 10 April 2017]. |
| [63]  | E. Environments, “Commercial Solar PV - Knowsley Safari Park, Sea Lions,” [Online]. Available: http://www.eco-environments.co.uk/portfolio/knowsley-safari-park/. [Accessed 10 April 2017]. |
| [64]  | M. Ahmed, M. Mourshed, D. Mundow and M. Sisinni, “Building energy metering and environmental monitoring – A state-of-the-art review and directions for future research,” *Energy and Buildings,* vol. 120, pp. 85-102, 2016.  |
| [65]  | V. Filimonau, J. Dickinson, D. Robbins and M. Huijbregts, “Reviewing the carbon footprint analysis of hotels: Life Cycle Energy Analysis (LCEA) as a holistic method for carbon impact appraisal of tourist accommodation,” *Journal of Cleaner Production,* vol. 19, no. 17-18, pp. 1917-1930, 2011.  |
| [66]  | Guardian, “What's the carbon footprint of ... building a house,” [Online]. Available: https://www.theguardian.com/environment/green-living-blog/2010/oct/14/carbon-footprint-house. [Accessed 10 April 2017]. |
| [67]  | M. Burners-Lee, How Bad are Bananas - The Carbon Footprint of Everything, Profile Books, 2010.  |
| [68]  | C. Visuals, “Carbon Footprint of 40,000 UK Public Buildings,” 24 October 2011. [Online]. Available: http://www.carbonvisuals.com/projects/google-earth-uk-public-buildings. [Accessed 10 April 2017]. |
| [69]  | VCS, “Standards for a Sustainable World,” Voluntary Carbon Standards, 2017. [Online]. Available: http://www.v-c-s.org/. [Accessed 8 April 2017]. |
| [70]  | UNFCCC, “UNFCCC Clean Development Mechanism,” [Online]. Available: http://unfccc.int/kyoto\_protocol/mechanisms/clean\_development\_mechanism/items/2718.php. [Accessed 23rd May 2016]. |
| [71]  | Climatecare, “Climatecare Carbon Offsetting,” [Online]. Available: http://climatecare.org/carbon-offsetting/. [Accessed 23 May 2016]. |
| [72]  | JLR, “Jaguar Land Rover Sustainability Report,” 2013. [Online]. Available: http://www.jaguarlandrover.com/media/22638/Sustainability-Report-1213-Interactive-080114.pdf. [Accessed 23 May 2016]. |
| [73]  | S. Gössling, J. Broderick, P. Upham, J. Ceron, G. Dubois, P. Peters and W. Strasdas, “Voluntary Carbon Offsetting Schemes for Aviation: Efficiency, Credibility and Sustainable Tourism,” *Journal of Sustainable Tourism,* vol. 15, no. 3, pp. 223-248, 2007.  |

1. The word carbon in this paper refers to carbon dioxide equivalent (CO2e). A term used to group all greenhouse gas emissions together into a common form following the Kyoto Protocol guidance. [↑](#footnote-ref-1)
2. Where a direct energy value (kWh) is not available a further conversion factor is used. For example, LPG used on site is recorded in volume (litres) and converted to kWh using an equivalent energy conversion. [↑](#footnote-ref-2)
3. 0.41 kgCO2e per kWh of electricity generated

0.23 kgCO2e per kWh of LPG used (net CV used)

0.26 kgCO2e per kWh of diesel used (net CV for average diesel used) [↑](#footnote-ref-3)