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Energy Use and the Associated Carbon Emissions – An Analysis of Two Nature-Based Tourism Properties in the Greater Kruger National Park

Tovhowani Thandi Nomagugu Mudau
Department of Environmental Sciences, University of South Africa, Pretoria, South Africa, Email, tntmudau@gmail.com, https://orcid.org/0000-0002-6656-463X

Natascha Child
Department of Environmental Sciences, University of South Africa, Pretoria, South Africa, Email, taschachild17@gmail.com, https://orcid.org/0000-0001-7575-3021

Kevin Mearns*
Department of Environmental Sciences, University of South Africa, Pretoria, South Africa, Email, mearnkf@unisa.ac.za, https://orcid.org/0000-0001-5874-3542

Corresponding Author

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Abstract

The effects of climate change are a global issue with the potential to threaten human existence on Earth. All aspects of society must find innovative ways to reduce their contributions to climate change and prevent a further rise in global temperatures. The tourism industry is in a position where it has the potential to help solve many critical socio-economic and environmental issues. Environmental concerns and market pressures are encouraging tourism companies to implementing strategies to "go green". In this article the energy use and relative carbon emissions of two South African nature-based lodges in the Greater Kruger National Park are analysed. The recent conversion away from using a diesel generator to solar energy were analysed at Property A, this showed a significant reduction in carbon emissions. Property B also showed an encouraging reduction in emissions for most years, through the successful implementation of energy-efficient management practices. The highest carbon emissions outside electricity related emissions, was vehicle diesel, which is used in game drive activities and general transportation. These results provide valuable examples of the steps tourism ventures can take to reduce carbon emissions.

Keywords: Energy use; carbon emissions; nature-based tourism; solar power

Introduction

"The natural world is the greatest source of excitement; the greatest source of visual beauty; the greatest source of intellectual interest. It is the greatest source of so much in life that makes life worth living". Sir David Attenborough (Bury, 2006: 60). Tourism is considered to be the most significant economic sector worldwide in terms of potential growth and GDP contributions (Musora & Mbaiwa, 2018; Pan et al., 2018). It is an industry that could help in solving many important social and environmental issues, such as poverty alleviation (Folarin & Adeniyi, 2020; Fourie & Santana-Gallego, 2011; Suchkova, 2021) and could significantly assist in reaching the global Sustainable Development Goals (SDGs). However, as an industry, tourism and associated international travel are significant contributors to global greenhouse gas (GHG) emissions. If more is not done, the required reduction in emissions to avoid catastrophic climate change will not be reached (Peeters & Dubois, 2010; UN Climate Change, 2018).

In recent years there has been a noticeable shift in consumer behaviour from the traditional "sun, sea and sand" holidays, towards more eco-sensitive, nature-related activity holidays (Musora & Mbaiwa, 2018). Pristine environments and healthy ecosystems can draw huge numbers of tourists to previously low-income areas, creating economic opportunities for local people. Tourists flock from all over the world to witness the unrivalled biodiversity that the African continent has to offer. Finding a balance between reaping the economic benefits from tourists and conserving the natural environment is the key to a sustainable future for Africa's nature-based tourism. Nature-based tourism is tourism that centres around natural environments (Gaia discovery, 2017). It is a broad term, which can include other branches of tourism including adventure tourism, ecotourism and conservation tourism; where the main aim of the tourist is to enjoy and experience undeveloped natural areas (Markowski, et al., 2019).

Tourism in Africa has increased significantly in popularity over the last two decades. Booyens (2016) describes how, over the previous 20 years, South African tourism services grew at a disproportionate rate when compared with all other nationwide economic services. South Africa is the most popular tourist destination in sub-Saharan Africa; and received an annual average increase of nearly 10% in tourism receipts from 1995-2008 (Fourie & Santana-Gallego, 2011). Similarly, significant annual increases were recorded in many other African countries including: Nigeria, Ghana, Ethiopia, Rwanda and Cape Verde (Dieke, 2020; Fourie & Santana-Gallego, 2011). This illustrates the importance of the tourism industry to African economies and reaffirms the potential it has to help alleviate socioeconomic issues like poverty. More recently, Dieke (2020), found that Sub-Saharan Africa enjoyed a steady increase in tourist arrivals from 2010-2017; and in 2017, the African region received the highest increase in tourism growth worldwide. The number of tourists to Sub-Saharan Africa reached an all time high in 2018 with over 56 million visitors to the region, which dropped slightly to just over 55 million the following year (The World Bank Group, 2022). The Covid-19 pandemic and its associated lockdowns in 2019-2021 caused the global tourism industry to come to an abrupt halt, this had devastating effects on countries that rely on tourism; with South Africa being one of the worst affected destinations in the world (Rogerson & Rogerson, 2020).

The effects of climate change and global warming are predicted to have further drastic impacts on nature-based tourism. Hoogendoorn and Fitchett (2018) argue that the African continent has the lowest ability to adapt to changes brought about by the severe impacts of climate change, namely: drought, variable precipitation levels and rising sea levels. There is currently little evidence of strategic planning for these impacts amongst tourism operators in South Africa (Pandy & Rogerson, 2018). Of the many strategies companies can use to reduce and mitigate their emissions, converting away from fossil fuels to renewable energy is one of the most effective (Shahsavari & Akbari, 2018). Solar energy technologies in particular have been identified as having huge potential to reduce emissions and help Africa meet its sustainable development goals (Adenle, 2020).

There is growing pressure on African safari lodges, especially those in very remote wilderness areas, to switch to renewable energy sources. The most common energy source at these remote locations is from diesel-powered generators (Suchkova, 2021). The use of fossil fuels directly opposes the idea that visitors want to witness these unique natural environments with the knowledge that by doing so they are helping to preserve them for future generations. Tourism companies in Africa are now motivated to "go green" or eco-efficient; not only for a sustainable future but also as a marketing promise to keep up with their competition. A recent study by Booking.com found that more than half of global travellers want to travel more sustainably in the future (Donovan, 2021). Similarly, Morrison-Saunders et al. (2019) conducted a survey of visitors to the Kruger National Park (KNP), South Africa, and their expectations for responsible tourism, which recorded that "energy, water and waste management were all considered very important by all respondents" (Morrison-Saunders et al., 2019: 1).

Due to these global and industry challenges the authors analyse the energy-use and carbon emissions of two nature-based lodges in South Africa's Greater Kruger National Park (GKNP). These will be referred to as Property A (PA) and Property B (PB). Property A recently converted its main energy source from diesel generators to solar power, making it a useful comparative example. The aim of this article is to showcase the importance of reducing fossil-fuel derived energy use and the associated carbon emissions in the tourism industry; and to demonstrate the benefits of African nature-based tourism converting to renewable, clean energy sources.

Tourism and climate change

Adapting to climate change is vital to the survival of tourist destinations (Mushawemhuka et al., 2018). The tourism industry is in a precarious position, as tourism activities significantly contribute to the climate crisis; and yet the tourism industry is already falling victim to the impacts of global warming and the associated extreme weather events (Dube et al., 2020). A study by Dube and Nhamo (2020) describes the considerable detrimental impacts climate change induced extreme weather events have already had on South Africa's KNP; droughts, floods and excessively high temperatures have lead to losses in biodiversity as well as park infrastructure. Additionally, changes in rainfall patterns, associated with climate change, have been recorded across the African continent (Dunning et al., 2018; Rowell & Chadwick, 2018); and South Africa's annual average temperatures have risen significantly when compared to average global temperature rises (Ziervogel et al., 2014). These changes in rainfall and temperature put Africa's carefully balanced and unique ecosystems at risk. Whilst the African continent produces the lowest amount of carbon compared to the other continents; South Africa alone produces ~50% of the entire continent's carbon emissions and is the 12th highest generator of absolute carbon emissions worldwide (Shahsavari & Akbari, 2018). This is because the country relies mainly on coal fuel to support its ever-expanding population and industries (Amusan & Olutola, 2017).

As an economic sector, international tourism is estimated to be responsible for 8% of the overall carbon emissions between 2009 and 2013 (Lenzin et al., 2018) These emission levels have been predicted to increase by 4% on an annual basis if the industry does not act to mitigate or reduce them (Fava, 2020). The industry's main producer of carbon and greenhouse gas (GHG) emissions is international air travel related to tourist activity; this is followed by automobile transportation, with accommodation being the third highest contributor (Mearns, 2016). African nature-based travel is highly popular amongst international tourists and therefore the large number of international flights associated with travelling to the continent must be considered. South Africa alone welcomed an estimated 15 million international tourists each year between 2016-2019 (The World Bank, n.d.). Of these international visitors, nearly 1%, ~150,000 people, visited the KNP, to enjoy South Africa's largest national wilderness area and the biodiversity within it (Department of Environmental Affairs and SANParks Corporate Communications, 2015).

Once guests travelling to KNP have reached their destination accommodation, the most popular activity is the game drive. This involves guests being driven by a nature guide, usually in a 4x4 vehicle, to look for and view the unique biodiversity Africa offers. Game drives are offered twice daily at most lodges hosting overnight guests. These drives obviously contribute to the property's energy use and carbon emissions. Although some lodges have introduced electric safari vehicles - in some cases charged by solar energy - this is rare and not yet an industry-wide practice. When air travel and game drives are considered, safari holidays seem far from sustainable – the remaining opportunity for reducing emissions falls to the third highest emissions producer, accommodation.

Measures to reduce and mitigate carbon emissions

One strategy used by tourism companies to be more eco-efficient, is to focus on their environmental impacts and the ways in which they can improve their environmental performance. This is done by looking at every aspect of the business and seeing where energy can be saved. Examples of how energy can be saved in this way include: switching to energy-saving appliances and light bulbs; teaching energy-saving practices to staff; and encouraging guests to be more energy-conscious. These strategies are often relatively cost-effective and do not require significant resources to initiate. On top of introducing energy-conserving practices, a new trend has begun to emerge within the travel industry, which gives travellers the option to take some responsibility for their carbon footprint – a voluntary carbon-offsetting fee (Cordes, 2020). Carbon offsetting refers to the counterbalancing of generated carbon emissions by the proceeding investment in carbon reducing initiatives (Baker & Mearns, 2017). Some tourism companies have gone so far as to calculate the average carbon emissions their guests will generate throughout their stay (including travelling to the destination); converting this into a monetary value; and then incorporating it into the cost of the stay. These funds are ring-fenced to procure and invest in certified carbon mitigation projects. Recent papers analysing the general public's willingness to pay (WTP) for pro-environmental goods in the aviation industry, such as a carbon-offsetting fee, have found that in general WTP for pro-environmental services is consistently positive (Cordes, 2020; Sonnenschein & Mundaca, 2019).

Solar energy

Of the numerous "eco-efficiency strategies" employed by African tourist companies, the foremost is the use of solar energy in the place of diesel-fuelled generators (Suchkova, 2021). Solar energy has huge potential as a renewable energy source due to its "inexhaustible supply, universality, high capacity and environmental friendliness" (Gong et al., 2019: 1). According to Kabir et al. (2018), solar technologies are predicted to greatly reduce emissions in the transport sector, as well as help to reduce global issues such as energy security, energy poverty and unemployment. The African continent is the sunniest of the continents (Kabir et al., 2018); and most areas of South Africa receive sunshine all year round, therefore it is an ideal place to base solar initiatives.

Solar energy technologies fall into two main categories, passive and active. Passive technologies collect solar energy without transforming it; this technology is used for water heating systems (Kabir et al., 2018). Active solar technologies convert solar radiation into electricity; the most popular example of this is photovoltaic technology (Mohanty et al., 2016). When light is shone on the photovoltaic technology, atoms release electrons, which create a flow of electricity; this can then be used immediately or stored in batteries (Dhar, 2017).

Several lodges, in Kenya, Botswana and South Africa, have successfully switched to solar power; with one company in Botswana reporting a $400,000 saving to date, after converting five of their camps (Suchkova, 2021). Although these savings are enviable, the conversion to solar power is not an inexpensive process. The high price of initial installation of solar technologies is the biggest drawback of this energy system (Kabir et al., 2018). Mearns (2016) describes case studies of two accommodation providers in Southern Africa; the first, Sandibe Okavango Safari Lodge in Botswana, spent R6.4 million rand (over $400,000 in December 2021) on their conversion to solar. This sum could be made back in fuel savings after seven years (Mearns, 2016). However, the large upfront costs mean that without support, smaller, less profitable companies lack the resources to convert to renewable energy. Unfortunately, this is the case for the majority of African tourism companies, which still use fossil fuels as their main energy source.

The first nature-based tourism property in the GKNP, South Africa, to convert to solar energy as a primary power source was private safari concession, Singita Kruger National Park. In 2015, when they announced the conversion, they predicted that the 40,000 litres of diesel consumed on a monthly basis by the old generator would be halved after the assembly of 1188 solar panels was complete (Singita, 2015). The next year, Singita announced that they would be installing batteries produced by Tesla Energy and trialling new "Powerpack energy storage systems" to further reduce their diesel consumption (Singita, 2016). Today, almost 80% of the power needed to run Singita Kruger National Park is provided by this solar energy technology, which has remarkably reduced their carbon emissions (Bakchormeeboy, 2021).

Methodological procedures

Characterization of the study area

The GKNP is the largest National Park in South Africa. It is located across two different provinces namely, Limpopo and Mpumalanga. It further borders Mozambique to the East and Zimbabwe in the far North. In 1927 when the Kruger National Park (KNP) opened its gates to tourism, they initially had 27 visitors that year. In 2016/2017 that number had increased to 1.8 million visitors, excluding the visitor numbers in the reserves adjacent to the park. This makes it the most successful National Park in the country with regards to its local and international profile as well as the revenue generated from tourism (Brett, 2018). The Park is open to day visitors and overnight visitors who can stay in either the National Park rest camps, the private concessions within the park or the private game reserves adjacent to the park. The main tourist activities within the park are game drives, either self-drive or guided game drives.

Property A is located in the central KNP, it contains two lodges which comprise a total of 24 suites. It also has a total of 136 staff rooms across its staff villages, bringing the total number of units (suites and rooms) in Property A to 160. These two lodges in Property A fall within a 33 000 acre concession. Property B is located in the Sabi Sands Reserve, which is adjacent to the KNP there is, however, no fence between the two areas. It contains three lodges, which comprise a total of 30 suites; it also has 128 staff rooms, bringing the total number of units in Property B to 158. These three lodges fall within 45 000 acres. In 2021 Property A had a staff compliment of 188 staff, with 173 staff members living onsite, of which only an average of 130 staff would be staying onsite at the same time and around 43 staff would be on leave, a further average of 12 would be travelling into work daily. Property B in this same time period had a staff compliment of 246 staff, with 121 staff members living onsite, only an average of 91 staff would be staying onsite at the same time and around 31 staff will be on leave, a further average of 94 staff members would be travelling into work daily. On average, annually, during the years of the study (2016 - 2019), these staff numbers have not fluctuated greatly nor have the room numbers fluctuated greatly, meaning the same approximate parameters can be set for 2016 to 2019. The two properties in this study provide guided game drives twice a day; and they offer 3 meals per day for the guests as well as pre-game drive snacks. Property A's suites include a shower, bath, air conditioner, mini bar, telephone, coffee machine, hair dryer and speaker in each suite. In addition, the main lodges have a television in the main area, bar, kitchen, swimming pool, boutique, gallery, spa with a dry sauna and fitness centre. Property B's suites include a shower, bath, air conditioner, mini bar, telephone, coffee machine, hair dryer and speaker in a room; two of the lodges also have a plunge pool in their suites (24 of the 30 suites). In addition, the main lodges have a television in the main area, bar, kitchen, swimming pool, boutique, gallery, spa and fitness centre.

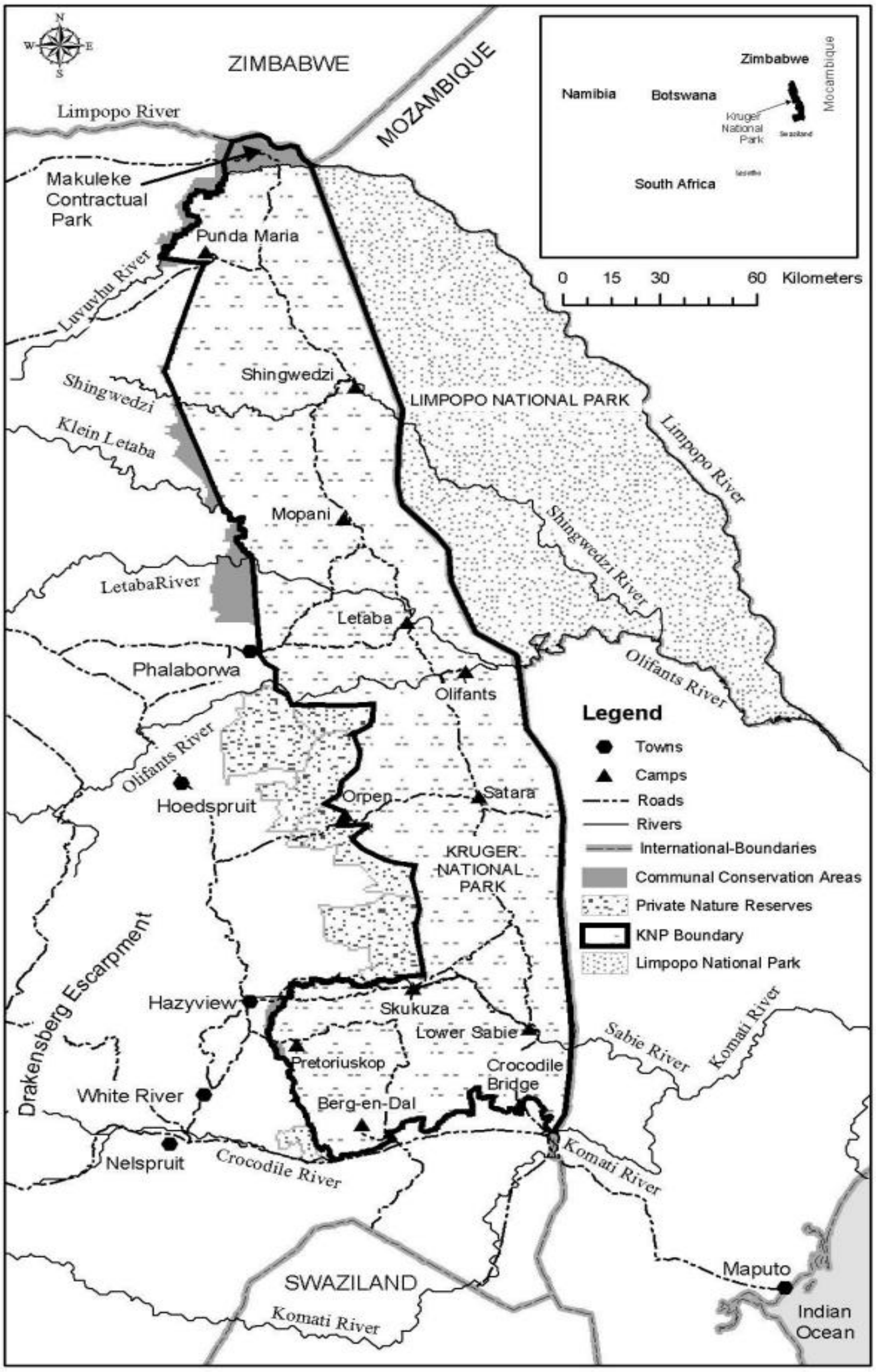


Figure 1: Map of the Greater Kruger National Park in North Eastern South Africa
Source: Kruger National Park Management Plan (Freitag-Ronaldson & Venter, 2008: 14)

Furthermore, both Properties lodges' have administration offices/areas at back of house, which include office equipment such as computers, printers and other electronic equipment. They both have residential areas for staff to live on the property and kitchen facilities to cater three meals a day for the staff. Most of the guests that frequent these lodges fly into the reserve, with a small percentage driving in. In the tourism industry, the main activities at all lodges are game drives and bush walks which are spent away from the lodge facilities. On average guest spend 9 hours away from the lodge during the day and an additional 2 – 4 hours outside their rooms during meal times. Staff members spend an average of 9 – 14 hours at work away from their staff accommodations.

Property A is off the grid. The property was running on diesel generators to supply electricity to both lodges, back of house and the staff villages. In mid-November of 2014 construction began for two solar photovoltaic (PV) plants, one to service the lodges and the other to service the staff village. The solar PV plant installation was completed in March of 2015 and the 1st phase of the solar PV project went live. In 2017 there was a capacity upgrade to increase the size of the solar PV plant for the lodges. They replaced the lead-acid with lithium-ion batteries and transferred the lead acids to the solar PV plant for the staff village to expand their battery capacity. In March 2017, the 2nd phase of the solar PV project went live. In 2020 the 3rd phase of the solar project saw the installation of all lithium-ion batteries, which replaced the lead-acid batteries and expanded the battery capacity at the staff village. The carbon emission results for Phase 1 and Phase 3 of the solar project were not included in this study because Phase 1 occurred in 2015 and Phase 3 in 2020, which do not form part of the years (2016 - 2019) that were included in this study. Property B uses electricity supplied by the largest producer of electricity in South Africa, which is the utility called Eskom.

Methods and techniques

Carbon emissions at nature-based lodges offering safari experiences in Africa is a topic that has not been adequately investigated and thus requires an increase in supporting data to cover this topic, considering that greenhouse gases which include carbon, are a contributing factor to climate change. In Southern Africa, the predicted effects of climate change include, and are not limited to, warmer and drier conditions in the region. An increase in temperature happening at twice the average rate globally, could lead to biodiversity loss and premature species extinction (Scholes & Engelbrecht, 2021) which has a direct effect on nature-based lodges offering safari experiences.

To collect the data a qualitative research method was used in the form of an interview with the sustainability co-ordinators of the properties; observation of the lodge structure, operations and activities; and a secondary data analysis with data received from the sustainability manager of both Property A and Property B. The documents analysed for this article stem from the respective Properties' Sustainability reports and Carbon emission reports. The sum of both the lodges' and staff quarters' carbon emissions in Property A were included in the reports; and the sum of the three lodges' and staff quarters' carbon emission in Property B were included in the reports. The article will be focusing on the source of greenhouse gases, limited to scope 1 and scope 2 emissions. A total of 5 lodges were selected to carry out the research but the interrelation between the carbon emissions in each of the lodges in Property A and each of the lodges in Property B could not be ignored. As a result of the connections between the lodges in Property A and Property B respectively, the sum of each lodge's carbon emission, including that of back of house and the staff village, was tallied and presented as a collective in each property.

Scope 1 emissions cover mobile combustion in the form of vehicle petrol and diesel as well as stationary combustion in the form of diesel for generators, paraffin, wood and liquefied petroleum gas (LPG) for cooking and water heating. Scope 1 emissions exclude refrigerants in this study due to data limitations for this section. Scope 2 will focus on electricity purchased from energy suppliers. Scope 3 emissions, which include *inter alia* guest and staff transportation and air travel, were not included in this study. The data was reviewed over a four-year period, namely 2016 to 2019. The 2020 data was not reviewed as the emissions would not represent a true reflection of the properties' operations, as a result of the Covid-19 pandemic. The lodges at both Properties were temporarily closed and even when they opened, due to restrictions, and international borders closing, they were not operating at full capacity, both in relation to guests and staff numbers.

The diesel, petrol and paraffin, measured in litres, as well as the wood and LPG, measured in kg, were later converted into $kgCO_2e$ using the following formula to estimate emissions:

$E(CO_2): \sum Qi \times Fc$ (Melo et al., 2021).

Where:

$E(CO_2)$: total CO_2 emissions in kilograms (kg);
Qi: energy consumption in kilowatt hours (kWh), diesel, petrol and paraffin in liters (l), LPG consumption and wood in kilograms (kg);
Fc: conversion factors to transform the collected data into kg CO_2

The below table lists the number of bed nights (guests) and staff members on property for each year on PA and PB respectively. They are the sum of each bed nights and staff numbers calculated per day.

Table 1: Annual bed night and staff numbers in Property A

Property A			
Year	**Bed night numbers**	**Staff numbers**	**Total**
2016	9,223	43,435	52,658
2017	10,228	48,180	58,408
2018	10,966	48,180	59,146
2019	9,566	48,180	57,746

Table 2: Annual bed night and staff numbers in Property B

Property B			
Year	**Bed night numbers**	**Staff numbers**	**Total**
2016	16,624	79,556	96,180
2017	15,981	78,264	94,245
2018	15,481	80,203	95,684
2019	13,437	82,285	95,722

The relationship between the total number of bed nights and staff numbers, is positively correlated to total carbon emission. This is because an increase/decrease in guest or staff numbers increases/decreases activity on the properties (game drives, energy use, food preparation, and other activities on the properties), thus an increase/decrease in lodge activity increases/decreases carbon emissions.

Results and discussion

Scope 1 and scope 2 emissions comparison

In this section, we review the Scope 1 data, which consists of Mobile Combustion (Petrol and Diesel for vehicles) and Stationary Combustion (Diesel for generators, Paraffin, Wood, LPG (Cooking Gas)) figures. We also review Scope 2 data, which consists of electricity received or purchased from energy suppliers. In the below tables, we look at the areas where PA and PB decreased their scope 1 combustion namely the mobile and stationary combustion. The research further looks at the methods they used to reduce it over the 4-year study period. A per bed night (pbn) figure is further calculated annually by dividing the combustion figures by the total bed night figures for the respective years.

Table 3: Scope 1 emissions for Property A

Property A: Scope 1								
Mobile Combustion								
Source of Green House Gas	**2016**	**Pbn**	**2017**	**Pbn**	**2018**	**Pbn**	**2019**	**Pbn**
Petrol (l)	156	0.02	384	0.04	245	0.02	291	0.03
Diesel – Vehicles (l)	79,173	8.58	81,837	8.00	82,860	7.56	83,986	8.78
Stationary Combustion								
Source of Green House Gas	**2016**	**Pbn**	**2017**	**Pbn**	**2018**	**Pbn**	**2019**	**Pbn**
Diesel – Generators (l)	398,084	43.16	200,614	19.61	173,655	15.84	140,669	14.71
Paraffin (l)	1,632	0.18	1,922	0.19	2,320	0.21	2,171	0.23
Wood (kg)	59,309	6.43	57,627	5.63	50,268	4.58	54,540	5.70
LPG Cooking Gas (kg)	16,026	1.74	18,106	1.77	20,109	1.83	21,147	2.21

Property A reduced their diesel consumed by generators between 2016 and 2019 by 65%. In 2017 Property A's primary power source was converted to between 70% - 90% solar energy as part of the Phase 2 of their solar upgrade. The reduction in diesel used for the generators can be greatly attributed to this upgrade, in addition Property A also increased their efforts to save electricity by preventing wastage at the source, and by introducing energy saving appliances and light bulbs. In addition, in 2019 Property A reduced their wood consumption to 54 540kg, from 59 309kg in 2016. This is a reduction of 4 769kg of wood in 4 years, however this can be attributed to an average decrease in bed nights per day, which would mean less wood would be used daily for recreational activities like outdoor dinners (bomas and bush dinners) and fire places. In addition, a Standard Operating Procedure (SOP) on wood use on fires across the lodges was put into place which stated among other things that internal (indoor) fireplaces should only be lit in the evening during the colder months (mid-May to mid-September), with the exception of warmer days that fall in those months, whereby the fires will not be lit. On the warmer months (mid-September to mid-May) they should only be lit on guest request, with the exception of colder days whereby managers on duty will use their discretion as to when and where to light them. In addition, the sizes of the fires were reduced from large fires to medium fires that create enough warmth and ambience. This SOP is believed to have contributed to the wood reduction. The other GHG emissions (Petrol and diesel for vehicles, Paraffin and LPG) have however increased over the four-year study. This increase can be attributed to the fact that both lodges in property A were renovated during the years of the study, more noticeably a Pool suite was added in one lodge in 2017, this pool suite has a private pool which can be heated upon request, in addition a fully staffed Villa with its own kitchen and boma was built in the other lodge in 2016, this Villa features two family suites each with a private pool and an additional shared pool which can be heated at request. These renovations both during construction and the operational phase expanded the energy use and thus had the effect of increasing GHG emissions. There is insufficient data to divulge further the rationale behind this increase and any presumption would be speculation.

Table 4: Scope 1 emissions for Property B

Property B: Scope 1								
Mobile Combustion								
Source of Green House Gas	**2016**	**Pbn**	**2017**	**Pbn**	**2018**	**Pbn**	**2019**	**Pbn**
Petrol (l)	1,748	0.11	2,833	0.18	1,750	0.11	1,559	0.12
Diesel – Vehicles (l)	69,693	4.19	70,610	4.42	61,608	3.98	58,957	4.39
Stationary Combustion								

Source of Green House Gas	2016	Pbn	2017	Pbn	2018	Pbn	2019	Pbn
Diesel – Generators (l)	23,620	1.42	12,800	0.80	9,616	0.62	9,913	0.74
Paraffin (l)	9,086	0.55	7,847	0.49	6,594	0.43	6,104	0.45
Wood (kg)	76,860	4.62	70,126	4.39	80,620	5.21	67,140	5.00
LPG Cooking Gas (kg)	35,058	2.11	34,764	2.18	34,446	2.23	31,122	2.32

During the four-year study period Property B managed to decrease all emissions in scope 1 in absolute terms when considering the combustion levels per year, however, the per bed night figures show that per bed night the only decrease in combustion was generator diesel and paraffin. The data available could not elucidate the reason for the positive linear results with those stationary combustions, aside from a solar panel that was inserted to power a borehole in the beginning of 2018, which reduced generator diesel and reduced the diesel used to transport fuel to the borehole pump. The majority of the generator use in Property B was dependant on loadshedding as the main generators that power the lodges and staff village was used as back up energy supply during load shedding. The exact load shedding schedule was not available for the years of this study, but consequently one can presume the reduction of generator diesel was due to a reduction of loadshedding. The decrease in paraffin use can be attributed to the fact that starting a fire with the use of paraffin was put to an end during the course of the study, and in addition the use of paraffin lantern was rationalised. Furthermore, a core pillar in Property Bs' operation is sustainability, in addition, they adopted the Bioregional's One Planet Living framework into their operations, where carbon foot printing is done to account for environmental impacts (Bioregional, 2018). Applying these principles may have had the effect of reducing negative impacts. The principle that aims to reduce carbon emissions could be part of why Property B reduced some scope 1 emissions over the four-year timeline. That said, Property A also adopted and follows the One Planet Living framework.

Table 5: Scope 2 emissions for Property B

Source of Green House Gas	2016	Pbn	2017	Pbn	2018	Pbn	2019	Pbn
Electricity (kWh)	2,787,727	167.69	2,637,462	165.04	2,618,532	140.08	2,553,410	190.03

The data included in scope 2 is electricity purchased from an energy supplier and accounts for emissions generated at the source of the energy production. Property A is off the grid and has never received or purchased electricity from grid energy suppliers in the years the study was conducted, which was 2016 to 2019. During these years 70% to 90% of its electricity was generated by renewable resources, namely solar energy and the remaining 30% to 10% was produced by diesel generators, which was already accounted for in scope 1. Therefore, Property A can claim 0 emissions in Scope 2 (Sotos, 2015). Over the 4-year period that the data was examined, Property B greatly reduced their electricity consumption by over 234 314 kWh. However, taking into consideration that the 2019 bed night figures were at an all-time low when compared to the preceding years, then the reduction of electricity can be in part attributed to a reduction of bed nights over the 4-year period. In addition to the bed night numbers decreasing, it has to be noted, as seen in Table 2, that the number of staff members increases exponentially from 2016 to 2019. Notably there was an increase to 2729 staff between those years which is an increase of 7.48 staff members on site a day in 2019 compared to that of 2016, which were 225.44 staff a day in 2019 and 217.96 staff on site a day in 2016. The bed night value for electricity used does however decrease substantially between 2016 and 2018 as seen in table 5 but there was a peek in 2019 which cannot be accounted for in the data present. However, it was noted from Property Bs quarterly reports that the reasons for the decline in kWh per bednight generated from 2016 to 2018 is because of several contributing factors, which include, but are not limited to:

- Replacing old air conditioners with power efficient air conditioners that have inverters, which can save around 35% of electricity consumed by a standard air conditioner (Siriwardhana & Namal, 2017).
- Installing solar geysers at all units at one of the three lodges in property B, as well as in some units at the main staff village. Geysers form about 40% of residential electricity consumption (Hashiyana et al., 2020) and as a result, solar geysers can greatly reduce energy consumption, even more so at nature-based lodges where almost all units in staff villages and all units at guest rooms are fitted with geysers including and not limited to kitchens and restrooms. A reduction in geyser electric consumption can ultimately lead to a reduction in the overall load.
- Installing solar blankets on all electrical geysers, which reduces the rate at which the water cools keeping the water warmer for a longer period, resulting in a reduction in electricity used to reheat the water, and ultimately leading to an overall electricity use reduction.
- Replacing old, traditional incandescent bulbs with Light Emitting Diodes (LED) bulbs which use only 20% - 25% of the energy that traditional bulbs use, and they last longer than traditional bulbs that have the same light output.
- Reducing phantom energy by switching off and unplugging electrical appliances and lights when they are not in use, both in staff villages and unoccupied guest rooms.
- Load shedding by the electricity provider (Eskom), resulting in more generator use and less electricity use.
- Inserting power efficient electrical appliances to replace older ones, which has the effect of improving the efficiency of the appliances and ultimately their energy-efficiency and use.

Total CO2 emissions

In this section the consumption which was recorded in kilowatt hours (kWh) for electricity, litres (l) for diesel, petrol and paraffin, kilograms (kg) for LPG cooking gas and wood were converted to $kgCO_2e$ using the following formula: $E(CO2)\text{: } \sum Qi \times Fc$. Therefore, all total carbon emissions are thus represented in $kgCO_2$ in the graphs below. The carbon emission results are compared against their annual emission figures internally for each property.

During the years reviewed the GHG emission factors were derived from the Department for Environment, Food and Rural Affairs (DEFRA) for the United Kingdom (UK) which are listed in the table below. The conversion factors used were those that correlated with the data that was reported for the corresponding years (DEFRA, 2020). The values inputted were rounded off to 3 decimal places for purpose of the table, however for all calculations the values as listed on DEFRA (2016 – 2019) were used in their entirety.

Table: 6: DEFRA Conversion factors 2016 – 2019

DEFRA Conversion factors				
Source of Green House Gas	**2016**	**2017**	**2018**	**2019**
Petrol (litres (l))	2.197	2.197	2.198	2.203
Diesel (litres (l))	2.612	2.612	2.600	2.627
Paraffin (litres (l))	2.532	2.532	2.532	2.536
Wood (kilograms (kg))	0.053	0.053	0.052	0.062
LPG Cooking Gas (kilograms (kg))	2.942	2.942	2.940	1.519

Property A: Scope 1
Mobile combustion

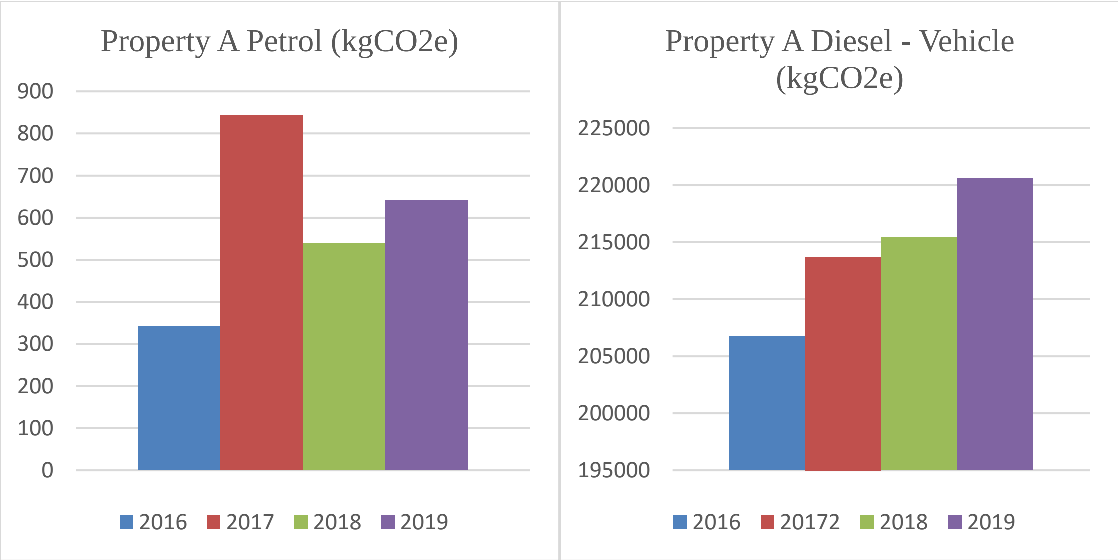
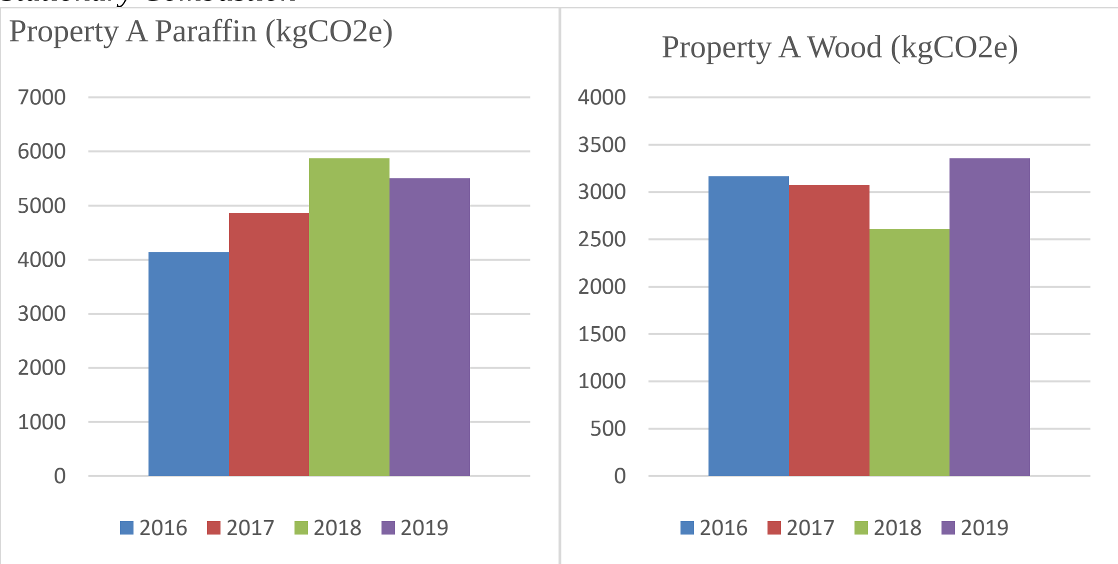


Figure 2: Carbon emission from mobile combustion in Property A

Stationary Combustion



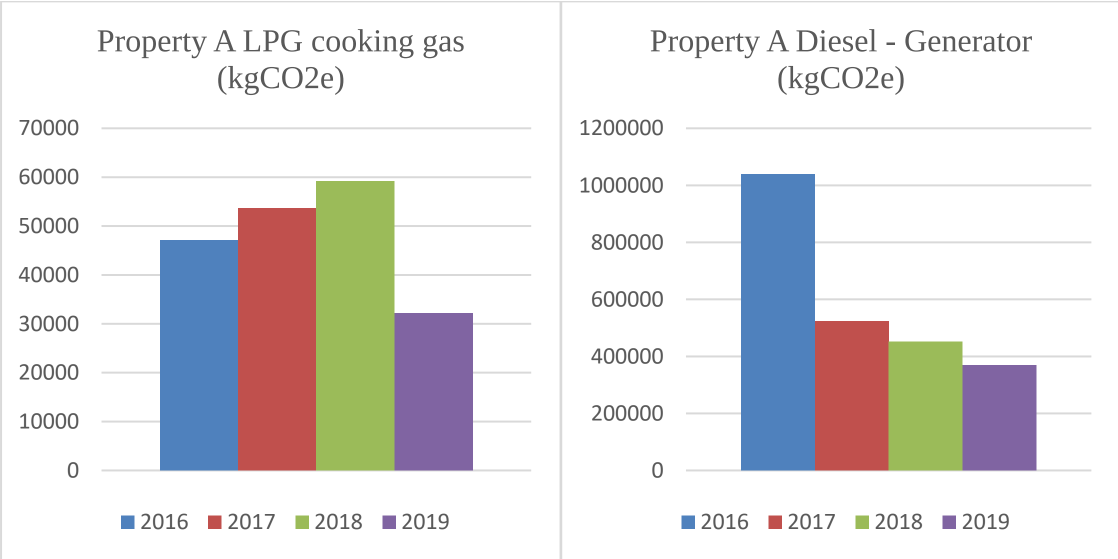


Figure 3: Carbon emission from stationery combustion in Property A

The sum of the total carbon emission values for Property A Scope 1 is 1 301 201.21kgCO_2e in 2016, 799 705.64kgCO_2e in 2017, 757 489kgCO_2e in 2018 and 631 781kgCO_2e in 2019. The total carbon emission per bed night was calculated using the following formula:

$E(CO_2)$ per bed night: $E(CO_2)/BN$

Where:

$E(CO_2)$: total CO_2 emissions in kilograms (kg);

BN: bed night

The carbon emission value per bed night for Property A Scope 1 is 141.08kgCO_2e/bed night in 2016, 78.19kgCO_2e/bed night in 2017, 69.08kgCO_2e/bed night in 2018 and 66.04kgCO2e/bed night in 2019. Property A has managed to reduce their carbon emission value per bed night annually during the four-year study.

Property B: Scope 1
Mobile combustion

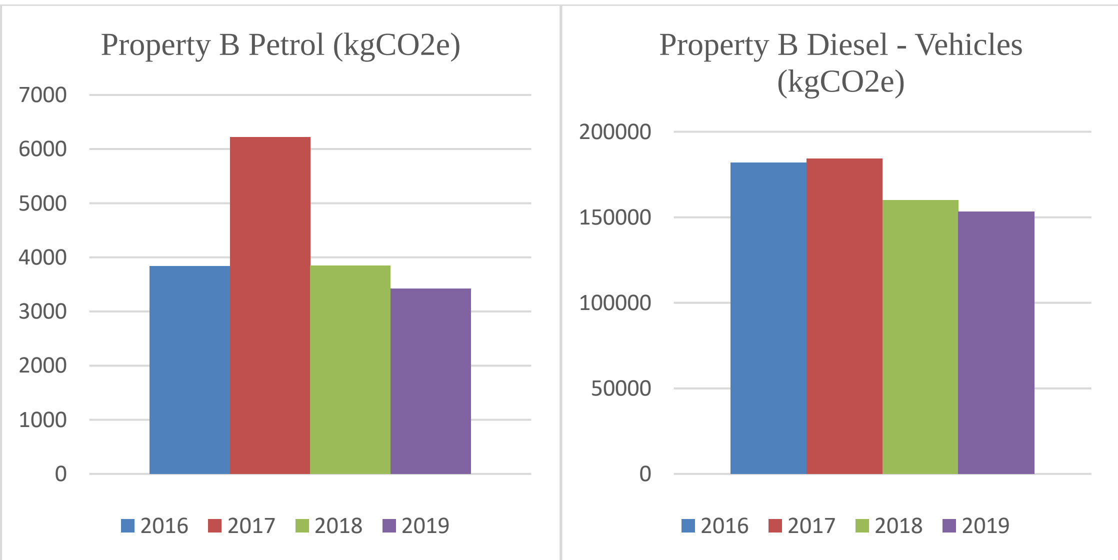


Figure 4: Carbon emission from mobile combustion in Property B

<u>Stationery combustion</u>

Figure 5: Carbon emission from stationery combustion in Property B

The sum of the total carbon emission values for Property B Scope 1 is 377 782kgCO_2e in 2016, 349 939kgCO_2e in 2017, 311 209kgCO_2e in 2018 and 292 955kgCO_2e in 2019. The total carbon emission per bed night was calculated using E(CO_2)/BN. The carbon emission value per bed night for Property B Scope 1 is 22.73kgCO_2e/bed night in 2016, 21.90kgCO_2e/bed night in 2017, 20.10kgCO_2e/bed night in 2018 and 21.80kgCO2e/bed night in 2019. Property B has managed to reduce their bed night carbon emission annually for the years 2016 to 2018, however in 2019 the downward curve spiked back up and there is insufficient data to explain why.

Scope 2
Electricity
The carbon emission value per bed night for Property B Scope 1 and 2 is 190.41kgCO_2e/bed night in 2016, 186.93kgCO_2e/bed night in 2017, 189.25kgCO_2e/bed night in 2018 and

211.83kgCO_2e/bed night in 2019. The carbon emission value per bed night fluctuates and there is no notable pattern nor is there sufficient information to confidently write about the fluctuation.

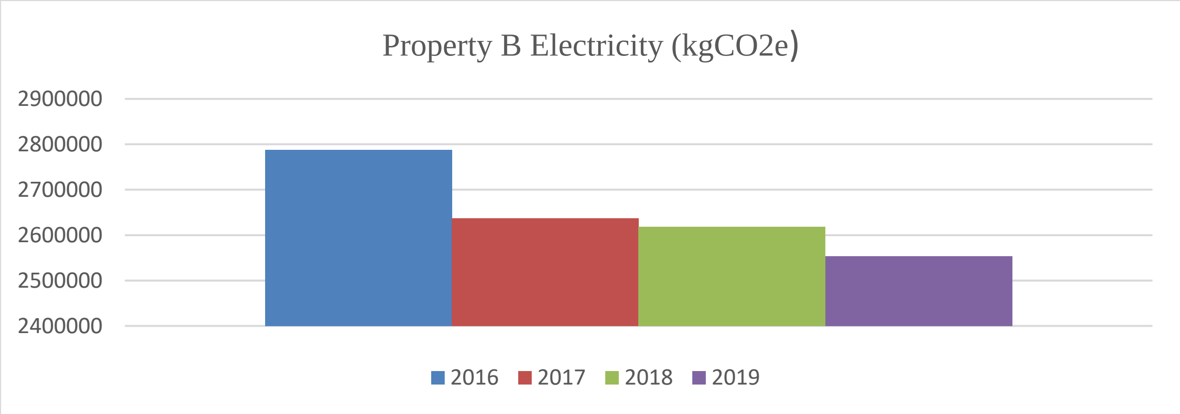


Figure 6: Carbon emission from stationary combustion electricity in Property B

For both Property A and B, the study reveals that the highest carbon emission value outside electricity related emissions, which is the diesel generator that supplements energy use in Property A and the Scope 2 emissions for Property B, is the vehicle diesel which is expected, given the fact that both Properties main activities consist of game drives which takes place twice a day, in addition shuttle services to and from the airstrip is offered to guests, as well as is used for staff transport to and from work. If these properties were able to move away from diesel cars and use electric/solar vehicles they would be able to substantially reduce their Scope 1 carbon emissions. The data discussed in this study is crucial as not much data exist of this nature in the tourism industry, specifically looking at nature-based lodges that have a majority of their staff staying full time on site, in addition to regular lodge operations. What makes remote nature-based lodges an outlier from other accommodations such as hotels that are easily accessible by commuters, is that for the most part staff live onsite, with three meals being provided for all staff on duty/on property. In addition to the carbon emissions that staff members generate while on duty at the lodge (including catered meals), they make an additional contribution when they are off duty in their homes and the commute for both Property A and Property B to and from work is included in the total carbon emission as the mode of transport to work is provided by the company. This gives the nature-based lodges a disproportional carbon emission figure that cannot easily be compared with international standards.

The recommendation to nature-based lodges is to separate GHG emissions directly caused by guests (bed nights) and lodge operations, to those indirectly caused by bed nights such as staff off duty staying onsite in the staff village. This would then be able to clearly determine what the lodge operational carbon emission figures would be as a standalone value and would then put these nature-based lodges in a position to compare their lodging emissions per bed night with global figures. In addition, lodges should be able to clearly define their sources of emission so they can prioritise interventions that will have the most impact to reduce their emissions. This would enable these properties to dissect their carbon emission sources and plainly focus on their major carbon emission sources. Furthermore, nature-based lodges need to get staff buy in so when principles and values are introduced and implemented, it can follow through into the staff villages, which can reduce adverse environmental impacts and reduce carbon emissions. With nature-based lodges being in the heart of nature, it is highly recommended that energy sources be changed from non-renewable resources to renewable resources to reduce their carbon footprint and in addition lodges should monitor their carbon emissions and aim to reduce those emissions annually, by setting realistic carbon emission goals that aim to do better than they did the year before.

Conclusion

More needs to be done to assist the tourism industry with converting to renewable energy sources. Currently the conversion is limited to larger, successful organisations with enough funding to afford the initial installation fees. The onus is currently on the individual companies to make the change and, although the benefits of converting include long-term savings and greater market competitiveness, too few businesses are making renewable energy a priority. It is encouraging to see some lodges in South Africa successfully moving away from fossil fuels, like Property A. However, they are the minority in a large industry. The South African government needs to do more to promote renewable energy initiatives nationwide, but especially within the tourism industry, either by providing financial support or incentives to companies that convert, or through legislative means. Initiatives like the IDC Green Tourism Incentive Programme (GTIP) for South African Tourism Enterprises, which provide grants of up to R1 million to small tourism businesses to aid in the installation of energy and water efficiency solutions, are a step in the right direction (OFA, 2021). Where tourism companies are currently unable to convert to clean energy sources, carbon emissions can be effectively reduced by alternative strategies. Implementing energy-efficient management practices, installing energy-efficient technologies, raising awareness of energy saving practices amongst staff and guests, are all examples of ways to reduce carbon emissions. Combining renewable energy technologies with effective responsible tourism management practices is a solution to reduce carbon emissions within the tourism industry and aligns with the conservation goals of eco-tourism companies. The growing awareness of the value of our natural world, in an economic, social and emotional sense is reflected in the increased popularity in nature-based tourism worldwide. Africa hosts some of the most spectacular biodiversity on Earth and everything must be done to protect and conserve it.

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