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UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG



FACULTY OF SCIENCE

ORGANISATIONAL ENERGY EFFICIENCY AND CONSUMPTION: ATTITUDES, PERCEPTIONS AND BEHAVIOUR IN THE CONTEXT OF ENERGY IN A SOUTH AFRICAN UNIVERSITY

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A research report submitted to the Faculty of Science, University of the Witwatersrand, in partial fulfilment of the requirements for the degree of Master of Science

25 May 2020, Johannesburg

DECLARATION

I declare that this thesis* is my own, unaided work. It is being submitted for the Master of Science research report at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.



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(Signature of candidate)

25tt day of May 2020 at Johannesburg

Abstract

The study explores whether individuals' energy consumption behaviours and attitudes are modified to achieve energy efficiency when different feedback formats about the energy consumption of the buildings they occupy are presented to them. It focuses on designing energy behaviour interventions in the form of energy consumption feedback and comparative feedback to investigate whether the intervention will influence more energy-efficient behaviours. The aims of the study were (a) to establish whether energy consumption feedback influences energy-conserving behaviour and; (b) to assess the attitudes and behaviours of employees towards an energy-conserving behaviour.

The study followed a three-step-process. Step one consisted of the intervention of providing energy consumption feedback. Three buildings, used predominantly for office space, teaching and learning, and research and one students' residence located on the university campuses, were selected for the intervention using purposive sampling. In step two of the process a survey was distributed to the building occupants, the survey covered questions on attitudes and behaviour in the workplace coinciding with the components of the theory of planned behaviour (TPB). The last step consisted of the analysis of energy consumption of pre- and post-intervention, including historical data dating back at least three years.

The data were analysed using factor analysis and ANOVA. The results of the study provided further evidence that TPB can be used to determine the attitudes and behaviours of employees in the work environment. In line with this theory, Attitudes, Subjective Norm, Descriptive Norm, PBC, Collective outcome expectancy, Injunctive Norm were strong determinants of energy-conserving behaviour. Secondly, the study highlighted that Descriptive Norm and Situational Factors are areas that require particular focus in developing interventions differing from previous studies that suggested PBC, Behavioural Intention and Attitudes as strong determinates of behavioural change. These results further emphasised the need for tailor-made interventions in tackling energy-wasting behaviours. Thirdly, the analyses of the energy consumption data pre and post-intervention, showed a sharp decline in energy consumption, suggesting that the provision of consumption feedback can leave a lasting positive impact in an organisation. Lastly, the results of the regression analysis in this study indicated that the subjective norm, which refers to the perceived social pressure to perform or not to perform the behaviour was the most critical factor for behavioural change.

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1. Introduction

Over the past decade, there has been increasing evidence that anthropogenic activities are significant contributors to the major worldwide problem of climate change (Cook et al., 2016; Le Treut, 2007; Wuebbles et al., 2017). There has been a general assumption that the earth has an enormous ability to recycle waste and regenerate itself. However, if that were the case, global climate change would not be our era's most significant global challenge (Shove, 2010; Wuebbles et al., 2017). Industry, science, governments and citizens across the globe must work in tandem to halt rising greenhouse emissions. The problem of climate change is complex which has a detrimental impact on all spheres of life on our planet. It has a direct impact on current global issues such as food security, globalisation, economics, sustainable development, and resource management. The response to the reduction of the effects of climate change has been focussed on the reduction of emissions and reduced energy consumption (Bull et al., 2015; Ozawa-Meida et al., 2017; Stuart et al., 2016). The climate protection challenge has led to a call for global strategies and support to the goals set by the Kyoto Protocol and its subsequent amendments.

According to Stephenson et al., (2010, p. 6120), the International Energy Agency has concluded that "a huge step-change in the attitudes to energy efficiency and consumer purchases by hundreds of millions of people worldwide is needed. Governments, through information provision, sound regulation and targeted fiscal incentives, have a key role to play in ensuring that, worldwide, the right decisions are taken to safeguard the future of the energy sector—and the planet."

Roberts and Bacon (1997) argue that if the government and the legislature are to be successful in encouraging people to be environmentally conscious in their behaviour; it is, therefore, essential that they have a clear understanding of the antecedents of such behaviour. Research has shown that people have a desire to save energy, but their behaviour is inconsistent with such desires (Moloney et al., 2010; Owens & Driffill, 2008; Poortinga et al., 2004; Roberts & Bacon, 1997; Stephenson et al., 2010; Vassileva et al., 2012; Whitmarsh, 2009; Zografakis et al., 2008). It has also been observed that the characteristics of the people who perform specific, environmentally conscious behaviour were distinctly different from those that achieved the opposite or different (Roberts & Bacon, 1997). Carbon reduction targets and energy efficiency

will rely on individuals, operating in both cultural and social context, while emotional influences cannot be taken for granted (Faiers et al., 2007). Therefore, to achieve acceptable levels of energy efficiency and secure sustainable energy supply for future generations, peoples' attitudes and behaviours would also need to be modified (Moloney et al., 2010; Owens & Driffill, 2008).

1.1. World Energy Use

According to Darby (2006), the world produced approximately 49 000 Mt CO2-equiv, which mainly attributed to energy generation and deforestation. The contribution from South Africa was about 440 Mt, which at the time was equivalent to 1% of the global emissions (Darby, 2006). Although 1% may seem insignificant, these emissions are significant relative to South Africa's economy and population size. Historically, the primary source of energy in South Africa had been coal-based, and this resulted in relatively low energy prices which favoured high energy-consuming industries (Benhin, 2006; Spalding-Fecher et al., 2000).

Global energy use has been growing at a rate that has created concerns over future energy supply challenges, depletion of energy reserves and substantial impacts on the natural environment including the atmosphere (Höök & Tang, 2013; Narbel & Hansen, 2014; Wuebbles et al., 2017). These impacts include, amongst others, global climate change, global warming, and ozone layer depletion. The energy use from buildings has also been steadily increasing to between 20% and 40% in developed countries and as a result, surpassed other significant sectors such as trade and production (Karjalainen, 2016). The increase in building energy use can be attributed to population growth which led to a demand in building services and comfort levels. While the growth in building services increases, so does time spent inside buildings, thus resulting in an increasing demand for energy in the future (Pérez-Lombard et al., 2008). Historical data shows that primary energy use had increased to 49% between 1984 and 2004, with an average increase of 2% annually, according to the EIA report (Sieminski, 2014). In the same report, the energy use by developing countries was projected to grow at an average annual rate of 3.2% and expected to surpass that of developed countries by 2020 which was projected at an average growth rate of 1.1%; the "World Energy Outlook" (2019) confirms this projected annual growth rate (Pérez-Lombard et al., 2008).

1.2. Contextualising Energy Use

Data presented in the analysis of the global energy use trends and indicators from 1973 and 2014 are worth noting (*Energy Information Administration (EIA)—International Energy Outlook 2006*, n.d.; *Publication: Key World Energy Statistics 2015*, n.d.; *World Energy Outlook 2019 – Analysis*, n.d.). According to these reports, primary energy use has been growing at a rate far above the population growth, which led to an increase of its per capita value of 15.7% globally in the years covered by the report. Additionally, the global Gross Domestic Product (GDP) has grown at a rate well above the population growth, resulting in a notable increase in personal income and global wealth. In the same period, electrical energy consumption had more than doubled leading to a rise of 18% in 2014; and the efficiency in utilising energy resources declined by 7%, mainly due to the rapid demand of technology and electronic appliances. Lastly, the final and primary energy potency decreased due to the rapid increase of GDP over the ratio of energy use, which somewhat led to the overall improvement of energy efficiency globally.

These insights reaffirm that energy consumption is directly proportional to population growth and economic development; while questioning the global efforts in policy development to turn-around this continuous trend by increasing energy efficiency (including the use of renewable energy and green technologies). As evident in the sections above, the enhancement of conditions of living in developing countries and the development of global network communications promotes living comforts in developed countries. Nevertheless, it increases the intensity of energy consumption to levels that will deplete energy reserves and have a detrimental impact on the environment through increased release of carbon dioxide. Therefore, it is clear that the current scenarios of energy consumption and socio-economic arrangements are categorically unsustainable (Energy Information Administration (EIA)—International Energy Outlook 2006, n.d.). In comparison, with other developed and developing countries, South Africa's emissions intensity is high (Development of Policy – Sustainability Plan (White Paper)—Google Search, n.d.). The per capita emissions are measurably higher than China, India (these are also coal-based economies) and Brazil; except that Brazil's emissions are due to land-use changes, mainly deforestation (Spalding-Fecher et al., 2000).

Various studies have shown that the energy produced in South Africa cannot meet the demand and this unmet demand is likely to persist or even increase (Beckerman, 1992; Benhin, 2006;

Burton, 1987; Omer, 2008). This assertion was demonstrated by the country-wide power blackouts in the year 2010 and again in 2020, which led to the construction of more power utilities and diversification to meet the increased energy demands. South Africa is among the developing countries that approved the United Nations Framework Convention on Climate Change (UNFCCC) and its Kyoto Protocol, including playing a pivotal role in climate negotiations and hosting some of the meetings. However, it was exempt from taking necessary steps to reduce its above-average relative emissions. The Convention's principle of equity and "common but differentiated responsibility" called for all developed countries to take the lead in reducing emissions; however, South Africa had a non-binding quantified target (Ziervogel et al., 2014). As the debate on reducing the world's emissions matures, South Africa's energy options will be severely constrained in the future. Should South Africa continue with the business as usual scenario, there are a few characteristics that can be observed. Firstly, overall emissions in the year 2003 were 440 Mt of CO2-eq, and by 2050 the emissions would have quadrupled to approximately 1600 Mt per year (without any change in policy). Secondly, on the demand side, overall consumption could grow five times more, especially in the transport and industry sectors. Lastly, on the supply side, the country will need more coal electricity generating plants (Spalding-Fecher et al., 2000; Ziervogel et al., 2014).

1.3. Sustainability and Energy Efficiency

The commonly used definition of sustainable development was derived from the report of the World Commission on Environment and Development, in its attempts to describe the new directions for "our common future". Sustainable development is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Burton, 1987, pg. 43).

The United Nations, together with non-governmental organisations, have arranged several meetings in this era to derive a framework in which the meaning and implications of sustainability can be clarified (Clugston & Calder, 1999). These series of events which are mainly attended by political leaders, business leaders and civil society some notable agreements were developed such as Agenda 21 at the United Nations Conference on Environment and Development in Rio. What makes Agenda 21 very significant is that it emphasises the fact that the primary cause of environmental change is population growth which leads to increased consumption and technology (Sitarz, 1993). The sustainability debate is intertwined with the

climate change debate within which reducing energy consumption and reducing emissions is a matter of highest importance leading to the development of the 'Sustainable Development Goals' (Nilsson et al., 2013). Moreover, the International Energy Agency (IEA) has announced that the manner in which energy is supplied and consumed currently is unsustainable and must be modified. As a response, the EU Commission then prioritised energy matters and derived the so-called 20/20/20 goals, intending to acquire at least 20% of its overall energy production from renewable sources, lower energy consumption by 20% and reduce emissions by at least 20% by the year 2020 (Ellegård & Palm, 2011). These efforts should not only be applied to the developed nations, but energy is considered to be one of the primary basic human needs, and as such, it is most evident when it is scarce.

Darby (2006) reaffirms that energy use occurs with detrimental effects on the ecological environment as it is produced from various unsustainable activities such as mining, extraction of gas and oil, and the construction of the required infrastructure such as dams, power utilities, power lines, and pipelines. At a local level, it may not be readily visible to see the repercussions of energy production on the natural environment. As a result, awareness of its impact may be vague because it is mainly invisible in consumption. The effect is hidden in various ways: energy plants and their extensive distribution networks are usually hidden away from the majority of the population; the lack of interest in energy issues until it becomes scarce or expensive; through the hidden costs of production and lack of information there; and indirect metering and billing systems. As such, energy consumers, especially those in developing nations, need to understand the impact of excessive consumption and have access to information on how to be energy efficient. Therefore, it is argued that feedback and information systems should be easily accessible and self-explanatory (Darby, 2000).

It can be deduced that energy consumption reductions have substantial financial, social, ecological, and cultural characteristics that have not yet been sufficiently paid attention to because they are generally hidden in various ways. It is quite clear that global diplomacy aimed at efficiency as cited above is inadequate to tackle the impact of climate change (Burton, 1987; Richard, Clugston & Calder, 1999; Nilsson et al., 2013; Palm & Ellegaard, 2011; Sitarz, 1993; Spalding-Fecher et al., 2000; Ziervogel et al., 2014). For example, a study in the UK titled 'Lower Carbon Futures', concluded that solutions that exclude any behavioural change would not achieve the reductions in carbon emissions by 2020, needed to achieve sustainability by

2100 (Fawcett et al., 2000). To do so requires behavioural change. Some of this can be encouraged through policy changes, particularly the provision of information and feedback to consumers (Darby, 2006).

In the past decade, strategies employed at encouraging people to change their energy consumption patterns and behaviour have included awareness campaigns, energy labelling of low impact goods, energy advice, protests (Abrahamse et al., 2005; Ellegård & Palm, 2011). However, these strategies have not always yielded quantifiable results. As a result, energy efficiency should be at the top of the list for policymakers in developed nations and developing nations. The competitiveness of these countries and future energy supply will be dependent on their impact on the environment and the reduction of emissions (Patterson, 1996). Most of the efforts given to the development of energy efficiency policies, which are informed by many books and reports, have paid little attention to people's views, perceptions, and attitudes. These policies have relied on the general understanding of energy efficiency, which is understood merely as 'doing more with less'; in other words, it means producing the same amount of goods and services with less energy (Mallaburn & Eyre, 2014; Song & Oh, 2015). Thus, they have relied heavily on many quantifiable variables but at times miss the bigger picture in measuring the changes in energy efficiency.

Although people are aware of the importance of saving energy, there is still a lack of intentional effort to do so, and the demand for energy use is still on the rise. Mainly because people cannot relate their daily energy use to the energy demands of their appliances in their households or offices (Boork et al., 2015; Karjalainen, 2016; Lokhorst et al., 2015; Nilsson et al., 2015; Vos, 2013). For example, technology and innovation have led to a rapid rise in electronic devices, white goods are on the rise because of fashion trends, there has been an increased use of lighting in buildings, and the spread of specialised and individualised appliances. Moreover, the demand for heating and cooling systems has not declined. Another reason for the increased energy use is that decreased energy use often leads to less comfortability and convenience in addition to changing lifestyles (Ellegård & Palm, 2011). The lack of research into energy use is that its main focus is in regarding energy as a scarce resource, and therefore this leads to increased efforts to increase the energy supply. As a result, all sectors of the economy are expected to use more energy as their economies grow, but the peoples' utilisation of the energy supply has not been part of the debate (Ellegård & Palm, 2011).

1.4. Attitudes and Behaviour in the Context of Energy

Research has shown that a fifth of the total energy consumption in the northern hemisphere can be attributed to residential energy use, and peoples' behaviour characteristics, such as the choice of appliances, may influence energy use levels (Lindén et al., 2006). Such behavioural characteristics affect household energy use to the extent that energy use may differ by a factor of two, even when the same appliances are the same (Lindén et al., 2006). For example; the extent to which people use the bath or shower, switching on and off of lights and appliances that are not in use, regulation of room temperatures or even covering pots and how they fill the kettle with water they will only use, is dependent on their behaviour (Lindén et al., 2006).

According to Owens and Driffill (2008), governments have been trying to regulate energy use with economic measures and incentives, including awareness and information campaigns to educate people. These models have been criticised for being theoretically flawed and impractical. Barr and Gilg (2006) suggest that energy efficiency measures have failed because peoples' behaviours have increasingly become more energy demanding and one of the most fundamental reasons is a lack of information and energy use feedback. As far as energy consumption is concerned; the physical, social, cultural, and organisational cultures which influence people's choices need to be taken into account. Attitudes and behaviours of energy use need to be changed or modified.

Economic incentives, awareness, trust, commitment, and a sense of moral obligation are the biggest drivers of energy-efficient behaviour and attitudes. In contrast, Steg and Vlek (2009) are of the view that although the distribution of information in some may affect attitudes towards energy efficiency in some circumstances, it often does not go a long way in influencing behavioural change. As a result, research also suggests that the citizens may see the government as the sole entity that is responsible for addressing environmental issues and do not consider their contributions.

Steg and Vlek (2009) suggest that when studying energy consumption personal factors such as attitudes, values, norms, and behaviour should be considered together with contextual factors. For example, energy use is dependent on existing infrastructure and technology which shapes the activities of daily life such as heating and cooling systems and lighting (Shove et al., 2010; Stephenson et al., 2010). It is also affected by the preconceived notions of comfort, convenience

and tidiness which become commissioned in architecture and embedded in the built environment. Also, income and material growth may have a substantial impact on behaviour, as well. In the struggle to improve energy efficiency, more effort has been placed on improved technologies rather than on behavioural interventions (Bull et al., 2015; Bull & Janda, 2018). Technological improvements have gained a much broader focus than related behavioural interventions. In response to this, the IPCC[1] report (2007) emphasised the need for changes in lifestyle and pointed out that the modification or change in peoples' behaviours can make a significant difference.

Recent studies indicate that theoretical and pragmatic approaches to energy efficiency and sustainable development will only be attainable if they are firmly embedded in human behaviour (Barr & Gilg, 2006; Moloney et al., 2010; Nguene et al., 2011; Poortinga et al., 2004; Steg & Vlek, 2009). Nguene et al. (2011) suggest that constant and consistent commitment from all spheres of society (governments, organisations, and individuals) is key to pursuing sustainable development objectives. Amongst these, individuals play the most significant role for three primary reasons. "Firstly, they can have the opportunity to vote for politicians who act in favour of sustainable issues. Secondly, they can decide to purchase products and services made by sustainable industries. Thirdly, they can decide to consume natural resources more rationally (e.g., water, electricity or gasoline) to contribute to higher recycling rates" (Nguene et al., 2011, pg. 73).

1.5. Behavioural Change in the Workplace

Research studies designed to understand people's perception, attitudes and behaviour towards energy efficiency and conservation have measured these variables for family household use (Abrahamse et al., 2005, 2007; Faruqui et al., 2010; Hargreaves et al., 2010; Karjalainen, 2011; Midden et al., 1983; Stedmon et al., 2013; Steg & Vlek, 2009). This research shows that as a result of behavioural modifications, savings of up to 30 per cent can be realised (Siero et al., 1996). Furthermore; in their study, Sauer et al. (2007) found that feedback in whatever form has a positive effect on energy consumption. However; generalisation of these findings in the workplace creates challenges because energy costs and savings in the household are experienced directly by the individuals, while in an organisation employees do not receive a

[1] The IPCC - The Intergovernmental Panel on Climate Change prepares comprehensive Assessment Reports about knowledge on climate change, its causes, potential impacts and response options.

direct benefit from their extra efforts (Carrico & Riemer, 2011; Chen et al., 2012; Foster et al., 2012). Katzeff et al. (2012) concluded that some of the factors that contribute to people not making use of feedback interventions are; lack of motivation, the intended users' engagement is limited in time and space, interference with personal life or day-to-day activities amongst other. Thus, this begs the question: how can an organisation motivate its employees to modify their behaviour to be more energy efficient? Mainly because any "profits" from energy efficiency will go to the company and shareholders rather than the employees who contribute to the savings directly.

Compared to other building types, energy use in office buildings is one of the highest (Balaras et al., 2002). However, the consumption of energy can fluctuate significantly depending on external and internal factors such as weather conditions, infrastructure, and building use. In the higher education environment, energy consumption may differ based on the primary use of the building. In essence, energy consumption in a building mainly used for lecturing/teaching will vary from a building used for laboratory work, a library or an administrative office block – even the consumption rates and patterns may vary depending on the duration and time of use.

Chen et al. (2012) noted that there had been many strategies and technologies employed to encourage energy efficiency in office buildings. The investments in this area were primarily concentrated at equipment and infrastructure to improve the energy use and demand of the physical infrastructure such as building components and facilities (e.g. heating, ventilation and air-conditioning units), including the acquisition and implementation of renewable energy sources (e.g. solar power) (Karjalainen, 2016; Lokhorst et al., 2015; Nilsson et al., 2015; Chen et al., 2012). Notwithstanding the enormous progress made, the consideration of possible measures and behavioural change tactics to encourage energy efficiency of the building occupants has been relatively limited. More effort has been placed on how people can modify their behaviours and lifestyles in their households to be more energy-efficient (Ozawa et al., 2017; Cheung et al., 2017; Ohler & Billger, 2014; Karjalainen, 2011; Hargreaves et al., 2010; Abrahamse & Steg, 2009; Abrahamse et al. 2007; Abrahamse et al. 2005; Poortinga et al. 2004). However, the very same individuals spend an extraordinary proportion of their daily lives at work where they contribute towards energy use and the efforts to encourage energy efficiency in the workplace have been limited (Foster et al., 2012). South Africa has a substantial number of public and private sector organisations which account for 11% of energy consumption

(Foster et al., 2012). There is a need for interventions aimed at improving energy efficiency in the workplace and behavioural modifications (Foster et al., 2012; Spalding-Fecher et al., 2000)

According to Foster et al. (2012), people can be motivated to make better and informed decisions if they are furnished with correct information and the resources to do so. Siero et al. (1996) added that there are four steps that an organisation can follow to instil behavioural change amongst its employees. The first step is that the organisation should inform its employees about the proposed behavioural change and reasons thereof. Secondly, the organisation should refer to the collective rather than individual interests. Thirdly, the organisation has to set goals, and these should be accompanied by feedback. Lastly, when employees show the proposed behaviour, the behaviour has to be preserved, and it will eventually become part of the organisational culture. They suggest that for the behaviour to be maintained the organisation should actively monitor and control the behaviour of its employees until the behaviour is retained without the need for continued supervision.

Burgess and Nye (2008) suggest that feedback from a meter or monitor can be used as a reference point from which energy behaviour can be evaluated and informed. It can be a significant driver of energy efficiency because it offers the opportunity to merge daily energy use with its economic or environmental impacts. They also concluded that immediate feedback which is instantaneous and directly linked to energy use is a crucial driver of energy consumption behaviour. However, the feedback should be in a format that is understandable and relevant. Furthermore, research shows that several feedback programmes such as smart meters or real-time displays can initiate savings as high as 20% (Burgess & Nye, 2008; Chen et al., 2012; Darby, 2000, 2006).

Two approaches can be observed in the reduction of emissions to improve energy efficiency. The first approach starts by developing emission reduction targets and goals, followed by the identification of areas in which the reduction can take place most efficiently to convince people to behave in a particular manner (Siero et al., 1996). The second begins by identifying the existing characteristics of energy consumption in their cultural context, followed by the identification of the needs and goals and identify the needs and aspirations, to find the actions that people should undertake to use energy in a more efficient way (Burgess & Nye, 2008).

This study was concerned with both approaches; but aimed at a nuanced understanding of people's perceptions, attitudes, and behaviour towards energy efficiency.

It is quite clear that the current policies aimed at emissions reduction, energy efficiency and adoption of renewable energy sources cannot bring about the impact in a reasonable timeline that is necessary to avoid significant climate change. The literature cited in this study shows that any approach to energy efficiency, which does not include a change in human behaviour and attitudes to achieve sustainability is futile. Besides, continuing interest for policymakers and researchers on the topic of 'energy efficiency', little attention has been given precisely to peoples' attitudes behaviours and perceptions. The present study attempts to encourage energy efficiency behaviour by using information and consumption feedback in a university environment. Employees and students from select buildings were provided with feedback information about the consumption of their buildings and comparative historical consumption for the same building to see whether the feedback would yield savings in energy use.

1.6. Theoretical Underpinnings

There have been different approaches to tackling climate change; the first approach was Neo-Malthusian. According to this theory, population growth is exponential, but the food supply does not increase at the same rate and may reach saturation levels (Hartmann, 2013; Stephenson et al., 2013). Thus, the rate of energy use and demand will supersede the capacity to discover and produce new energy sources and result in a disaster. The disaster is expected to self-correct and return the population to desired and sustainable levels. Therefore, the increase in the energy use demand together with the population growth will lead to the depletion of natural resources and leave a detrimental effect on the environment or ecological collapse. A complimentary theory to the Malthusian theory is the Boserupian theory which similarly focusses on the association of population growth, with the environment and technology development (Marquette, 1997). However; in contrast, Boserup's theory concentrates on placing population growth at the centre and as a constant variable that influences both the technology development and energy demand (Marquette, 1997). While both these theories go a long way in formulating the relationship between population growth and energy demand adequately, they omit the impact of human behaviour on future energy demand and supply.

The second approach was known as the Gaia theory; which states that organisms and their inorganic surroundings on earth are tightly integrated to form a single and self-regulating complex system, maintaining the conditions on the planet (Lovelock & Margulis, 2007). In other words, the theory claims that this system, as a whole, called Gaia, seeks a physical and chemical environment optimal for contemporary life. The eventual outcome of Gaia's self-regulation theory is relatively crude (IEA, 2015; *World Energy Outlook 2019 – Analysis*, n.d.). The implementation of alternative forms of climate control and energy efficiency to reduce the impacts of climate change or augment existing feedbacks depends on people's attitudes and behaviour.

The third approach was a theory termed the "Tragedy of the commons" (Hardin, 1968). It is described as a problem that arises from a set of circumstances in which individuals in their numbers acting autonomously and selfishly will eventually deplete a commonly shared limited resource. The depletion of the resource happens even though it is clear that it will not be beneficial to anyone in the future—resulting in proposals of strict control and management of shared resources through international governance bodies (e.g. Kyoto Protocol). However, critics such as the Nobel Prize Laureate Professor Ostrom, (2009) say that local people have often developed solutions to common problems on their own, suggesting that when the commons are taken over by external entities, the answers are not useful. While investigating the impact of the 'tragedy of the commons' on energy use, Ohler and Billger (2014) concluded that energy consumption suffers from the tragedy of the commons because respondents failed to reduce their electricity use even when they understood that doing so was socially significant. The study also showed that self-interests have a significant impact on energy-saving behaviours.

1.6.1. The theory of planned behaviour

Behavioural change is an area currently underplayed in the literature on climate change and energy efficiency research. These findings point to the use of a psychological model to understand people's perceptions, attitudes, and behaviour towards energy efficiency and conservation. It also suggests that there is an inherent need to know how individuals choose from different energy-efficient options and the factors that underpin those choices. Attitudes, situational and psychological characteristics have been recognised as the most significant predictors of behavioural change (Chen & Knight, 2014). However, a theoretical framework is

required to systematically investigate their influence on energy-efficient behaviour (Davis et al., 2006; Tonglet et al., 2004). This study adopts the 'Theory of Planned Behaviour' (TPB) (Ajzen, 1991). Compared to other theories or models such as the Technology Acceptance Model and Social Cognitive Theory, the Theory of Planned Behaviour has two additional variables that are important for predicting intentions and these are social influences and perceived behavioural control (PBC) (Thatcher & Ndabeni, 2013). The former have been criticised for being too simplistic and limited in predicting behaviour. The central factors in this theory are the individual's intention (motivation) to perform a particular behaviour and perceived behavioural control (opportunities and resources) introduced by (Ajzen, 1991) – see Figure 1.

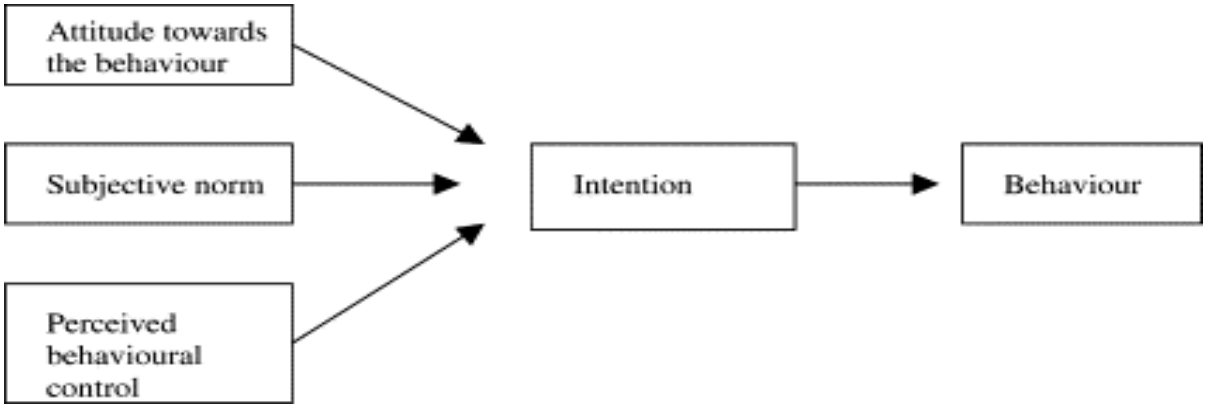


Figure 1: The Theory of Planned Behaviour, adapted from Ajzen (1991)

According to this theory, behavioural intention combined with perceived behavioural control, can be used directly to predict behavioural achievement/change. Intentions are comparable to the motivational factors that influence behaviour; in other words, they are an indication of how much of an effort people are planning to exert to perform the behaviour. For as long as there is a high intention to achieve a particular behaviour, then it should be more likely for the behaviour to be carried out. The more robust the intent to engage in a behaviour, the more likely it should be its performance. While motivation (intention) may be the prerequisite for the behaviour to be performed, the performance is also dependent on the environment being conducive with resources and opportunities to support the behaviour (e.g., time, money, skills, the cooperation of others). Therefore, if the environment is conducive with resources and opportunities and an individual has the intention to perform a behaviour then he or she should be able to be successful in doing so (Abrahamse & Steg, 2009; Davis et al., 2009; Niaura, 2013; Tonglet et al., 2004; Zierler et al., 2017).

The TPB was developed as an augmentation of the theory of reasoned action (TRA) made possible by the limitations of the TRA's limitation to behaviours over which people have little or no control (Ajzen, 1991). In previous studies, the subjective norm, which refers to the perceived social pressure to perform or not to perform the behaviour, is a consistent predictor of intention (Armitage & Conner, 1999; Davis et al., 2009; Gao et al., 2017; Norton et al., 2015). Additionally, Chang (1998) investigated the relationship between attitude and subjective norms and found a significant correlation between the two factors. Chang (1998) further suggested that the link could be explained with the social environment's influence on an individual's attitude formation.

Two rationales are given for TPB. Firstly, if the intention is a constant variable; then the effort exerted at successfully performing a particular behaviour is expected to increase with perceived behavioural control. For example, two individuals may have the same intention to learn a new skill, and both may attempt to do so. However, the person who is more convinced that he can master the skill is more likely to see it to the end than the other who has doubts about his abilities to acquire the skill. Secondly, in order to link perceived behavioural control with behavioural achievement, perceived behavioural control can be used as a substitute for a measure of actual control. However, the accuracy of the perceptions is essential for perceived behavioural control to be substituted for a measure of actual control. To that end, for the perceived behavioural control to be realistic, the conditions are that the individual should have enough information about the behaviour, the environment should be conducive, and the individual should have actual control of the situation. If those conditions are met, then perceived control could be used to predict the likelihood of a successful behavioural change (Buchanan et al., 2018; Bull & Janda, 2018; Davis et al., 2009; Staddon et al., 2016).

It has been acknowledged that other factors are external to the model, such as personality, past-experience, and demographic characteristics that may also influence behaviour. However, these factors have been incorporated into the components of the model through the augmentation of subjective norms. The TPB has been used to study behaviours in a wide range of different but related studies such as weight loss and voting choice (Ajzen, 1991; Davis et al., 2006, 2009; Gao et al., 2017; Harland et al., 1999; Jacobs et al., 2011; Niaura, 2013; Tonglet et al., 2004; Zierler et al., 2017). It has also been successfully applied in the area of environmentally relevant

behaviours such as the use of energy-saving light bulbs, and car use, and bus use for commuting (Abrahamse & Steg, 2009; Cheung et al., 2017; Harland et al., 1999; Nie et al., 2019; Wu et al., 2017). While these studies explored pro-environment behaviour in the household, several studies have successfully made use of TPB to explore pro-environment behaviour in the workplace Gao et al. (2017), Norton et al. (2015), and Zierler et al. (2017). It is, therefore, appropriate to adopt TPB as the theoretical framework in this study to explore whether individuals' energy consumption behaviours and attitudes are modified or changed to achieve energy efficiency and secure energy supply for the future when different feedback formats about the energy consumption of their building are presented to them.

1.7. Aim of Research

This study suggests that attitudes and behaviours in the context of energy behaviour need to change. It focuses on designing energy behaviour interventions in the form of energy consumption feedback and comparative feedback to investigate whether the intervention will influence energy-conserving behaviour. It also attempts to identify and describe employees' general attitudes towards energy efficiency in an attempt to identify critical issues that will enable further investigation of energy efficiency in the workplace.

The aims of the study are (a) to establish whether energy consumption feedback influences energy-conserving behaviour and (b) to establish the attitudes and behaviours of employees towards energy-conserving behaviour.

1.8. Objectives of the Research

This study suggests that individuals' energy consumption behaviours and attitudes should be modified or changed to achieve energy efficiency and secure energy supply for the future. The primary objective of this study is to explore the attitudes and behaviours of employees towards energy conservation in the workplace and the impact of energy consumption feedback.

1.9. Research Questions

1. What are the attitudes and perceptions of employees towards energy efficiency and energy conservation?
2. Does energy consumption feedback positively influence energy-conserving behaviour?

2. Methods

2.1. Research Strategy

The study followed a three-step process where the steps were interlinked with the other steps in the process:

(1) intervention – feedback and comparative feedback

(2) a survey that covers questions on attitudes and behaviour at work,

(3) analysis of energy consumption of pre- and post-intervention.

As described above; according to Siero et al. (1996), there are four steps that an organisation can follow to instil behavioural change amongst employees. Step one is that the organisation should inform its employees that it wants a change in behaviour and the benefits thereof. This study leveraged on the fact that the university had communicated several times to its employees on the need to save energy. Also; the study leveraged on the energy crisis in South Africa, which caused load-shedding in recent years, which would have raised awareness for energy conservation. Secondly, the organisation should refer to the collective rather than to individual interests. Again, the university had already referred to energy conservation as of interest to the entire university community. Thirdly; the organisation had to set goals, and these goals were accompanied by feedback. Lastly, when employees showed the proposed behaviour, the behaviour needed to be preserved so that it will eventually become part of the organisational culture. This study was only concerned with the first three steps by Siero et al. (1996).

A method similar to Carrico and Riemer (2011) was adapted to conduct a study on motivating energy conservation in the workplace. Several buildings in the university campuses were selected for the intervention using a cluster randomised sampling. In this sampling method, different groups of building occupants within a population were selected as a sample. The selection was based on building occupancy type and availability of historical consumption data and occupancy numbers (see Table 1 below). This method differs from stratified sampling in that it uses the entire cluster or in this case all the building occupants as a sample rather than a random selection of building occupants. Cluster sampling is advantageous when the whole population is unknown; when the sample clusters are geographically convenient; and when the clusters are ‘natural’ in a population. Thus, the information collected from the clusters (groups) represents the entire population. The clusters were four buildings; three buildings used predominantly for office space, teaching and learning, and one students’ residence located on

the university campus. All the selected buildings received information on a combination of general feedback (i.e. their own building's consumption pattern) and comparative feedback (which is feedback about the energy consumption at the time of the study compared to the historical consumption per building). The buildings were as follows:

Table 1: Sample groups

Building Use/Operation	**Occupancy numbers**	**Occupancy Types**	**Name of Building**
Office Space	>150<200	Mainly Professional Staff	Solomon Mahlangu House
Residence	>150<200	Students	Jubilee Hall
Office and Teaching Space	>150<200	Office Space and Small/Med size lecture halls	Biology Building
Office and Teaching Space	>150<200	Office Space and Small/Med size lecture halls	Umthombo Building

The interventions ran simultaneously on all study groups/buildings over six weeks.

2.2. Intervention – Feedback and Comparative Feedback

2.2.1 Information

All university employees received emails urging them to conserve energy. The emails had the following information: (1) information about energy conservation and the benefits thereof; (2) information on various steps to take to save energy in the workplace; and (3) consequences of not conserving energy. The report had no goals set for buildings or the entire university community.

2.2.2. Feedback

A contact list of all occupants in the selected buildings was sought and received from the Planning and Infrastructure Management Department of the University. The feedback data were sent to all the occupants of the buildings chosen through their work email addresses and the residence occupants through the student email weekly containing a graph summarising the total energy use for the building during the previous weeks. The presentation considered the recommendations of Foster et al. (2012), Burgess and Nye (2008), and Siero et al. (1996). All of them made a recommendation that feedback information should be easily understandable,

relevant, and instantaneous. The data was simplified and presented in graphical form and contained the most recent consumption weekly; as presented in Figure 2 below:



Figure 2: Weekly feedback information

The occupants of the selected buildings received general feedback. The graphs indicated the current week's consumption and the previous week's energy use presented in the kilowatt-hours (kWh) electricity units. These buildings received feedback in comparison with their consumption, including the last two-to-four years in the same period depending on the availability of data. The electricity use data were collected over eight weeks, including a week before the implementation of the intervention and covering the six weeks in which the intervention was active and one week after.

2.3. The Survey Sample

The intervention was evaluated using an analysis of energy consumption and a survey. At the end of the feedback intervention, occupants of the selected buildings were invited to participate in a survey. Four buildings at the University of the Witwatersrand campuses were selected for inclusion in the study. The study deliberately included buildings that were primarily utilised as office spaces. These did not include large lecture theatres, libraries, or laboratory environments which are known for intensive energy demand. All buildings utilised heating and cooling systems as well as lights and appliances; therefore, the meter readings for each building should reflect the global energy use of the building. The study followed a heterogeneous purposive sampling – a deliberate sampling strategy of choosing the sample because they shared similar characteristics which enabled exploration of the underlying factors of the adopted theory in this study. Thus, the sample size should be significantly high enough to generalise the results. It is generally accepted that for quantitative samples for a single study involving individuals usually lies under 50 (Ritchie et al., 2013). According to Adler and Adler (as cited in Ritchie et al., 2013) the sample size should be between 12 and 60 while Ragin (also cited in Richie et al., 2013) suggested a sample size between 20 and 50. Therefore, in this study response, a response rate of less than 12 in a building was disregarded.

2.4. Questionnaire and Operationalisation

The survey was designed to measure exposure to the feedback information, disclosed attitudes towards energy efficiency behaviour, perceived subjective norms, collective outcome expectancy, and behavioural intention as adapted from Ohtomo and Hirose (2007), Carrico and Riemer (2011), and Davies et al. (2008). However, the survey was expanded to suit the research questions and the context of Wits University. The survey used a quantitative questionnaire-based methodology. Still; there were two open-ended questions; a qualitative method was used to get as much discursive input as possible from all participants. A five-point rating scale was used for large parts of the questionnaire, with 1 indicating the lowest degree of agreeability *(Strongly disagree).* In contrast, higher numbers indicated a higher degree of agreeability (*Strongly agree).* An option for *Not applicable/No opinion* was provided. In line with components of TPB, the questionnaire included the following sections:

- Information exposure – participants were asked two questions on exposure to information; for example, “do you remember receiving an email with information about

energy efficiency from Wits communication in the last 6 to 12 months?" With the follow-up question "If yes, did you read the contents of the email?" the second question was "did you notice the information on the energy usage of your building sent to your email?" With the same follow up question.

- Attitudes towards energy efficiency in the workplace.
- The subjective norm – the individual's perception of social pressure to save energy.
    - Descriptive norm - are people in the group/department doing it (performing the behaviour)
    - Injunctive norm – how other people in the building/shared space approve/disapprove of the behaviour
- Perceived behavioural control – the individual's conviction of their ability to perform the behaviour.
- Situational factors – physical factors that are conducive to intended behaviour.
- Behavioural intention - how much of an effort is the individual planning to exert to perform the behaviour.
- Collective outcome expectancy – the outcomes of saving energy.
- Demographic information – age, gender, ethnicity, designation, staff category and campus of affiliation.

2.4.1. Information exposure

There were questions included in the survey to measure the respondents' exposure to general energy-efficient information received via emails and whether they had read the contents of the emails. Respondents had three options to choose from: "no, I did not read them," "yes, I read some of it" and "yes, I read all or nearly all of it." The same items were used to determine the respondents' exposure to the feedback information provided as part of the intervention (i.e., "Did you notice the information on the energy usage of your building sent to your email?"). For each of these questions, respondents who reported that they did not notice the information was coded as a "0", respondents who noticed the information, but did not engage with it received a "1", and those who noticed and engaged with the contents "some" or "nearly all" of the contents of the monitors "2" and "3" respectively.

2.4.2. Attitudes towards energy efficiency

Five items were created to measure attitudes towards energy efficiency through their future intentions. Survey participants were asked to report if they thought that turning off computers,

lights, and other office appliances when not in use was important. These items were adapted in part from Chen and Knight (2014) and modified to measure specific attitudes in the intended sample. Furthermore, those who used air conditioners and heaters were asked if they intended to switch off the appliances before leaving the office for the day. Respondents were also asked to indicate how often they intended to turn off their lights before leaving their workspace for extended periods (i.e., for lunch or meetings). Participants were asked to rate to what extent they agreed or disagreed with the statements.

2.4.3. Subjective norms

The part of the questionnaire that was designed to measure the subjective norms included two items. Subjective norms are identified through the perceived social pressure from peers for an individual to perform a particular behaviour and their motivation to succumb to the pressure of the peers' views. These two questions focussed on the latter while the former is addressed in the injunctive and descriptive sections of the framework. On a five-point Likert scale ranging from "strongly disagree" to "strongly agree", participants were asked to rate their level of agreement with these statements: "Electronic items consume a lot of energy during their operation" and "Electronic items still use energy during their standby mode".

2.4.4. Descriptive norm

In this part of the questionnaire, three items were included to measure the descriptive norms for energy efficiency; this is also the measure of the extent to which individuals believe their co-workers engage in energy efficiency activities. Respondents were asked to report, to the best of their knowledge, if the other building occupants involved themselves in three energy-efficient activities and these were switching off computers, turning off lights, and turning off other electric appliances.

2.4.5. Injunctive norm

As in Ohtomo and Hirose (2007) and Carrico and Riemer, (2011), to measure the injunctive norm, three items were used. These items measured the perception of which other building occupants would approve or disapprove of energy-efficient behaviour. Respondents were asked to indicate how the people in their building would react if they did not switch off a computer, lights left on, and other electronic appliances left on.

2.4.6. Perceived behavioural control

Perceived behavioural control is the measure of the extent to which respondents had control over reducing energy consumption and was measured using three items. These items referred to self-reported energy use, i.e., “I would like to reduce the amount of energy that I personally use”, as well as the organisation as a whole, i.e., “The University should do more to save energy”, and “Energy conservation should not be a priority for the University at this time”. Similarly, the answer types were made on a five-point scale ranging from “strongly disagree” to “strongly agree.”

2.4.7. Situational factors

Four items were used in the study to measure the extent to which the physical environment encouraged or inhibited energy efficiency behaviour. The survey participants were asked to rate their level of agreement with the following: “Saving energy takes too much time”, “I would be more likely to save energy in the office if there was more information about energy consumption”, “I would be more likely to save energy in the office if I was more aware of the benefits of saving energy” and “The University provides enough information about the energy consumption of my office/building/department”. Responses were made on a five-point scale ranging from “strongly disagree” to “strongly agree.”

2.4.8. Collective outcome expectancy

Two items were used to measure the collective outcome expectancy. Respondents were asked to indicate their level of agreement with these statements, “together we can reduce the University’s energy use” and “by changing our behaviour, employees like me can reduce the University’s energy use”. Similarly, the answer types were made on a five-point scale ranging from “strongly disagree” to “strongly agree.”

2.4.9. Behavioural intention

Three items were offered as options, with a five-point Likert scale ranging from “strongly disagree” to “strongly agree”. Respondents were asked to indicate their intended future behaviour in the three energy efficiency practices: switching off computers, turning off lights, and turning off other electric appliances.

2.5. Demographic Characteristics of Respondents

2.5.1. Staff

There was a total of 107 respondents on the staff survey, and most participants were professional and support staff (64%), while the academic staff constituted 35% and 1% chose not to declare. The overall participation rate in the survey was 13%. Most participants were female (64%), 33% were male, and 3% did not declare their gender. Most respondents were Black (38%) followed by White (35%), Indian (10%), Coloured (7%) and the remaining 9% chose not to disclose their race/ethnicity. Most of the respondents were in the 45-59 age bracket (45%) followed by 30-44 (36%), 60+ (13%) and 18- 29 (4%) while 2% did not disclose their age bracket. On designation most of the respondents were professional staff (49%), 21% were administrative staff, 12% were Heads of Unit/Department/School, 11% were technical staff, 2% were the executive staff. In comparison, 5% chose not to respond (see Table 2).

Table 2: Respondents' demographic characteristics (staff)

Characteristic	**Range**	**N**	**Percentage (%)**
Staff Category	Academic	37	35%
	Professional and Support	69	64%
	Undisclosed	1	1%
Gender	Female	69	64%
	Male	35	33%
	Prefer not to say	3	3%
Ethnicity/Race	Black	41	38%
	Coloured	8	7%
	Indian	11	10%
	White	37	35%
	Prefer not to say	10	9%
Age	18 - 29	4	4%
	30 - 44	39	36%
	45 - 59	48	45%
	60+	14	13%
	Undisclosed	2	2%
Designation	Administrative Staff	23	21%
	Executive Management/Director	2	2%
	Head of Unit/Department/School	13	12%
	Professional Staff	52	49%
	Technical Staff	12	11%
	Undisclosed	5	5%
		107	**100%**

Despite the survey being web-based, questions were not compulsory, and as a result, some of the participants did not answer some questions, leaving some missing data. However, this was minimal and did not account to more than 5% missing data for any item, no values that were manually imputed. In each of the following analyses, items with missing values were excluded. There were no significant differences observed based on the above demographic variables. Table 3 shows the number of respondents per building.

Table 3: Building occupation of respondents

Building	**N**	**Percentage (%)**
Biology Building	20	14.39%
Solomon Mahlangu House	69	49.64%
Umthombo Building	18	12.95%
Grand Total	**107**	**100%**

2.5.2. Students

The targeted student population was an all-female residence with a total of 59 respondents and a response rate of 17% to the survey. The majority of students were undergraduates (58%) who were not first-year students, while only 10% were postgraduate students. The demographics of the student respondents are presented in Table 4.

Table 4: Respondents' demographic characteristics (students)

Characteristics	**Range**	**N**	**Percentage (%)**
Student category	First-Year Student	19	32.20%
	Postgraduate Student	6	10.17%
	Undergraduate but not First Year	34	57.63%
Gender	Female	59	100.00%
Ethnicity/Race	Black	57	96.61%
	Prefer not to say	2	3.39%
Age	16 – 17	4	6.78%
	18 – 20	32	54.24%
	20 – 24	23	38.98%
		59	**100%**

2.6. Data Collection Technique

The survey was delivered online on a self-administered questionnaire to elicit staff and students' responses to the questions above. The advantages of web-based surveys are that they are cost-effective, efficient, and timely – real-time results. It is also easier to export the data and directly import it into data processing software, eliminating the human error in data capturing. The link

to the survey was emailed directly to the target population in all the four buildings, with a maximum of three follow-ups/reminder emails the survey was open for two weeks only.

2.7. Ethics

Permission to conduct this survey was obtained from the University of the Witwatersrand's Human Research Ethics Committee (HREC): Ethics Protocol Number HA1805. Ethical and moral questions were addressed. This included informing the participants of the confidentiality and anonymity of the survey and that they were not compelled to respond to the questionnaire. This was done through a Participant Information Sheet that was presented to potential respondents on the first page of the online survey. Many researchers generally accept that an email-based electronic response is never truly anonymous, since researchers may know the respondents' email addresses. However, there was no means to link responses to particular individuals. The responses were, therefore, anonymous. A high level of confidentiality was, therefore, possible for all participants. Respondents participated in this study voluntarily and were free to withdraw from the study at any time until they submitted their responses. After which respondents were unable to withdraw due to the anonymity of the data collection method. The contact details of the researcher were provided with a link to information about the study, including the project timelines, ethics certificate, and permission from the university registrar.

Quality is linked to ethical research execution through ensuring adherence to the stipulated research approach and methodology as well as paying attention to how tools are applied.

2.8. Data Analysis

After the data collection was completed analysis was done for the interpretation and discussion of the responses to the questionnaires that were filled online by the 107 respondents from the three selected staff buildings and the 59 students from one selected residence at the university. The statistical analysis was done using SPSS 26. The presentation of the finding starts by explaining the demographic profile of the respondents; it then proceeds to provide a factor analysis and how variables were selected according to the significance and other important considerations. The ANOVA statistical technique was performed on the data to assess whether there were any statistically significant differences between the means of the three groups or buildings that were the target sample for the study. These were Solomon Mahlangu House, Biology Building, and Umthombo Building. The results provide a narrative on relationships

between independents variables and dependent variables and how they interact. A discussion of the results will follow this analysis, and comparisons will be made in relation to literature. The theoretical model of this research, namely; the theory of planned behaviour model, will be incorporated into the discussion of the findings.

Before the ANOVA results were interpreted, the six assumptions underlying the model were checked to ensure that the one-way ANOVA would provide a valid result. Using the factor analysis results from the dependent variables were (a) continuous for the themes of the TPB, (b) the independent variables consisted of more than two categorical groups, (c) observations were independent, there were different participants in each group with no participants being in more than one target sample, (d) there were no significant outliers, (e) the dependent variable should be approximately normally distributed for each category of the independent variable, and (f) variances were homogeneous, this assumption was tested using Levene's test for homogeneity of variances.

Secondly, a test for reliability of the measuring instrument was performed on the data to test whether the study justifies its predicted aims and hypothesis and also ensures that the results do fit the conducted research and not any possible unrelated and irrelevant variables.

Lastly, factor analysis was performed on the data. Factor analysis is used as a statistical technique that aims to describe the correlations among multiple items as the result of one or more underlying factors. Because the study adopted the TPB model, the questionnaire included questions assessing the respondents' subjective norm, descriptive norm, perceived behavioural control, situational factors, collective outcome expectancy, behavioural intention and injunctive norm. The eigenvalue was used as a measure of how much of the variance of the observed variables were explained by a factor. The factor results were found to be consistent with the components of the TPB.

Thematic content analysis was used to analyse the open-ended questions. These questions were: *"what do you think are the main barriers to energy efficiency within Wits University?" and "please list two highest priority actions that Wits University can undertake immediately to make its campuses more energy-efficient"*. Thematic analysis is usually applied to the qualitative research method. Due to the mixed-method approach of the study, this technique was applied

to the qualitative responses. Nowell et al., (2017), p.2 state that thematic content analysis can be applied across a range of knowledge areas and research methods, and that it is a method for "identifying, analysing, organising, describing, and reporting themes found within a data set…thematic analysis is a useful method for examining the perspectives of different research participants, highlighting similarities and differences, and generating unanticipated insights". Atlas.TI was used for the thematic coding and sorting.

3. Results

3.1. Determining if Results Fit the TPB model

3.1.1. Descriptives of survey

The descriptive statistics of the variables of the study are provided in Table 5. These statistics include the mean, standard deviation, minimum, maximum, and the median of each scale. In order to choose the best measure of central tendency, the means and the medians were compared, and since the data were symmetric, the mean was the one chosen. Minimum and maximum values were used to identify potential outliers and to assess the spread of the data. The model was used to confirm if the data were not from more than one distributions (unimodal). Standard deviation was used to measure the dispersion and how spread out the data were about the mean. A higher standard deviation would indicate a greater spread in the data.

Furthermore, the table below indicates responses in percentages for 25 questions in Likert-type scales which range from strongly disagree to strongly agree. The response sequence for each statement is a linear scale indicating the extent to which the survey respondents agreed or disagreed with each statement. A generic response continuum is minimum (Strongly Disagree) to maximum (Strongly Agree) for statements favourable to the construct. The sentiment means will thus range from 1 (minimum) to 5 (maximum). A sentiment mean of 4.5 and above would represent a "strongly agree" / above average response. The responses are presented in Table 5 as follows. The low sentiments (<3) will be highlighted.

Table 5: Description of constructs and items with corresponding statistical characteristics.

Constructs	Items	N	Min	Max	Mean	Std. Error	Std. Dev
Attitudes towards energy efficiency (5)	1. I think turning off computers/monitors when leaving the office for the day is important	107	1	5	4.44	.104	1.074
	2. I think turning off lights when they are not being used is important	107	2	5	4.83	.045	.466
	3. I think turning off the power switches on the wall when leaving the office for the day is important	105	1	5	3.95	.127	1.304
	4. I think turning off the air-conditioner/heater if leaving the room for more than 20 minutes is important	105	2	5	4.56	.080	.820
	5. I think encouraging my co-workers to save electricity is important	105	2	5	4.62	.063	.641
Subjective Norm (2)	6. Electronic items consume a lot of energy during their operation	105	1	5	4.10	.106	1.082
	7. Electronic items still use energy during their stand-by mode	107	1	5	4.18	.084	.867
Descriptive Norm (3)	8. My colleagues always turn off the lights at the end of the day	105	1	5	3.83	.124	1.267
	9. My colleagues always turn off their computer/monitor at the end of the day	102	1	5	3.39	.124	1.252
	10. My colleagues always turn off other office/lab equipment	107	1	5	3.35	.119	1.229
PBC (3)	11. I am able to maintain an environmentally friendly place to work	105	1	5	3.67	.118	1.206
	12. I have control over the amount of energy I personally use at work	104	1	5	3.78	.120	1.222
	13. The University has control over the amount of energy that is used at work	105	1	5	3.16	.136	1.395
Situational Factors (4)	14. Saving energy takes too much time	106	1	5	2.02	.121	1.242
	15. I would be more likely to save energy in the office if there was more information about energy consumption (such as dashboards or information screens)	106	1	5	3.61	.128	1.321
	16. I would be more likely to save energy in the office if I was more aware of the benefits of saving energy	107	1	5	3.74	.129	1.334
	17. The University provides enough information about energy consumption of my office/building/department	107	1	5	2.50	.123	1.277
Collective outcome expectancy (2)	18. Together we can reduce the University's energy use.	107	1	5	4.70	.055	.570
	19. By changing our behaviour, employees like me can reduce the University's energy use	106	1	5	4.66	.063	.646
Behavioural Intention (3)	20. For the next three months, I intend to save more energy by always turning off my computer/monitor	107	1	5	4.32	.106	1.095
	21. For the next three months, I intend to save more energy by always turning off lights when I leave my office	107	1	5	4.60	.082	.845
	22. For the next three months, I intend to save more energy by always turning off office/any electric appliances when I don't need to use them]	107	1	5	4.53	.089	.925
Injunctive Norm (3)	23. How do you think your colleagues in your building/department would react if they saw a monitor/computer left on	106	1	5	3.23	.080	.820
	24. How do you think your colleagues in your building/department would react if they saw lights left on	106	1	5	3.74	.087	.898
	25. How do you think your colleagues in your building/department would react if they saw any other office/lab equipment left on	106	1	5	3.49	.085	.876
	Valid N (listwise)	86					

3.1.2. Factor analysis

In accordance with the literature, the TPB model adopted included questions that assess the respondents' subjective norm, descriptive norm, perceived behavioural control, situational factors, collective outcome expectancy, behavioural intention and injunctive norms. In order to determine whether the eight underlying dimensions were discernible in the data, the questions were reduced using the principle axis factoring analysis (varimax rotation).

Table 6: KMO and Bartlett's test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.624
Bartlett's Test of Sphericity	Approx. Chi-Square	591.568
	df	136
	Sig.	.000

Table 6 shows the results for two tests that indicate the suitability of the data to the TPB model. The Kaiser Meyer Olkin (KMO) measure indicates the proportion of variance in the variables that might be caused by underlying factors. High values closer to 1 generally indicate that factor analysis can be used to explain the data. Assumption checks showed sampling adequacy (KMO) with only seven factors being chosen, and these constituted at least two-thirds of the variation (62%). The Bartlett's test of sphericity tests the hypothesis that the correlation matrix is an identity matrix, which would indicate that the variables in this study are unrelated and therefore, unsuitable for structure detection. Small values (less than 0.05) of the significance level indicate that factor analysis may be useful with the data. The results of this study show that the Barlett's test for this analysis is far below 0.05, and therefore the factor analysis if useful.

Table 7: Factor analysis variance

Total Variance Explained						
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.366	19.797	19.797	3.366	19.797	19.797
2	2.624	15.434	35.232	2.624	15.434	35.232
3	1.928	11.339	46.571	1.928	11.339	46.571
4	1.660	9.764	56.335	1.660	9.764	56.335
5	1.386	8.152	64.487	1.386	8.152	64.487
6	1.117	6.568	71.055	1.117	6.568	71.055
7	1.088	6.399	77.454	1.088	6.399	77.454

Table 7 shows the total variance explained by the initial solution. Data shows that only seven factors in the initial solution have eigenvalues greater than one and together, they account for

almost 78% of the variability in the items. These results suggest that latent influences are associated with energy consumption and usage in the workplace, but there remains room for unexplained variance. It can be observed that the eigenvalue for the first factor is larger than the eigenvalue for the next factor. The first factor explains most of the variation, followed by factor 2 and factor 3 with the last factor accounting for at least 11.339 of the variance. The results do not show a difference in the extracted factors before rotation; thus, no variation explained by the initial solution was lost due to latent factors unique to the original variables and variability that simply cannot be explained by this factor model.

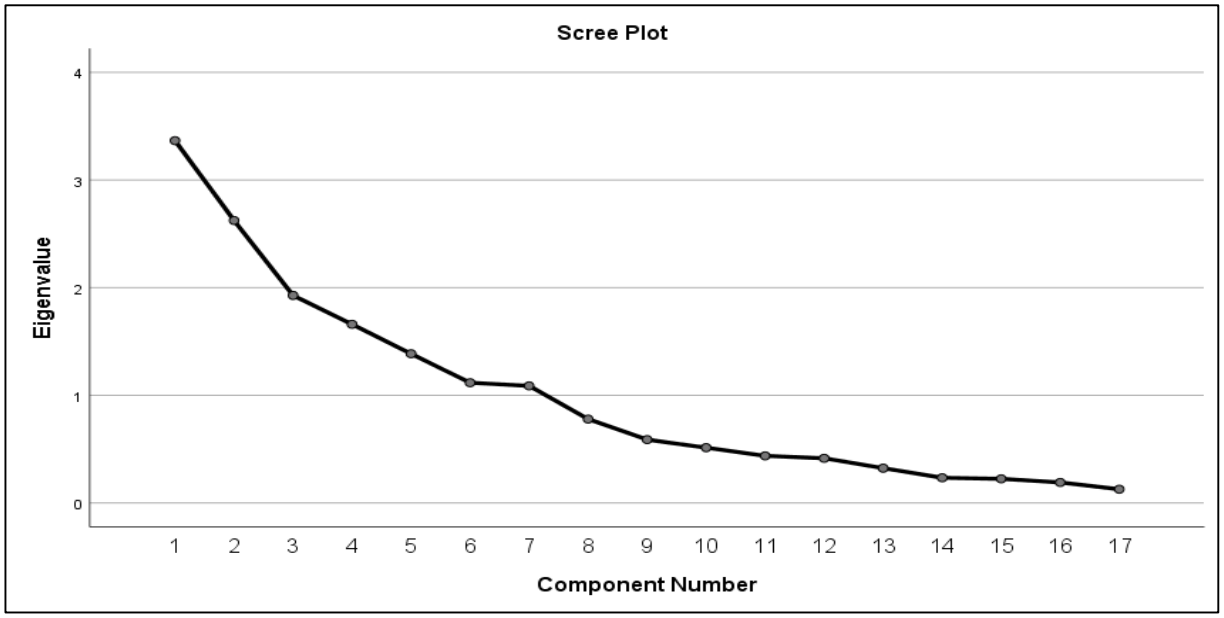


Figure 3: Scree plot Eigenvalue vs. component number

The scree plot confirms the choice of eight components.

The pattern of items loading onto the underlying factors was clear and easy to interpret. Factor 1 included three items representing behavioural intention. Factor 2 loaded on three factors as well, which were the injunctive norms. Factor 3 loaded on three variables which were concerned with the descriptive norm. Factor 4 included two items concerned with the subjective norm. Factor 5 loaded on two items which were situational factors or physical factors which may facilitate or inhibit energy-saving behaviour. Factor 6 included two items concerned with the perceived behavioural control – PBC. Lastly, factor 7 loaded with two items under attitudes towards energy efficiency at a personal level. As depicted in Table 7 and Table, 8 shows all the variables loaded onto one of the seven factors with a loading factor above 0.30.

The factor solution was generally consistent with the components of the TPB:

1) Behavioural intention (Factor 1);
2) Injunctive norm (Factor 2);
3) Descriptive norm (Factor 3);
4) The subjective norm (Factor 4);
5) Situational factors (Factor 5);
6) Perceived behavioural control – PBC (Factor 6);
7) Attitudes towards energy efficiency (Factor 7).

Table 8: Rotated Factor Pattern

Rotated Component Matrix[a]							
	Component						
	1	2	3	4	5	6	7
For the next three months, I intend to save more energy by always turning off lights when I leave my office	.881						
For the next three months, I intend to save more energy by always turning off office/any electric appliances when I don't need to use them	.844						
For the next three months, I intend to save more energy by always turning off my computer/monitor	.821						
How do you think your colleagues in your building/department would react if they saw any other office/lab equipment left on		.922					
How do you think your colleagues in your building/department would react if they saw lights left on		.910					
How do you think your colleagues in your building/department would react if they saw a monitor/computer left on		.711					
My colleagues always turn off the lights at the end of the day			.845				
My colleagues always turn off other office/lab equipment			.812				
My colleagues always turn off their computer/monitor at the end of the day			.801				
I would be more likely to save energy in the office if I was more aware of the benefits of saving energy				.893			
I would be more likely to save energy in the office if there was more information about energy consumption (such as dashboards or information screens)				.889			
Electronic items still use energy during their stand-by mode					.815		
Electronic items consume a lot of energy during their operation					.801		
I have control over the amount of energy I personally use at work						.787	
I am able to maintain an environmentally friendly place to work						.768	
I think turning off lights when they are not being used is important							.891
I think turning off the air-conditioner/heater off if leaving the room for more than 20 minutes is important							.578

Extraction Method: Principal Component Analysis.

Rotation Method: Oblimin with Kaiser Normalization.[a]

a. Rotation converged in 11 iterations.

It is quite clear from the results of the factor analysis that some questions did not fit within the predetermined model of PBC, these are question 1, 3, 5, 13, 14, 17, 18 and 19. These questions were removed from the further analysis that follows. Consequently, question 18 and 19 were within the Collective Outcome Expectancy construct these means that this study is unable to make any conclusive remarks on this construct. The number of factors was reduced from 8 to 7 and the number of items from 25 to 17. However; using principal axis factors extraction, the study has uncovered seven latent factors that describe relationships between the 17 items developed with the TPB model framework. These factors suggest various patterns of behaviours, which can be used to inform organisational energy efficiency.

3.1.3. Testing for reliability

In order to calculate the reliability of the construct, an approach similar to Lin and Hsu (2013) was adopted for this study which is that of calculating the composite reliability instead of the Cronbach's alpha and other related tests. This method was chosen because various researchers have suggested that the precision of the reliability coefficient is dependent on the sample size; thus, the larger the sample used to compute the reliability coefficient the more precise the estimate of the population reliability (Nunnally & Bernstein, 1994; Charter & Feldt 2002; Cosidine et al., 2005; Peterson & Kim, 2013). Nunnally and Bernstein (1994) suggested a minimum N of 300. Therefore, since the sample size (N) for this study was 107, the composite reliability was the most suitable method to determine the reliability of the items. Nunally and Bernstein (1994) further suggested that composite reliability values of 0.60 to 0.70 are acceptable in exploratory research, while in more advanced stages of research, values between 0.70 and 0.90 can be regarded as satisfactory.

Fornell and Larcker (1981) as cited in Lin and Hsu (2013) suggested that the items in each construct should meet three criteria: (1) the factor loading (λ) should be greater than 0.5; (2) the values of the composite reliability (CR) must be greater than 0.8 and (3) the values of the average variance extracted (AVE) should be greater than 0.5. The results of the reliability test analysis for each construct are presented in Table 9. The results of the factor loadings for this study are presented in Table 8, and the item loadings were all greater than 0.5. The CR for this study ranged between 0.71 and 0.89; while the AVE was between 0.56 and 0.79. The correlations and AVE of the variables are also presented in Table 9. Because the AVE for all

variables was greater than the coinciding correlation values; therefore, the variables in this study display acceptable discriminant validity.

Table 9: Correlation, CR and AVE

				Construct					
Construct	CR[a]	AVE[b]	AT	BI	IN	DN	SF	SN	PBC
AT	0.71	0.56	1.00						
BI	0.89	0.72	0.27	1.00					
IN	0.89	0.73	0.08	0.36	1.00				
DN	0.86	0.67	0.03	0.23	0.22	1.00			
SF	0.89	0.79	0.12	0.09	-0.15	-0.06	1.00		
SN	0.79	0.65	0.19	0.18	0.25	0.14	0.10	1.00	
PBC	0.75	0.60	0.18	0.16	0.04	0.29	0.03	0.13	1.00

AT, Attitudes towards energy efficiency; BI, Behavioural Intention; IN, Injunctive Norm; DN, Descriptive Norm; SF, Situational Factors; SN, Subjective Norms; PBC, Perceived Behavioural Control
CR[a] Composite Reliability
AVE[b] is average variance extracted (i.e. the proportion of variance in a construct that is not due to measurement error)

3.2. Differences between Sample Groups and Results of Behaviour

The results showed that the 17 items used in the study were a good fit for the TPB model. To determine whether there were any statistical differences between the means that were significant. In this case, the null hypothesis is that the means of the respondents from the different buildings were all equal. While the alternative hypothesis is that there is at least one significant difference among the groups. The results are presented in Table 10. An ANOVA confirmed that there was a difference of means between buildings. The significant p-value for the descriptive norms (are people in the group/department doing it, i.e. performing the behaviour) was 0.001, and that of situational factors (physical factors that are conducive to intended behaviour) was 0.002 which is less than the significance level of 0.05. The null hypothesis was rejected, and it was concluded that some of the groups have different means. An important observation is that the mean differences for 5 TPB variables were not significant.

The posthoc analysis results show that the differences in the descriptive norms were between the Biology Building and Umthombo Building and Solomon Mahlangu House. It is worth noting that on attitudes towards energy efficiency, the means of these groups were not significantly different but very high (between 4.30 and 4.56) on a 5 point Likert-scale. At the same time, the descriptive norm is defined as whether people in the group/department are

performing the behaviour or not. These results suggested that individuals' attitudes towards energy efficiency vary across different buildings. Additionally, the post-hoc results also showed the differences in the situational factors were between Solomon Mahlangu House and Biology Building. Again, closely linked to the individual attitudes, the results suggest that the occupants of the Solomon Mahlangu House have more control or have physical factors that are conducive to energy efficiency compared to the occupants of the Biology Building.

Table 10: Difference of mean across groups for TPB variables (ANOVA and posthoc tests).

Tukey HSD								ANOVA	
Dependent Variable	(I) Which building is your office located at?	(J) Which building is your office located at?	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval		F	Sig.
						Lower Bound	Upper Bound		
AT	BB	SHM	-0.38	0.27	0.35	-1.02	0.27	0.98	0.38
		UB	-0.29	0.34	0.68	-1.11	0.53		
	SMH	BB	0.38	0.27	0.35	-0.27	1.02		
		UB	0.09	0.28	0.95	-0.58	0.76		
	UB	BB	0.29	0.34	0.68	-0.53	1.11		
		SMH	-0.09	0.28	0.95	-0.76	0.58		
BI	BB	SHM	0.47	0.53	0.64	-0.78	1.73	1.22	0.30
		UB	-0.32	0.68	0.88	-1.93	1.28		
	SMH	BB	-0.47	0.53	0.64	-1.73	0.78		
		UB	-0.80	0.55	0.32	-2.11	0.51		
	UB	BB	0.32	0.68	0.88	-1.28	1.93		
		SMH	0.80	0.55	0.32	-0.51	2.11		
IN	BB	SHM	0.81	0.56	0.33	-0.53	2.15	1.05	0.35
		UB	0.77	0.72	0.54	-0.95	2.48		
	SMH	BB	-0.81	0.56	0.33	-2.15	0.53		
		UB	-0.04	0.59	1.00	-1.44	1.36		
	UB	BB	-0.77	0.72	0.54	-2.48	0.95		
		SMH	0.04	0.59	1.00	-1.36	1.44		
DN	BB	SHM	-0.03	0.75	1.00	-1.82	1.77	9.18	0.00
		UB	3.41*	0.98	0.00	1.07	5.76		
	SMH	BB	0.03	0.75	1.00	-1.77	1.82		
		UB	3.44*	0.82	0.00	1.48	5.39		
	UB	BB	-3.41*	0.98	0.00	-5.76	-1.07		
		SMH	-3.44*	0.82	0.00	-5.39	-1.48		
SF	BB	SHM	-2.55*	0.57	0.00	-3.89	-1.20	10.15	0.00
		UB	-2.15*	0.72	0.01	-3.87	-0.43		
	SMH	BB	2.55*	0.57	0.00	1.20	3.89		
		UB	0.40	0.59	0.78	-1.01	1.80		
	UB	BB	2.15*	0.72	0.01	0.43	3.87		
		SMH	-0.40	0.59	0.78	-1.80	1.01		

SN	BB	SHM	-0.26	0.44	0.83	-1.30	0.78	0.22	0.80
		UB	-0.34	0.55	0.82	-1.65	0.98		
	SMH	BB	0.26	0.44	0.83	-0.78	1.30		
		UB	-0.08	0.45	0.98	-1.14	0.98		
	UB	BB	0.34	0.55	0.82	-0.98	1.65		
		SMH	0.08	0.45	0.98	-0.98	1.14		
PBC	BB	SHM	-0.11	0.52	0.98	-1.34	1.13	0.18	0.84
		UB	0.20	0.65	0.95	-1.35	1.76		
	SMH	BB	0.11	0.52	0.98	-1.13	1.34		
		UB	0.31	0.53	0.83	-0.95	1.57		
	UB	BB	-0.20	0.65	0.95	-1.76	1.35		
		SMH	-0.31	0.53	0.83	-1.57	0.95		

AT, Attitudes towards energy efficiency; BI, Behavioural Intention; IN, Injunctive Norm; DN, Descriptive Norm; SF, Situational Factors; SN, Subjective Norms; PBC, Perceived Behavioural Control

BB = Biology Building; SMH = Solomon Mahlangu House; UB = Umthombo Building

[a] Post-hoc test: Tukey's HSD (honestly significant difference) to find means that are significantly different from each other.

[b] Levene's tests have confirmed the homogeneity of the variance between groups for all variables.

*. The mean difference is significant at the 0.05 level.

A similar analysis was done to test if there were any statistically significant differences in the respondents depending on the level of consumption of the feedback information of the intervention. Respondents were asked to respond to these two questions: "do you remember receiving an email with information about energy efficiency from Wits communication in the last 6 to 12 months?" With the following follow-up question "If yes, did you read the contents of the email?" the second question was "did you notice the information on the energy usage of your building sent to your email?". The results presented in Table 11 are for the latter, which is directly linked to intervention and the impact thereof. In this case, the null hypothesis is that the means of the respondents for the TPB constructs were all equal due to the different levels of engagement with the contents of the intervention email. The respondents were placed into three groups namely; those who responded "No, I did not read them", "Yes, I read some of it" and lastly "Yes, I read all or nearly all of it". The alternative hypothesis is that there is at least one significant difference among the groups. An ANOVA confirmed that there was no difference of means between the groups, the p-values for the constructs were far above the significance level of 0.05. The null hypothesis was not rejected, and it was concluded that the groups have no different means. An important observation is that there were no mean differences in the responses with regards to the engagement with the feedback.

Table 11: Difference of mean on a different level of engagement with the feedback intervention (ANOVA).

		Sum of Squares	df	Mean Square	F	Sig.
AT	Between Groups	0.907	2	0.453	0.398	0.672
	Within Groups	116.084	102	1.138		
	Total	116.99	104			
BI	Between Groups	7.632	2	3.816	0.877	0.419
	Within Groups	447.953	103	4.349		
	Total	455.585	105			
IN	Between Groups	3.539	2	1.769	0.355	0.702
	Within Groups	512.725	103	4.978		
	Total	516.264	105			
DN	Between Groups	6.343	2	3.172	0.311	0.733
	Within Groups	988.167	97	10.187		
	Total	994.51	99			
SF	Between Groups	28.661	2	14.33	2.53	0.085
	Within Groups	583.424	103	5.664		
	Total	612.085	105			
SN	Between Groups	15.722	2	7.861	2.913	0.059
	Within Groups	275.269	102	2.699		
	Total	290.99	104			
PBC	Between Groups	16.95	2	8.475	2.234	0.112
	Within Groups	375.569	99	3.794		
	Total	392.52	101			

AT, Attitudes towards energy efficiency; BI, Behavioural Intention; IN, Injunctive Norm; DN, Descriptive Norm; SF, Situational Factors; SN, Subjective Norms; PBC, Perceived Behavioural Control

The linear regression analysis model was tested to determine whether energy-efficient behaviour could be explained by the exposure to both general and feedback information. These were compartmentalised into an individual's attitude towards energy efficiency, descriptive norm, injunctive norm, behavioural intention, situational or physical factors, subjective norm, and PBC.

Table 12 depicts the results for the linear regressions of self-reported energy efficiency behaviour and intention to save more energy for staff respondents. The dependent variable was the level of engagement with the feedback information on group/building consumption. Regression analysis was conducted on the relationship between the TPB constructs and the actual engagement with the information on the feedback email. The null hypothesis is that there is no relationship between independent factors and the dependent factor; and an alternative hypothesis: there is a relationship between independent factors and the dependent factor. The

results suggest that the null hypothesis should not be rejected at 5% level of significance as there is not enough evidence that the independent factors were related to the dependent factor (F = 1557; P = 0.157). Table 12 presents the results. The model only explained 3.6% of the variance R^2 = 0.036. Therefore, attitudes, intention and energy-efficient behaviour did not influence the level of engagement with the information, suggesting that regardless of the provided feedback, individuals generally had a positive attitude towards energy efficiency and were more willing to perform energy-efficient behaviour. The results of the regression analysis support the findings in Table 11 above. The results of the study also show that the subjective norm, which refers to the perceived social pressure to perform or not to perform the behaviour was the most important determinants of behaviour.

The variance inflation was low for all variables which are indicative of the absence of multicollinearity (ranging between 1.096 and 1.171). All these factors were found to be independent of each other. The collinearity diagnostic results showed no collinearity amongst the factors, and the Eigenvalues were all below ten.

Table 12: Regression analysis

Model Summary[b]									
R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
				R Square Change	F Change	df1	df2	Sig. F Change	
.316[a]	0.100	0.036	0.731	0.100	1.557	7	98	0.157	2.045

Coefficients[a]										
	Unstandardized Coefficients		Standardized Coefficients			Correlations			Collinearity Statistics	
	B	Std. Error	Beta	t	Sig.	Zero-order	Partial	Part	Tolerance	VIF
PBC	0.04	0.08	0.05	0.45	0.65	0.09	0.05	0.04	0.87	1.15
BI	0.04	0.09	0.05	0.45	0.66	0.05	0.04	0.04	0.85	1.17
IN	-0.18	0.10	-0.18	-1.71	0.09	-0.08	-0.17	-0.16	0.87	1.15
DN	0.02	0.07	0.03	0.26	0.80	0.04	0.03	0.02	0.86	1.17
SF	-0.08	0.06	-0.13	-1.32	0.19	-0.07	-0.13	-0.13	0.91	1.10
SN	0.25	0.09	0.28	2.71	0.01	0.24	0.26	0.26	0.88	1.13
AT	0.05	0.15	0.03	0.33	0.74	0.08	0.03	0.03	0.86	1.16

a. Dependent Variable: If yes, did you engage with the graphs/information displayed?
b. Predictors: (Constant), AT, DN, SF, SN, PBC, IN, BI
AT, Attitudes towards energy efficiency; BI, Behavioural Intention; IN, Injunctive Norm; DN, Descriptive Norm; SF, Situational Factors; SN, Subjective Norms; PBC, Perceived Behavioural Control

3.3. Effect of Intervention on Energy Use

Prior to the intervention, the historic kWh consumption data was sourced and analysed to check for outliers and gaps. The meter readings took a reading every half an hour, which meant that in a 24-hour day, there were 48 readings. The data were converted to present a 24-hour consumption reading. On instances where the meter readings were malfunctioning, and no readings were recorded, they were left blank, and the results were unaffected.

Table 13 summarises the mean kWh consumption from the baseline years of 2017 and 2018 and the year of intervention 2019, the intervention was carried out between August and September 2019 the first feedback email was sent on 8 August 2019, and the last feedback email was sent on 16 September 2019. To ensure that the impact of the intervention was evident the month (July) before the intervention and the month after the intervention (October) are also presented in the analysis offering the pre, and post-intervention mean kWh consumption.

The test procedure of choice used in the study was a repeated analysis of variance (ANOVA) for its effectiveness in identifying variability where it exists. The analysis focused on variability within and between different time periods. Electricity consumption was compared yearly, monthly and according to buildings. The repeated analysis of variance (ANOVA) was able to determine whether there were any statistically significant differences between the means of the three years of electric usage and differences between the four months (July to October) with August/ October 2019 being the period of intervention. The first part of the analysis looks at all variables simultaneously (Table 13). The second part looks only at 2019 electricity usage (Table 14). The third analysis looks at October across different time frames (Table 15). Lastly, the following Table 16 compares the July (pre-intervention) usage against the October usage (post-intervention). All assumptions of equality and normality have been tested using Battles and Levene tests. The data follows a Gaussian distribution and all variables are independent of each other.

The mean kWh consumption comparisons indicated that consumption within all the targeted groups/buildings declined significantly compared to previous years over the same period with a p-value less than 0.05, respectively. Thus, the null hypothesis that there is no difference between the means is rejected and can safely conclude that there is a significant difference. There was an observed decline in mean kWh consumption from July to October across all the

years in the analyses (2017 – 2019). This trend was expected with the seasonal shift from winter to spring. However, relative to the baseline month of July and the baseline years (2017, 2018) the mean kWh consumption with the groups/buildings declined during the intervention (August to September 2019) with a month-on-month percentage difference of between 70% to 86% reduction. Additionally, the average year-on-year kWh consumption within the groups/buildings declined by more than 26%. The year-over-year percentage difference is the comparison of one period with the same period from the previous year. In this study, this period is the months during the duration of the study. For example, July of 2017 compared July of 2018 and 2019.

Table 13: Analysis from 2017 to 2019

Month	July	August	September	October	Month-on-month % Difference	Year-on-year % Difference
Mean of '2017 SMH'	490611	514811	367432	386742	24%	
Mean of '2018 SMH'	471147	270047	354857	367495	25%	
Mean of '2019 SMH'	459669	403067	221158	183616	86%	-39%
Mean of '2017 BB'	104148	103680	95407	96471	8%	
Mean of '2018 BB'	112892	56421	99431	104287	8%	
Mean of '2019 BB'	102103	108745	57629	49212	70%	-26%
Mean of '2017 UB'	2494	2044	1691	1937	25%	
Mean of '2018 UB'	1329	1741	1759	1748	-27%	
Mean of '2019 UB'	2163	2080	1038	967	76%	-31%
Mean of '2017 EC J'	31725	38656	29370	35183	-10%	
Mean of '2018 EC J'	16287	17682	14408	15297	6%	
Mean of '2019 EC J'	15214	16017	8269	7211	71%	-189%
p-value	0.000	0.000	0.000	0.000		
Significance	High	High	High	High		

SMH, Solomon Mahlangu House; ECB, East Campus Biology Building; UB, Umthombo Building; ECJ, East Campus Jubilee Hall Residence

Table 14: 2019 Analysis for all buildings

Month	Mean of '2019 SMH'	Mean of '2019 EC B'	Mean of '2019 UB'	Mean of '2019 EC J'	p-value	Significance
July	459669.04	102103.04	2163.4	15213.6	0.000	High
August	403066.93	108744.64	2079.8	16017.12	0.000	High
September	221157.98	57629.44	1038.4	8268.96	0.000	High
October	183616.07	49211.84	966.6	7210.8	0.000	High

SMH, Solomon Mahlangu House; ECB, East Campus Biology Building; UB, Umthombo Building; ECJ, East Campus Jubilee Hall Residence

Table 15: October analysis overtime

Building	2017	2018	2019[a]	Interpretation
SMH	386742.3	367494.7	183616.1	Decreased electricity usage
EC B	96471.0	104287.0	49211.8	Decreased electricity usage with a peak in 2018
UB	1937.4	1748.4	966.6	Decreased electricity usage
EC J	35182.6	15297.1	7210.8	Decreased electricity usage with a trough in 2018
Total consumption	**520333.3**	**488827.3**	**241005.3**	**overall decreased electricity usage overtime**

SMH, Solomon Mahlangu House; ECB, East Campus Biology Building; UB, Umthombo Building; ECJ, East Campus Jubilee Hall Residence
[a]Year of intervention

Table 16: July Vs October 2019

Building	July[a]	October[b]	Interpretation
SMH	459669.04	183616.07	high to low
EC B	102103.04	49211.84	high to low
UB	2163.4	966.6	high to low
EC J	15213.6	7210.8	high to low

[a]pre-intervention
[b]post-intervention

The data presented in Table 13 to Table 16 show a significant decline in electricity consumption in all buildings from July to October in all years. However, the decline was more significant in the year of the intervention as depicted in Table 14 and 15. The results also show a sharp decline in consumption between July and October, as presented in Table 16.

3.4. Content Analysis of the Open-Ended Responses

The respondents were provided with two overarching open-ended questions at the end of the survey, to include/highlight any relevant aspects that they felt may have been missed in the questionnaire, or that required specific attention. They were asked first to describe what they perceived as barriers to energy efficiency within the University. Secondly, respondents were asked to list the two highest priority actions that Wits University can undertake immediately to make its campuses more energy efficient. The responses were read attentively to highlight core topics from the respondents' descriptions. Six barriers were identified, and five priority areas were identified. Several of these topics can be viewed as closely related. For example, the discussion of raising awareness would naturally include enhanced communication and different communication strategies. Discussions on the lack of control of the environment are closely related to the ageing infrastructure, which is presumably energy-intensive. However, these areas were individually discussed by some respondents, and efforts were made to disaggregate

this discussion to provide a more detailed analysis. To ensure that topics did not overlap in terms of scope and meaning, each 'unit of meaning' was assigned only one code. For example, responses referring to issues related to university-wide strategy, goals and objectives, as well as policy were only coded 'Lack of policy' and not counted in the other codes unless relevant information was additionally provided.

From the staff respondents, 107 responded to the first question, while 108 responded to the second question. Of the student respondents, 26 responded to the first question, while 23 responded to the second question. The rest of the respondents left the answers blank, and there were only two statements that were non-descriptive (i.e., "*No", "Not sure*"), and they were not included in the count. The student responses were not thematised as they unanimously referred to the barriers as ignorance and lack of information and the next immediate thing to be done as information and awareness campaigns. Percentages were calculated while referring to the total sample of staff respondents who completed the survey since they had the option of answering and presented as frequencies.

3.7.1. Barriers to energy efficiency within the University

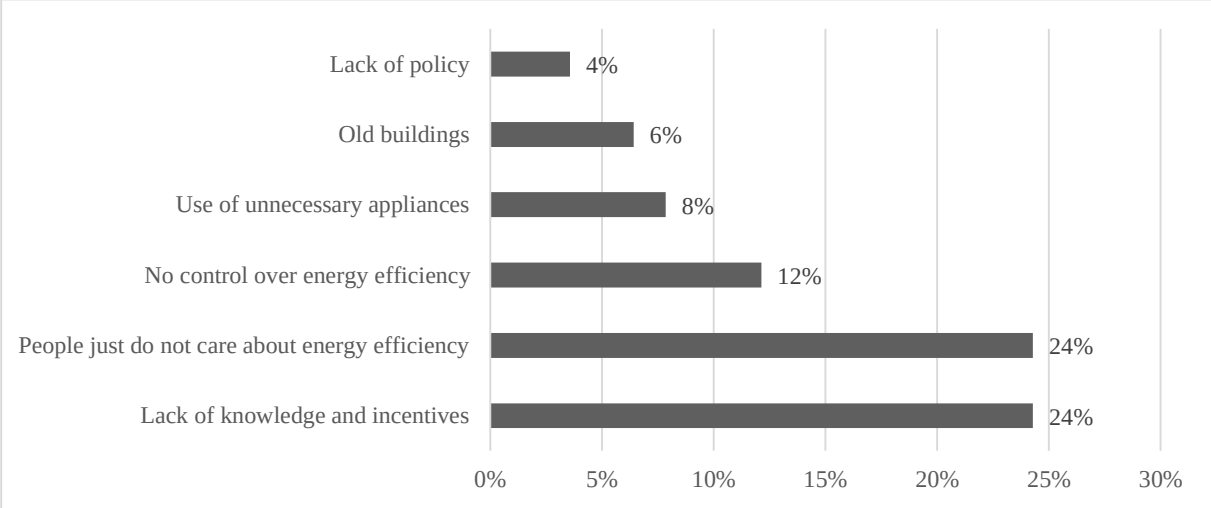


Figure 4: Barriers to energy efficiency within the University

The responses could be grouped into six main themes. Two of these themes ranked the highest namely; lack of knowledge and incentives (N=34) and people just do not care about energy efficiency (N=34), followed by no control over energy efficiency (N=17), use of unnecessary appliances (N=11), old buildings (N=9), and lack of policy (N=5).

Lack of policy

The description of staff respondents that referred to the lack of a policy direction indicated the lack of a central policy or strategy with clear objectives and targets for the entire organisation to save energy, for example: *"We have a policy which has not been implemented."*

No control over energy efficiency

The theme 'no control over energy efficiency' was interpreted to be very strongly linked to a lack of control over energy-consuming appliances in the buildings, especially in shared spaces or centralised systems such as HVAC. For example: *"I have little control over what and how my colleagues and students use devices and appliances that consume energy. I have very few choices about the energy efficiency of devices/appliances. I just have to use what I have been given … My office does not have independent control over its lights, so I cannot turn off my lights.*

"Some aspects are out of our control (air conditioning and ventilation), and the lack of shared resources means people duplicate (i.e. there is no urn so almost every office has its own kettle and some their own fridge so there are multiple appliances drawing energy unnecessarily)."

Old buildings

The theme of 'old buildings' was based on responses that referred to old infrastructure that generally consumes a lot of energy or requires a lot of energy as a barrier to energy efficiency. For example: *"Historic, old buildings with infrastructure barriers to energy efficiency such as general lighting, centralised air conditioners etc."*

"Old high energy-consuming fittings and fixtures; slow technology (quicker to boot up systems from standby mode than shutdown); most lectures are during the day so why are we not using solar energy to power lecture venues"

Lack of knowledge and incentives

In the analysis of the responses 'lack of knowledge and incentives' included descriptions that referred to the general lack of awareness, information and knowledge about energy efficiency, and energy-saving behaviours. For example: *"Lack of knowledge amongst staff/students about how to be efficient/the consequences of not being efficient; many people also do not seem to care that much."*

"Slow uptake to embracing the "Green" way of living. Also, people are not made aware of the cost of their actions i.e. they do not know how much money/energy they can save the university if they switch off the light, aircon or computer. This awareness and information need to be readily available somewhere."

"People still do not seem to think about deliberately saving energy - so more awareness campaigns are needed. I also believe that reducing waste and plastic waste, in particular, would have an impact on the long-term on energy consumption. Outlets could be encouraged not to use polystyrene, plastic bottles, straws etc. So the main barrier is actually the people who work at the university and the food outlets etc."

People just do not care

Within the analysis, responses that referred to ignorance and a general lack of interest were themed under 'people just don't care' about energy efficiency. For example: "*Carelessness - I think few people think about turning lights off when they leave common areas such as toilets at the end of the day. Also with equipment in common venues such as projectors, I think people are unsure about whether to turn off or not and what issues with rebooting might be"*

"Most people simply don't think about energy usage at Wits, and so are more or less unaware, or unconcerned. They don't have to pay for it directly, but are unaware that they actually do pay for it indirectly over the long term."

Use of unnecessary appliances

Lastly, responses that referred to people using multiple and unnecessary appliances were placed under one code which is described as 'use of unnecessary appliances' which consume too much energy. For example, "*Offices that are very cold in winter with no heaters and underfloor heaters in some offices that are uncontrollable. Staff members allocated in the cold and no heaters offices bring their own heaters and at some point leave them on throughout the night"*

"Use of inappropriate heating/cooling equipment: All of my colleagues and students use space heaters in their south-facing offices in the winter and some have small air conditioners in the summer. These use tremendous amounts of electricity. Also, until just this year we were using refrigerators that were 15 years old - a huge waste of electricity."

3.7.2. Highest priorities for energy efficiency

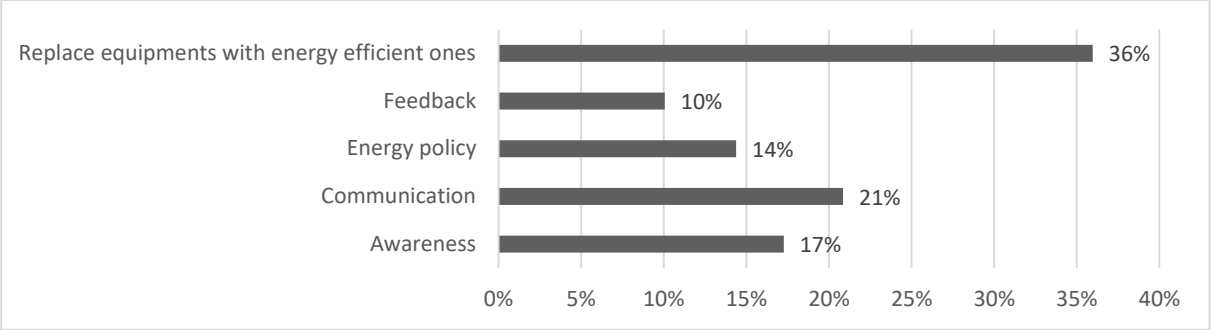


Figure 5: Highest priorities for energy efficiency

Respondents were asked to list the two highest priority actions that Wits University can undertake immediately to make its campuses more energy efficient. The analysis of the responses to the question fell within five thematic areas; namely, awareness (N=24), communication (N=29), energy policy (N=20), feedback (N=14) and replace equipment with energy-efficient ones (N=50).

Awareness

Within this section of the analysis, awareness refers to the descriptions made by the respondents about intentional and pro-active awareness campaigns. For example; *"Create an awareness campaign with a formal 'launch' for staff"; "Raise more awareness"; "educate Wits community about saving energy. by holding the workshop"; "More 'in your face ' awareness campaigns - list the cost of energy"; "Inform and equip the students and staff about energy efficiency usage."; "Give guidance on what is using electricity the most and how to save electricity."; "Raise awareness and educate staff by equating abuse of energy."*

Communication

Although the results showed a close link between awareness and communication, communication was distinctly used as a separate theme which refers to a more strategic and formal communication other than awareness campaigns more generally. This theme also includes educating the university community about the importance of energy efficiency. Examples include: *"Distributing pamphlets in campuses about energy-efficiency"; "provide notice boards and get staff and students more involved in saving."; "Provide more information and strongly encourage best practice."; "Educate Wits community to save energy and the reason of saving energy."; "Educating Wits community on appropriate measures of saving energy"; "Educate Wits community to urgently be more aware and save power!"; "Posters and*

training on energy saving methods."; "Better education of students and staff. Solar on ALL roofs."; "educate Wits community about saving energy. by holding workshops."

Energy policy

Respondents referred to the development of energy policy at the university in addition to clear objectives and targets of energy efficiency. The responses were also closely linked to communication as some of the respondents called for better communication of the university's energy efficiency strategy and targets. For example: *"Share any/educate us about any related energy-saving policies if they have any"*; *"Have a clear energy use policy that covers both procurement and behaviour"*.

Some of the suggestions made by the respondents were that there should be more enforcement of the rules and greater control across the university community, such as: *"control putting out of lights when not in use in offices."; "prohibit the usage of heaters and air conditioners."; "Consideration should certainly be given to the installation of sensors."; "Lights off in buildings over weekends, security could perhaps be asked."; "Request obligatory meetings in departments and post reminders in all media"; "Enforce zero tolerance on space heaters in the winter."; "Switch off air-cons when they are not in use."*

Some of the respondents called for more punitive measures to be put in place for people to modify their energy-wasting behaviours. For example: *"Be strict and punish offices that leave their lights on."; "Must charge the people using the energy more".*

Feedback

Respondents further indicated that in addition to awareness campaigns and improved communication that feedback about consumption patterns should also be prioritised. Therefore, this thematic area included only the responses that suggested a communication of energy consumption feedback beyond the general communication about energy-efficiency. For example: *"Make it clear how a building's energy use relates to an individual person's behaviour and then communicate the building's energy use clearly and unambiguously."; "Check what lights are left on (after staff have gone home) and where; and send reports to Heads of Departments concerned."; "provide noticeboards and get staff and students more involved in saving electricity."; "ask people to report on their energy usage as you have done in this questionnaire"; "Provide more information and strongly encourage best practice in relation*

to energy consumption (for those who may be less aware) by sending more frequent notifications to staff about energy consumption and how to save energy - even posters might have an effect."; "Make visible signage instructions (e.g., like signs encourage you 'save time, take the stairs')"; "The email with the usage I think could be improved if there were some context and interpretation to the email.[sic]"; "surface energy usage per department and have benchmarks to compare with."

Replace equipment with energy-efficient ones

In their responses, most of the participants suggested that there should be an implementation of energy regulation devices across the university. For example: "*Install sensors in corridors and buildings, toilets for lights to automatic switch on/off in the presence/absence of human beings"; "implement motion sensor lights to save power"; "Automatic lights in office buildings, solar panels."; "Provide more efficient heating and air conditioning"; "Reduce excessive lighting in buildings"; "Sensor lights that switch off automatically. Energy-efficient light bulbs rather than the monsters in use at the moment. Better temperature control systems.".*

Moreover, respondents suggested that the university should explore alternative energy sources and renewable energy solutions. For example: *"alternative electricity sources."; "Solar energy to provide energy for some needs in buildings would help."; "Switch to renewable energy provision, reduce the usage of fluorescent lighting.[sic]"; "Solar initiatives; centralise controls."; "Generating our own electricity:: get sponsors and also do research on erecting our own solar panels on the roofs of buildings - this is an investment in our futures.[sic]"; "invest in solar energy."; "Solar on ALL roofs." ; "more solar systems on the many flat roofs."*

Within the points that were made, some of the respondents suggested that the physical infrastructure should be enhanced and transformed to be more energy-efficient. For example: *"Making offices more reliant on natural light."; "Switch off and stop using central air conditioning"; "Insulate or fix windows/drafts to get rid of personal space heaters."; "Install LED lights in all buildings"; "replace hot water geysers."; "It would be good to centralise some of the appliances so there aren't five half-empty fridges on my floor".*

4. Discussion

This study aimed to gain knowledge that contributes to the understanding of whether energy consumption feedback influences energy-conserving behaviour; as well as the employees' general attitudes towards energy conservation in an attempt to identify critical issues that will enable further investigation of energy efficiency in the workplace. The study focused on the case of electricity consumption. For studies that focus on large organisations and institutions, the interventions require an approach that is effective, inexpensive, and relatively easy to implement and sustain on a large scale. The chosen intervention for this study met many of these requirements.

This led to the development of an intervention of energy consumption feedback and comparative feedback to investigate whether the intervention will influence perceptions and intended behaviours. The possible predictors of attitudes and behaviour were sought from literature and were tested in this study. Adopted from the theory of planned behaviour (TPB), the study was designed to measure factors such as exposure to the interventions (both general feedback and consumption feedback), attitudes towards energy efficiency behaviour, perceived subjective norms, collective outcome expectancy, and behavioural intention. Firstly, a combination of general feedback (i.e. their own building's consumption pattern) and comparative feedback (which is feedback about the energy consumption of another comparable building) was sent to selected groups/buildings. Secondly, a questionnaire was designed to measure the variables on attitudes and behaviour at work. Lastly, an analysis of the energy consumption of pre- and post-intervention was done. Data from 107 staff respondents and 59 student respondents were used in the analysis of the survey results.

The research strategy of using an online survey yielded high participation rates. The questionnaire was constructive in creating knowledge of a broad range of participants' attitudes and behaviours. The responses of the participants' assessing personal beliefs and attitudes towards efficiency showed good internal consistency and range. All the factors were found to be consistent with the elements of the theory of planned behaviour, namely descriptive norm; injunctive norm, behavioural intention, situational factors, subjective norm, perceived behavioural control – PBC, and attitudes towards energy efficiency. The mean kWh consumption comparisons indicated that consumption within all the targeted groups/buildings

declined significantly compared to previous years and months in the same period with p-value is less than 0.05 demonstrating the impact of the intervention.

4.1. Discussion on the attitudes and perceptions of employees towards energy efficiency and energy conservation

Most of the respondents had positive attitudes toward energy-efficient behaviour. The means of the five items for attitudes towards energy-efficiency were, respectively, 4.44, 4.83, 3.95, 4.56 and 4.62, which indicated that participants had positive attitudes towards energy-efficient behaviours. The three items on the intention to perform energy-conserving behaviour were also higher than 4, suggesting that respondents had good intentions as far as energy-efficiency as concerned. These findings were consistent with the results of similar studies by Obaidellah et al. (2019) and Wang et al. (2014) which found that attitudes and perception significantly influenced occupants' energy-saving behaviour. The same observations were made in China and Malaysia were studies found that attitudes together with the other TPB components such as perceived behavioural control (PBC) positively influenced energy-saving behaviour (Tan et al., 2017; Wang et al., 2018; Liao et al., 2020). Similarly, the means of the items for Subjective Norm, Descriptive Norm, PBC, Collective outcome expectancy, Injunctive Norm were relatively high, indicating that most of the respondents in this study felt social pressure. Thus; they felt that their peers did not approve of energy-wasting behaviour, they were convinced that they could contribute to energy efficiency, and they had the intention to perform energy-efficient behaviours.

The results of this study indicate that there were no significant differences in the respondents' across the three buildings for attitudes towards energy-efficient behaviour ($F = 0.976$, $p=0.380$); the subjective norm defined as the individual's perception of social pressure to save energy in this study ($F = 0.220$, $p= 0.803$); the injunctive norm which is where other people in the building/shared space approve or disapprove of an energy-wasting behaviour ($F = 1.053$, $p=0.353$); the perceived behavioural control which is the individual's conviction of their ability to perform the behaviour ($F = 0.175$, $p=0.840$); and lastly the behavioural intention which is about how much of an effort an individual is planning to exert in order to perform the desired behaviour ($F = 1.220$, $p=0.300$). What is important to note from these results is that the respondents were all in agreement with regards to these TPB constructs. These results suggest that in developing interventions for organisations, these TPB constructs have to be taken into

consideration. Interventions should be structured in a manner that addresses each of these components, together they can contribute to the desired behavioural change. The results of this study are consonant with the findings of Klöckner (2013) and Staddon et al., (2016). They suggest that individuals are more inclined to perform environmentally-friendly behaviour if they hold a positive attitude towards the cause; if others expect them to act in that particular manner; and if they perceive themselves as being able to implement their intentions. Similarly, the TPB has been applied to environmental behaviour in several studies, and their results have supported its proposed structure; e.g. Gadenne et al., (2011); Harland et al., (1999); Heath and Gifford, (2002); Tonglet et al., (2004); Nie et al., (2019).

In contrast, post hoc analyses revealed that respondents from the different buildings differed in their responses to the descriptive norm which is defined as whether other people in the building are performing the desired behaviour (F= 9.179 sig. 0.00). They also differed their responses to the situational factors which are defined as the physical factors that are conducive to intended behaviour (F= 10.148 sig. 0.00). Bronfman et al., (2015) and Stern, (2000), concur with these findings in suggesting that lack of motivation is one of the main barriers of pro-environmental behaviours because it requires conscious effort and significant changes in old customs and habits. Furthermore, some of the contextual factors that affect the desired behaviour are expectations from others, policies and regulations, available technology and infrastructure (Bronfman et al., 2015). These results suggest that an organisation cannot take a blanket approach in implementing energy efficiency interventions. Interventions have to be tailor-made to address differences in the building occupants and the physical aspects of the building. For example, an energy consumption audit may need to be implemented prior to the intervention to ascertain the energy consumption of the various appliances and types of equipment within the targeted buildings. Ozawa et al.'s (2017) study, designed to use energy feedback, reports based on electricity data analysis concluded that the feedback effect on tailor-made interventions was beneficial for more than 80% of their participants. Staddon et al. (2016), as well as Kollmuss and Agyeman (2002) further note that in communal settings such as the workplace, providing feedback on a group basis rather than an individual basis is more effective. While the information provided through feedback can be effective, the manner in which the information is provided is equally significant. This notion was further emphasised in the open-ended responses where the majority of the respondents suggested that buildings should be reconfigured to give people more control of the spaces they occupy and that the organisation

should continually reinforce information and feedback provision. For example: "*Install sensors in corridors and buildings, toilets for lights to automatic switch on/off in the presence/absence of human beings"; "implement motion sensor lights to save power"; "Automatic lights in office buildings, solar panels."; "Provide more efficient heating and air conditioning"; "Reduce excessive lighting in buildings"; "Sensor lights that switch off automatically. Energy-efficient light bulbs rather than the monsters in use at the moment. Better temperature control systems.".* Despite the consistency of the seven constructs aligning to the TPB model, collective outcome expectancy had to be removed from the analysis due to its items not fitting into the preconceived constructs. Two alternative explanations can be suggested: (1) that participants lacked the desired outcome to undertake energy-efficient behaviour or (2) the questions designed for this construct did not fit appropriately to the TPB model. These results suggest that there may be a lack of clarity at an organisational level on the desired levels of energy efficiency. Alternately there may be ways to improve the questionnaire in future research to ensure the inclusion of this construct. Carrico and Riemer (2011) and Siero et al. (1996) both concluded that collective outcome expectancy leads to an increase in energy conservation behaviour over time.

These results concur with Hardeman et al., (2002) who further emphasised that TPB has been used to make a valuable contribution to the development of effective interventions aimed at behavioural change. As in Whitmarsh and O'Neill (2010) and Murtagh et al. (2013), the results of this study show that there are various underlying psychological, social, economic and physical barriers that act against environmental concerns being converted into the desired behaviour. The results of this study suggest that these barriers may undermine any expectation that individuals work consistently and in tandem across diverse behavioural domains, or that there is a collective motivational basis for the desired behaviour.

4.2. Discussion on whether energy consumption feedback positively influenced energy-conserving behaviour (Intention)

The results of the study did not show any significant differences in the different levels of engagement with energy consumption feedback. Two explanations can be provided for this phenomenon; firstly, the study was not designed to have pre and post-intervention surveys of which the results could be used to measure the difference between the two points of data collection; secondly, the study was not designed to measure the change of the engagement with the feedback. However, the results from the energy consumption data per building showed a

significant decline for the year 2019 relative to the baseline years of 2017 and 2018 in the same period. These results suggest that the provision of energy consumption information and feedback led to a 32% decline in energy use on average. Moreover, the results of the regression analysis yielded a p-value greater than 0.05 (F= 1557; P = 0.157). These results suggest that although there was not enough evidence to suggest that the attitudes, intention and energy-efficient behaviour influenced feedback, the respondents generally had a positive attitude towards energy efficiency and were more willing to perform energy-efficient behaviour. Like other work done in this area, these results are consistent with other findings in the literature (Abrahamse et al., 2005, 2007; Gadenne et al., 2011; Murtagh et al., 2013; Ozawa-Meida et al., 2017; Staddon et al., 2016; Stuart et al., 2016). Siero et al. (1996) observed a lasting impact of basic feedback resulting in an overall reduction in energy consumption lasting up to 6 months; while Murtagh et al. (2013) suggest that significant shifts in energy consumption can be observed after three months of intervention. In this study, careful consideration was made to ascertain that the lower consumption of the electricity was not due to the seasonal effect such as a change in university closure or holiday. The design and implementation of the study ensured that the intervention was aligned to the academic terms, as well as baseline years of 2017 and 2018.

The majority of work in this field has been examined within household settings in which feedback closely relates to the behaviour of an individual or family (Gadenne et al., 2011; Litvine & Wüstenhagen, 2011; Ozawa et al., 2017; Ozawa-Meida et al., 2017). Research further shows that economic incentives are the key drivers of behavioural change in that regard (Bronfman et al., 2015; Gadenne et al., 2011; Litvine & Wüstenhagen, 2011). Contrary to these findings, the magnitude of the impact in this study is impressive, considering the kind of feedback that was provided since there were no direct economic incentives to individuals. The data that was presented was readily available from the institutional repositories and could be accessed on a daily, weekly, or monthly basis. The intervention ensured that the data were easily comprehensible, relevant and instantaneous when they were presented to the building occupants. However, the simplicity of the intervention should not suggest that organisations should not invest in more sophisticated and complex technological tools. Even though the study did not use a frequent and technology-based intervention, it was still successful. These results suggest that even more reductions could be made with a technology-based intervention, with frequent and more detailed feedback. The results of the study suggest that the constructs of the

TPB can produce meaningful levels of behavioural change even though there are no direct economic incentives to the individuals. As in Carrico and Riemer, (2011), this has several implications to the organisation such as decentralised metering system per unit or floor. With the rising cost of electricity, these results also suggest that there is a direct economic incentive to the organisation over time.

Moreover, the availability of feedback information from the decentralised metering system would facilitate comparative feedback against other groups or buildings. A study by Siero et al. (1996) concluded that when a group of employees received energy consumption feedback not only about their usage including that of a 'competing' group of similar employees, they significantly modified their energy consumption behaviour. The comparison feedback information may create a competitive orientation that motivates individuals to perform energy-efficient behaviours. The results of the regression analysis in this study suggested that the subjective norm, which refers to the perceived social pressure to perform or not to perform the behaviour was the most critical factor for behavioural change. In the open-ended responses, on the question about areas that the institution should prioritise for energy-efficiency, feedback about consumption patterns featured amongst most of the responses. Respondents emphasised that communication of energy consumption feedback should be more than just general communication about energy-efficiency. For example: *"Make it clear how a building's energy use relates to a person's behaviour and then communicate the building's energy use clearly and unambiguously."*; *"Provide more information and strongly encourage best practice in relation to energy consumption (for those who may be less aware) by sending more frequent notifications to staff about energy consumption and how to save energy - even posters might have an effect."*; and *"surface energy usage per department and have benchmarks to compare with."*

4.3. Limitations of this Research

It is essential to acknowledge that there are several limitations to the research even though the study was developed and executed as thoughtfully and precisely as possible. However, designing energy behaviour interventions for organisations presents various challenges associated with the motivation, social engagement, organisational culture, and technical capabilities (H.-M. Chen et al., 2012; Foster et al., 2012). For example, the cost of energy is the primary motivational reason for people to reduce their energy use in the household (Abrahamse

et al., 2005, 2007). Thus, the incentive of reducing energy use in the household is an economic reward of cost savings. In the workplace, however, there is a challenge in incentivising energy-efficient behaviour because employees are not liable for the cost of energy use. The designed intervention for this study did not include the cost of the energy used per building. Carrico and Reimer (2011) also suggested that there is a clear organisational sustainability incentive for organisations to address workplace energy efficiency by including the actual cost of the energy used in the interventions. Due to the diversified energy use in the institution, interventions should be tailor-made based on the different types of energy-consuming activities.

Secondly, some of the staff and students who make use of the targeted buildings of the study may not have received the emails with the feedback information. Technical, casual, and cleaning staff may not have access to emails or computing devices due to the nature of their work. Students did not receive emails as well as it was difficult to ascertain which buildings and venues they were using for lectures, tutorials and other academic or extramural activities. Initially, the study was designed to display the feedback information on monitors in each of the targeted buildings. However, not all the buildings had monitors and emails were chosen as the "best" alternative way to disseminate the information.

Thirdly, the study did not have a pre-intervention survey which means that there was no baseline data collected on attitudes and energy-saving behaviour to compare the change in attitude or behaviour after the intervention. Therefore, the study measures the attitudes and the energy-saving behaviours post feedback information. Lastly, while the results provide insights on how to tackle energy efficiency in the workplace, a larger sample size would further accentuate the findings of this study.

4.4. Theoretical Implications

At the beginning of this study, it is stated that there have been many strategies and technologies employed to encourage energy efficiency in office buildings. However, the investments in this area were concentrated mainly with improving the energy use and demand of the physical infrastructure such as building elements (e.g. ventilation and insulation) and facilities (e.g. lighting and air conditioning), including the acquisition and implementation of renewable energy sources (e.g. solar power). Most of these studies posed significant limitations; in

particular, the consideration of possible measures and behavioural change tactics to encourage energy-saving of actual building users.

This study highlights the predictive power of models that take psychological variables into account when measuring the impact of energy consumption and climate change, such as the TPB approach used in this research. Thus, this study provides a validation of the theory of planned behaviour and the notion that individuals can be motivated to make better lifestyle decisions provided that they are given the right information and the environment in which to do so (Foster et al., 2012). The responses to the open-ended question further substantiated these findings; respondents indicated that there was a need for more awareness and information and control of their environments. For example, *"Create an awareness campaign with a formal 'launch' for staff"; "educate Wits community about saving energy. by holding the workshop"; "More 'in your face ' awareness campaigns - list the cost of energy"; "Inform and equip the students and staff about energy efficiency usage."; "Give guidance on what is using electricity the most and how to save electricity."; "Raise awareness and educate staff by equating abuse of energy." "I have little control over what and how my colleagues and students use devices and appliances that consume energy. I have very few choices about the energy efficiency of devices/appliances. I just have to use what I have been given"; "My office does not have independent control over its lights, so I cannot turn off my lights."; "Some aspects are out of our control (air conditioning and ventilation), and the lack of shared resources means people duplicate (i.e. there is no urn so almost every office has its own kettle and some their own fridge so there are multiple appliances drawing energy unnecessarily)."*

This study was supported by the four steps that an organisation can follow to instil behavioural change amongst employees. As described by Siero et al. (1996), step one is that the organisation should inform its employees that it wants a change in behaviour and the benefits thereof. Secondly, the organisation has to refer to the collective rather than individual interests. Again, the university has already referred to energy conservation as interest on the entire university community. Thirdly, the organisation has to set goals, and these should be accompanied by feedback. Lastly, when employees show the proposed behaviour, the behaviour has to be preserved, and it will eventually become part of the organisational culture. The findings of the study further highlighted the need for these four steps to be institutionalised and maintain consistency.

To achieve this, researchers from diverse disciplines should collaborate and incorporate different scales of measurement into a single framework with an emphasis on human behaviour and policy implications. This approach should take into consideration the external and internal dimensions of energy efficiency. Therefore, this study proposes that research on energy efficiency or emission reductions to alleviate climate change impact should be interdisciplinary with an invested interest in human development at all stages. This approach should include the role of individual attitudes, perceived subjective norms, and collective outcome expectancies as variables that influence behaviour (O'Brien, 2010).

4.5. Policy Implications

For policymakers, the results of the study indicate that there is a willingness among employees and students to engage in energy-saving behaviours. The results of the study also provide a clear and interpretable set of the multiple factors that can influence behavioural change. The results of this study can be used to help inform other higher education institutions and entities that are interested in developing energy efficiency interventions and policies, and that are considering developing energy efficiency interventions. It also emphases that it is of paramount importance to keep energy efficiency feedback convenient and easily accessible to the university community.

For Wits University, the findings of this study have implications for a) expansion of existing energy efficiency measures, and b) future policies for promoting sustainability to employees and students. For example, some of the interventions that can be implemented immediately are constant consumption feedback, behavioural reinforcement, decentralised metering, automation of appliances in shared spaces. These findings are in agreement with Staddon et al., (2016) who suggests that automation of technologies holds great potential for energy consumption reduction because they provide a new context in which energy-efficient behaviour can take place. In line with these findings; when respondents were asked to list the two highest priority actions that the institution can undertake immediately to make its campuses more energy-efficient, the most cited response was that the organisation should implement energy regulating devices and appliances across the university. Thus, an institutional policy is recommended based on the findings of this study to create localised ownership of energy consumption.

5. Conclusion

The study focussed on designing energy behaviour interventions in the form of energy consumption feedback and comparative feedback to investigate whether the intervention will influence energy-conserving behaviour. The overarching aims of the study were (a) to establish whether energy consumption feedback influences energy-conserving behaviour and (b) to establish the attitudes and behaviours of employees towards energy-conserving behaviour. The study was designed within the TPB framework. The study adopted the factor analysis, which yielded seven constructs with a factor loading above 0.5 and all the composite reliability coefficients were greater than 0.7 a strong indication that the constructs were effective. These results suggested that the data was a good fit for the TPB model. Also, the analysis of variance was conducted on the different buildings and different levels of engagement with the feedback information.

The main conclusions in this study are as follow. Firstly, the results of the survey provided further evidence that TPB can be used to determine the attitudes and behaviours of employees in the work environment. In line with this theory, Attitudes, Subjective Norm, Descriptive Norm, PBC, Collective outcome expectancy, Injunctive Norm were strong determinants of energy-conserving behaviour. Secondly, the study highlighted that Descriptive Norm and Situational Factors are areas that require particular focus in developing interventions differing from previous studies that suggested PBC, Behavioural Intention and Attitudes as strong determinates of behavioural change. These results further emphasised the need for tailor-made interventions in tackling energy-wasting behaviours. Thirdly, the analyses of the energy consumption data pre and post-intervention, which indicated a sharp decline in energy consumption, suggesting that the provision of consumption feedback can leave a lasting positive impact in an organisation. Lastly, the results of the regression analysis in this study indicated that the subjective norm, which refers to the perceived social pressure to perform or not to perform the behaviour was the most critical factor for behavioural change.

Evidence gleaned from the data suggests that the technical recommendations that can be made as a result of the findings of this study are that the institution should reinforce energy feedback information by implementing decentralised metering. The energy consumption of the different equipment and appliances within buildings was beyond the scope of this study. Therefore, a

recommendation is made to source consumption data from the different utilities, especially in for energy-intensive equipment. Another critical factor to consider is the automation of lighting and other related equipment/appliances and the deployment of energy regulating devices in replacement of old equipment and refurbishment of buildings. Situational factors which are the physical factors that are conducive to intended behaviour will always be an issue when measuring long term energy performance of buildings.

Another recommendation is in the quality of information and the communication thereof. Lessons from the study further emphasised that the dissemination of feedback information should be easily understandable and instantaneous. In this regard, visualisation tools can be deployed to ensure instant data availability and easy access. Stuart et al. (2016) assert that visualisation of energy consumption data over time facilitates engagement with building occupants, who are more suitable to solve energy-efficiency problems within their domain effectively and efficiently. The results from the open-ended responses suggested the following as the highest priority for energy efficiency, replacement of equipment with energy-efficient ones, structured communication, awareness, energy policy and feedback in that particular order. It is quite clear that these initiatives can be more effectively informed by the information analysed from the metering system for evidence-based decision making.

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7. Appendices

Appendix A: Questionnaire items per variable (TPB)

Wits University is committed to having Environmentally Sustainable campuses and working toward the philosophy of "Green" campuses. As a key stakeholder, your opinion is important to Wits University. The Senior Executive Team has been working with the Global Change Institute (GCI) to develop a University Sustainability Strategy; thus, the survey aims to solicit your views, opinions and perceptions on sustainable issues. Please assist us in our goal of making Wits more sustainable and take 10 minutes to complete this survey. N.B, there are no right or wrong answers.

All answers will be held in confidence; all data will only be presented in aggregate form. Your assistance in 'greening' our campuses is highly appreciated. Please answer the following questions as accurately as possible.

Section A: Energy efficiency and consumption in the workplace

1. Please indicate the extent of your agreement with the following statements.

	Strongly agree	Agree	Disagree	Strongly disagree	I do not know/Not applicable
I think turning off computers/monitors when leaving the office for the day is important	☐	☐	☐	☐	☐
I think turning off lights when they are not being used is important	☐	☐	☐	☐	☐
I think turning off the power switches on the wall when leaving the office for the day is important	☐	☐	☐	☐	☐
I think turning off the air-conditioner/heater off if leaving the room for more than 20 minutes is important	☐	☐	☐	☐	☐
I think encouraging my co-workers to save electricity is important	☐	☐	☐	☐	☐
Electronic items consume a lot of energy during their operation	☐	☐	☐	☐	☐
Electronic items still use energy during their stand-by mode	☐	☐	☐	☐	☐
My colleagues always turn off the lights at the end of the day	☐	☐	☐	☐	☐
My colleagues always turn off their computer/monitor at the end of the day	☐	☐	☐	☐	☐
My colleagues always turn off other office/lab equipment	☐	☐	☐	☐	☐

	Strongly agree	Agree	Disagree	Strongly disagree	I do not know/Not applicable
I am able to maintain an environmentally friendly place to work	☐	☐	☐	☐	☐
I have control over the amount of energy I personally use at work	☐	☐	☐	☐	☐
The University has control over the amount of energy that is used at work	☐	☐	☐	☐	☐
Saving energy takes too much time	☐	☐	☐	☐	☐
I would be more likely to save energy in the office if there was more information about energy consumption (such as dashboards or information screens)	☐	☐	☐	☐	☐
I would be more likely to save energy in the office if I was more aware of the benefits of saving energy	☐	☐	☐	☐	☐
The University provides enough information about energy consumption of my office/building/department	☐	☐	☐	☐	☐
Together we can reduce the University's energy use.	☐	☐	☐	☐	☐
By changing our behaviour, employees like me can reduce the University's energy use	☐	☐	☐	☐	☐
For the next three months, I intend to save more energy by always turning off my computer/monitor	☐	☐	☐	☐	☐
For the next three months, I intend to save more energy by always turning off lights when I leave my office	☐	☐	☐	☐	☐
For the next three months, I intend to save more energy by always turning off office/any electric appliances when I don't need to use them	☐	☐	☐	☐	☐

2. How do you think your colleagues in your building/department would react if:

	Strongly approve	Approve	Disapprove	Strongly disapprove	I do not know/Not applicable
they saw a monitor/computer left on	☐	☐	☐	☐	☐
they saw lights left on	☐	☐	☐	☐	☐
they saw any other office/lab equipment left on	☐	☐	☐	☐	☐

Section B: (Participants Profile)

Please fill in the following information for statistical purposes:

3. Campus of affiliation:

☐ Braamfontein East Campus ☐ Braamfontein West Campus

☐ Parktown Education Campus ☐ Parktown Health Sciences Campus
☐ Parktown Management Campus

4. Which building is your office located at: (list of buildings to be provided)

☐ Solomon Mahlangu House ☐ Biology Building
☐ Umthombo Building ☐ Other

5. Do you remember receiving an email with information about energy efficiency from Wits communication in the last 6 to 12 months?

☐ Yes | ☐ No

6. If yes, did you read the contents of the email?

☐ Yes, I read all or nearly all of it | ☐ Yes, I read some of it | ☐ No, I did not read them

7. Did you notice the information on energy usage displayed on the monitors installed in your building?

☐ Yes | ☐ No

8. If yes, did you engage with the graphs/information displayed?

☐ Yes, I read all or nearly all of it | ☐ Yes, I read some of it | ☐ No, I did not read them

9. What is your staff category?

☐ Academic | ☐ Professional and Support

10. What is your gender?

☐ Female | ☐ Male

11. Ethnicity?

☐ Black ☐ Coloured ☐ Indian
☐ White ☐ Chinese ☐ Other

12. Age group?

☐ 18 – 29 ☐ 30 – 44 ☐ 45 – 59
☐ 60+

13. Designation?

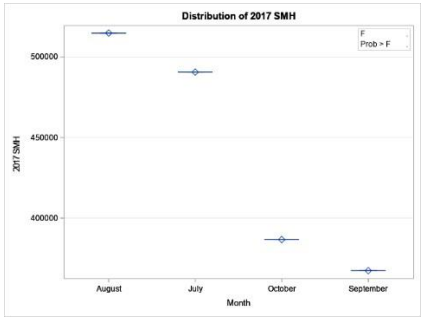
☐ Executive Management/Director ☐ Head of Unit/Department/School ☐ Technical Staff
☐ Professional Staff ☐ Administrative Staff

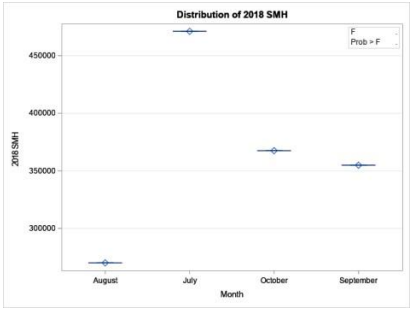
14. What do you think are the main barriers to energy efficiency within Wits University?

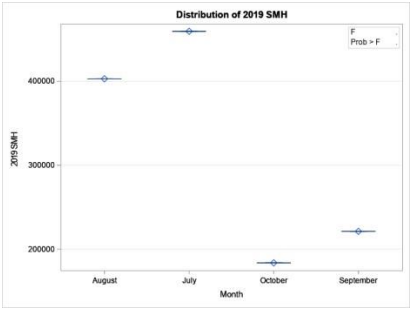
15. Please list two highest priority actions that Wits University can undertake immediately to make its campuses more energy efficient.

Appendix B: Scatter plots for electricity usage per building 2017 – 2019

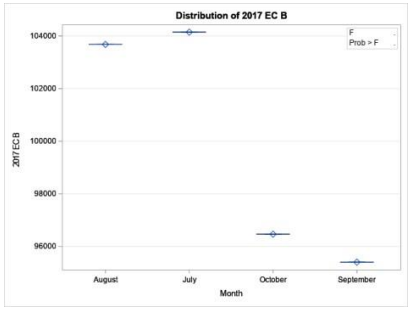
Solomon Mahlangu House

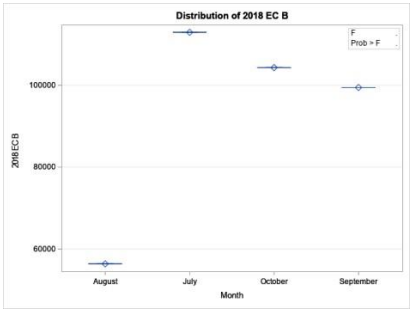


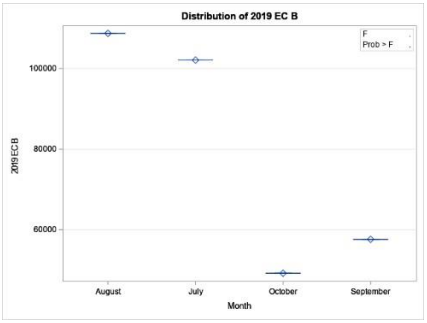




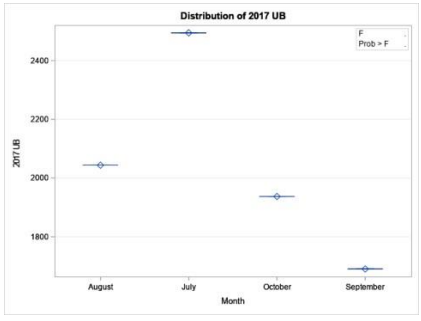
Biology Building

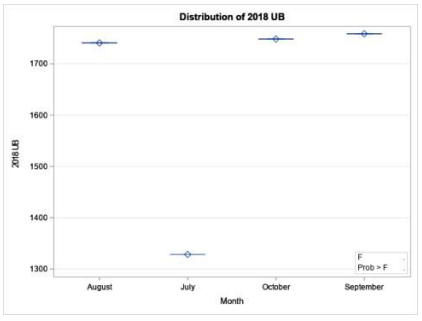


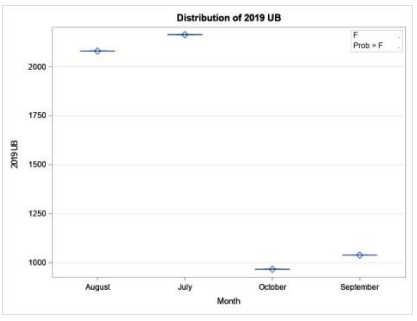




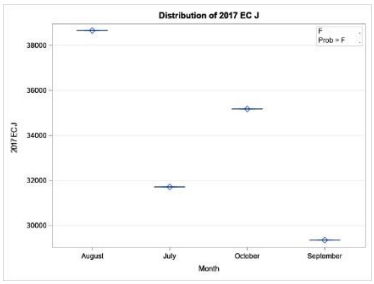
Umthombo Building

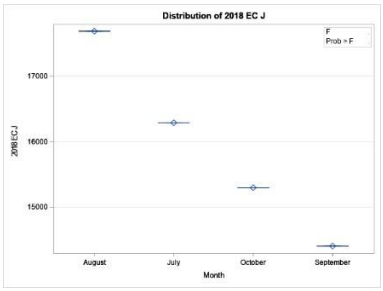


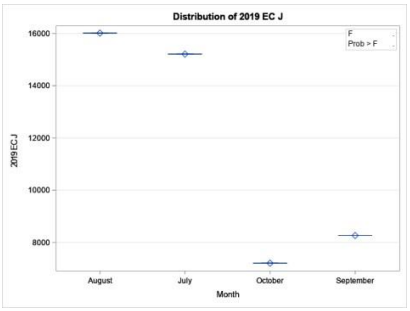




Jubilee Hall Residence


Distribution of 2017 EC J
F
Prob > F
38000
36000
34000
32000
30000
2017 EC J
August
July
October
September
Month


Distribution of 2018 EC J
F
Prob > F
17000
16000
15000
2018 EC J
August
July
October
September
Month


Distribution of 2019 EC J
F
Prob > F
16000
14000
12000
10000
8000
2019 EC J
August
July
October
September
Month