BELIEF AND ACTUAL BEHAVIOUR IN GREEN INFORMATION TECHNOLOGY WITHIN A SOUTH AFRICAN TERTIARY INSTITUTION

by

TAWANDA BLESSING CHIYANGWA

submitted in accordance with the requirements for the degree of

MASTER OF SCIENCE

in the subject

COMPUTER SCIENCE

at the

UNIVERSITY OF SOUTH AFRICA

SUPERVISOR: MRS TERTIA HÖRNE

CO-SUPERVISOR: MR TOBIE VAN DYK

February 2014

Student number: **499-184-94**

I declare that BELIEF AND ACTUAL BEHAVIOUR IN GREEN INFORMATION TECHNOLOGY WITHIN A SOUTH AFRICAN TERTIARY INSTITUTION is my own work and that all the sources that I have used or quoted have been indicated and acknowledged by means of complete references.

_____ _____

SIGNATURE DATE

(Mr T B CHIYANGWA)

Abstract

Most research in green IT tend to focus on the practices of large IT vendors and companies. There is therefore a need to examine the beliefs and actual behaviour of IT users about green IT, as it significantly impact of energy consumption and computer design on the broader society. The main question to be answered was “Are IT users generally concerned with regards to green IT issues?”. Therefore the main purpose of this study was thus to evaluate the beliefs and actual behaviour of IT users regarding green IT in South Africa through a survey that was completed by university students and lecturers. The paucity of available research on this subject pertaining to South Africa justifies the importance of conducting this study. A hypothesised research model based on the theory of planned behaviour (TPB) was used to evaluate the main factors contributing to green IT awareness in an empirical study. A mixed research method was used as the paradigm which combines aspects from both interpretive and positivist research approaches. A questionnaire was used to collect data from university students and lecturers. The data was captured and analysed for convergent validity. The reliability of measurement items was tested using Cronbach’s alpha. Structural Equation Modelling was used to model latent variables under conditions of non-normality. Subjective norm was the main factor contributing to intended belief and actual behaviour.

Keywords

Environmental Sustainability, Green IT, Green Computing, Theory of Reasoned Action, Theory of Planned Behaviour, Recycling, Electronic Waste, Management of Energy Consumption

Acknowledgements

I wish to thank the following people and institutions for their support:

- My supervisor, Mrs Tertia Hörne (University of South Africa), for her strong leadership and advice, my and co-supervisor, Mr Tobie van Dyk (University of South Africa), for his committed support and advice. I acknowledge their unwavering support and encouragement, and their professional and academic guidance during the development, writing, proof reading and compilation of the dissertation.
- All the participants who took part in the survey.
- Professor P J Becker, for his dedications, support and encouragement, evaluating statistical analysis and constructive criticism.
- My father, David Dzvakakuyambwa and my mother, Rugare Takawira, for their encouragement.
- My sister Mrs Beatrice Chiyangwa and her husband, Mr Joseph Chisasa for helping me develop research skills.
- Mrs Yvonne Pawlowski, for editing the entire dissertation.
- University of South Africa, for allowing me to do research for Master of Science in Computing.
- Tshwane University of Technology, for allowing me to use their students and staff D

Table of Contents

List of Figures

List of Tables

List of acronyms

TRA	Theory of Reasoned Action
TPB	Theory of Panned Behaviour
IT	Information Technology
TUT	Tshwane University of Technology
UNISA	University of South Africa
CRT	Cathode Ray Tube
USA	United States of America
EPA	Environmental Protection Agency
SA	South Africa
PBC	Perceived behavioural control
SN	Subjective norm
ROI	Return On Investment
TBL	Triple Bottom Line
DOE	Department Of Energy
LCD	Liquid Crystal Display
LEDs	Light Emitting Diodes
UK	United Kingdom
ICT	Information and Communication Technology
HP	Hewlett Packard
ROHS	Restriction Of Hazardous Substances
PDAs	Personal Digital Assistants
PCs	Personal Computers
LAN	Local Area Network
IBM	International Business Machines
EPEAT	Electronic Product Environmental Assessment Tool
CPU	Central Processing Unit
TV	Television
OS	Operating System
IS	Information Systems
CD/DVD	Compact Disc / Digital Versatile Disc
HK	Hong Kong
ANOVA	Analysis of Variance
CFA	Confirmatory Factor Analysis
EFA	Exploratory Factor Analysis

KMO	Kaiser-Meyer-Olkin
SD	Standard Deviation
VIF	Variance Inflation Factor
SEM	Structural Equation Modelling
DF	Degree of Freedom
ML	Maximum Likelihood
NPAR	Number of Parameters
RMR	Root Mean Square
GFI	Goodness of Fit Index
AGFI	Adjusted Goodness of Fit Index
PGFI	Parsimony Goodness of Fit Index
NFI	Normed Fit Index
CFI	Comparative Fit Index
IFI	Incremental Fit Index
TLI	Tucker Lewis Index
NNFI	Non-Normed Fit Index
PRATIO	Parsimony Ratio
CFI	Comparative fit index
PCFI	Parsimony Comparative Fit index
PNFI	Parsimony Normed Fit Index
RMSEA	Root Mean Square Error of Approximation
ATT	Attitude
INT	Intention
ACT	Actual Behaviour

Glossary

Cross-Sectional Study: A research study for which data is gathered just once (even though it may be stretched over a period of days, weeks, or months) to answer the research question.

Content Validity: An aspect of validity assessing the correspondence between the individual items and the concept through ratings by expert judges, and pre-tests with multiple sub-populations or other means.

Construct Reliability: An aspect of reliability measuring the internal consistency of a set of measures rather than the reliability of a single variable.

Construct Validity: An aspect of validity testing how well the results obtained from the use of the measure fit the theories around which the test was designed. In other words, construct validity testifies that the instrument did tap the concept as theorised.

Dependent Variable: A variable of primary interest to the study, also known as the criterion variable.

Independent Variable: A variable that influences the dependent or criterion variable and accounts for (or explains) its variance.

Information Technology: Computer technology, both hardware and software, for processing and storing information, as well as communication technology including networking and telecommunications for transmitting information.

Methods: The various means or techniques or procedures used to gather and analyses data related to some research question or hypothesis.

Methodology: The strategy, plan of action, process or design lying behind the choice and use of particular methods and linking the choice and use of methods to the desired outcomes.

Moderating variable: The moderator or the moderating variable is one that has a strong contingent effect on the independent variable and dependent variable relationship. That is, the presence of a third variable (the moderating variable) modifies the original relationship between the independent and the dependent variables.

Pilot Study: A study conducted to detect weaknesses in design and instrumentation, and to provide proxy data for selection.

Population: The entire group of people that the researcher wishes to investigate. In this research the population refers to IT students and lecturers at Tshwane University of Technology.

Pre-testing A trial run with a group of respondents for the purpose of detecting problems in the questionnaire instructions or design, and seeing whether the respondents have any difficulty understanding the questionnaire or whether there are any ambiguous or biased questions.

Questionnaire: A pre-formulated written set of questions which respondents answer, usually within rather closely defined alternatives.

Reliability: The extent to which research findings would be the same if the research were to be repeated at a later date, or with a different sample of subjects.

Sample: A sample is a subset of the population, comprising some members selected from the population.

Subjective Norm: The social pressure exerted on the person or the decision maker to perform the behaviour. It refers to an individual's perception about what other people think of their behaviour in question.

Theoretical framework: A collection of theories and models from the literature which underpins a positivistic research study. It is a conceptual model of how the researcher theories or makes logical sense of the relationships among the several factors that have been identified as important to the problem. The theoretical framework may be referred to as a conceptual framework or as the research model. These three terms are used interchangeably in this research.

Validity: The extent to which the data collected truly reflects the phenomenon being studied.

VMware: Is a virtualisation and cloud computing software provider for x86-compatible computers.

Salient: are facts about something or qualities of something are the most important things about them.

Chapter 1: Introduction

1.1 Background

Green IT is a well-known term in developed countries (Khan, Kumar and Razak, 2011:179). Green computing refers to the study and practices of using computer resources (hardware and software) more efficiently while maintaining their overall performance (Loeser *et al*., 2011:2; Lamb, 2009: XXIV; Chow and Chen, 2009:136; Harmon and Auseklis, 2009:1707; Murugesan, 2011:52). Information technology such as tablets, laptops, the internet, smart phones and data centres contribute significantly to the endangerment of a green environment (Lamb, 2009:XXIII). Information technology is an important and growing part of the environmental problem and not many people realise the seriousness of the problem (CNET Networks, 2007).

Information technology and the use of IT devices affect our environment in many different ways. Each stage of a computer's life, from its invention, production, use through to its finally disposal, has an environmental impact (see Figure 1.1). It is challenging to find optimal solutions to green IT issues since it concerns people, the planet as well as profit (i.e. the triple bottom line). Possible solutions may place the emphasis on energy consumption, recyclability of IT resources (software and hardware), return on investment (ROI) and end-user behaviour and beliefs (Chow and Chen, 2009:136).

The focus of green IT is on the environment, i.e. the economic and socially responsible use of hardware in an efficient and effective manner with no or minimal impact on the environment (Lane *et al.,* 2009:797; Murugesan, 2010:4). Moreover, IT users contribute to greenhouse emissions through electricity consumption. Students use computers, printers and IT resources daily. IT vendors and businesses mainly focus on a single business bottom line rather than a green triple bottom line (Lamb, 2009: XXIV). The triple bottom line concept is significant when it concerns anything environmentally green, and thus it is relevant in the case of green IT (Kabiraj et al., 2010:22). Moving data centres to locations where there are renewable energy resources resulting in a lower consumption of energy are currently the first phase that is being implemented by many researchers and companies (Kurp, 2008:11). For example, Facebook opened new data centres in Prineville and Oregon that use electrical distribution systems to reduce energy loss, avoid the need for a central uninterrupted power supply and remove components in the servers that are inefficient (Heilliger, 2011). An electrical distribution system reduces downtime and assists in troubleshooting power faults in the cabinets of data centres. The second phase involves recycling IT resources such as obsolete cathode ray tube (CRT) monitors, mouse pads and batteries and is already being implemented in many organisations (Williams and Curtis, 2008:12; Wilbanks, 2008:64). Up

to now most of the focus has been on IT vendors and business improvement in productivity, such as energy consumption and computer design sustainability.

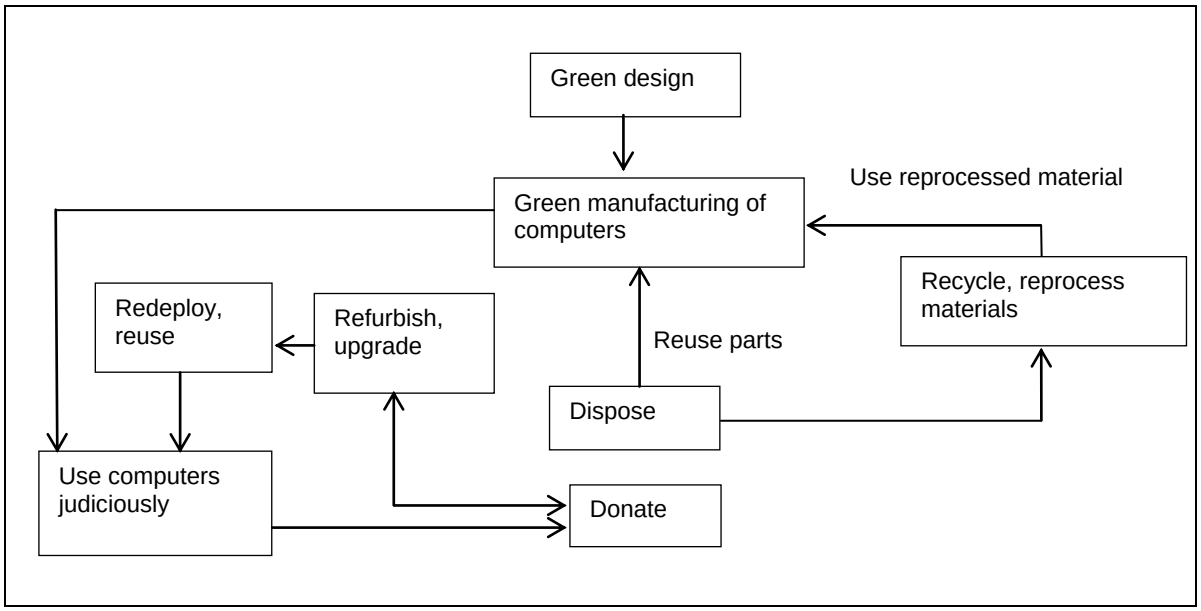
The importance of green computing and its conceptual origin is more than two decades old and originated in the United States of America (USA) guided by the Environmental Protection Agency (EPA). In 1991 the EPA in the USA introduced the Green Lights programme to promote energy efficient lighting (Harmon and Auseklis, 2009:1707). This was followed by the Energy Star programme in 1992, which established energy efficiency specifications for computers and other IT resources (Popescu *et al*., 2009:230). However, it has only been during the last decade that support for green IT has become widespread. Behaving in an environmentally responsible manner is vital to secure our future, otherwise our planet may no longer be able to sustain a viable environment for humans (Chow and Chen, 2009:136). Technology is to a large extent responsible for increased energy consumption, carbon dioxide emissions, landfill pollution and a loss of biodiversity (Petzer *et al.,* 2011:330). Moreover, the growing accumulation of greenhouse gases is affecting the world's climate and weather patterns, creating drought and subsequent famine in some countries and even leading to the destruction of infrastructure (Murugesan, 2008:25; Rana, 2010:46).

South Africa is still in the embryonic stage when it comes to implementing green IT. Corporations in South Africa are slow to consider environmental sustainability as a strategic issue (Petzer *et al.,* 2011:330). The country is also one of the largest emitters of carbon dioxide in Africa and is ranked in the top 20 in the world in this regard (Odhiambo, 2011:75). Most of South Africa's carbon footprint (about 47.6%) is produced by the electricity generation sector (Emissions, 2010:17). The electricity sector mainly relies on low-cost, fossil fuels-based electricity generation (Mwakasonda, 2007:2). It is well known that the use of fossil fuels leads to large-scale pollution problems in the environment. Moreover, there is already a high level of greenhouse-effect emission in SA which is expected to increase as the economy grows. The average temperature increase over the past 50 years has been at the rate of 0.2 degrees Celsius per year, largely as a result of human activity (Emissions, 2010:4). In addition, it is expected that the atmospheric concentration of gases could reach 550ppm of carbon dioxide and this figure might double by early 2035 (Emissions, 2010:4).

Green IT sustainability strongly depends on the individual beliefs and behaviour of users of IT resources (Chow and Chen, 2009:136). However, there is a lack of literature dedicated to the study and practice of IT users' beliefs and behaviour regarding green IT, such as the usage habits of IT resources by users (Chow and Chen, 2009:136). This study seeks to fill

the gap, by investigating these intended[1] beliefs and actual[2] behaviour regarding green IT at a South African university. The purpose of the study was therefore to evaluate IT users' beliefs and actual behaviour towards green IT at a specific SA tertiary education institution through a survey focusing on university students and staff as they are daily users of IT resources. A questionnaire was used to conduct the survey. A pilot study was conducted at Tshwane University of Technology and after a few amendments the final study was undertaken at the same university. Both the pilot and the final study targeted IT students and lecturers.

Figure 1.1 Green IT in a computer's entire lifecycle (Murugesan, 2008:27).



1.2 Research Problem

As the population increases, IT energy consumption also increases. The widespread use of IT resources such as smart phones and mobile computers means that computer power consumption is becoming an increasingly important topic. Moreover, the cost of energy is constantly rising and pollution, together with its side-effects, is also increasing and thus these issues require urgent attention.

Research in green IT focuses mostly on the practices of IT vendors and companies. There is thus a need to examine IT users' beliefs and actual behaviour about green IT, particularly regarding the effects of energy consumption and computer design within the broader society. The consumption of energy used by society is significant and energy reduction thus remains an actively discussed topic. Researchers, captains of industry and IT practitioners are eager to develop and implement solutions to implement green IT. This research aims to enable

[1] "Intended" is used to mean planned (designed or carried out according to plan).
[2] "Actual" is used to mean taking place in reality, not pretending or imitated.

them to take a significant step in making a positive contribution towards green IT. Note: All computer designers are by definition IT users.

1.3 Research Purpose

The purpose of this study is to evaluate the beliefs and actual behaviour of IT users regarding green IT at a tertiary institution within South Africa through a questionnaire, which is completed by university students and lecturers at the Tshwane University of Technology. A hypothesis research model based on the theory of planned behaviour (TPB) is used to determine the main factors contributing to green IT awareness in an empirical study.

1.4 Significance of the Study

There is a paucity of literature that answers the question, “Are IT users concerned with regards to green IT issues?”. This includes a lack of information regarding IT users at tertiary education institutions within the South African context. Chow and Chen (2009) have reported on some of the evidence studies conducted in Hong Kong. These studies were conducted outside South Africa and the results obtained may thus not be applicable to South Africa for the following two reasons: (1) Each country whether economically developed or not has different belief systems and behaviour. (2) Behaviour and beliefs change over time. The lack of available literature on this issue with regard to South Africa justifies the importance of conducting such a study. This current study thus focuses on South African university IT users.

Several benefits may accrue from this study. This study will enable researchers and practitioners to identify the most important factors of IT users’ beliefs and behaviour with regard to green IT. It may also provide an initial framework for educating IT users to behave in a sustainable manner regarding the environment, promote recyclability or biodegradability of products and factory waste, reduce the use of hazardous materials and maximise energy efficiency during the product’s lifetime. The study will expose the key issues that need to be considered when using IT resources to enable students and lecturers to optimise the ROI for ICT at universities and society at large.

1.5 Hypotheses

The research model was based on the theory of reasoned action (TRA) and the theory of planned behaviour (TPB) (Ajzen and Fishbein, 1980; 1975). It involved the following five decision variables:

- Attitude toward green IT (ATT)
- Subjective norm toward green IT (SN)
- Perceived behavioural control toward green IT (PBC)

- Intention to carry out green IT behaviour (INT)
- Actual green IT behaviour (ACT)

The following hypotheses model developed by Chow and Chen (2009:137) was used (see Figure 1.2):

H1: Attitude has an association with the intention to exercise green IT.

H2: Subjective norm has an association with the intention to exercise green IT.

H3: Perceived behavioural control has an association with the intention to exercise green IT.

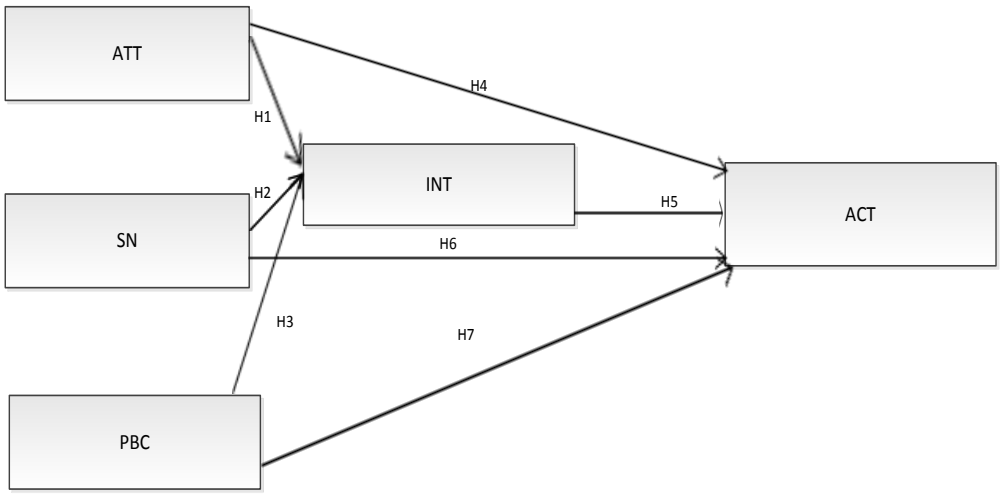
H4: Attitude has an association with actual green IT behaviour.

H5: Intention has an association with actual green IT behaviour.

H6: Subjective norm has an association with actual green IT behaviour.

H7: Perceived behavioural control has an association with actual green IT behaviour.

Figure 1.2: Research model for green computing (Chow and Chen, 2009:137)



1.6 General Objective

To determine the most significant factors associated with the (supporting or non-supporting) beliefs and (supporting or non-supporting) actual behaviour of IT users.

1.6.1 Specific objectives

- To promote the commitment of individuals to behave in a sustainable way to promote green IT
- To determine the main demographic factors that influence decision variables pertaining to green IT
- To identify the gap between literature trends and existing practices in green IT

- To determine whether the attitude of IT users has an association with the intention to exercise green IT
- To determine whether the subjective norm of IT users has an association with the intention to exercise green IT
- To determine whether perceived behavioural control of IT users has an association with the intention to exercise green IT
- To determine whether the attitude of IT users has an association with the actual green IT behaviour
- To determine whether intention of IT users has an association with the actual green IT behaviour
- To determine whether the subjective norm of IT users has an association with the actual green IT behaviour
- To determine whether perceived behavioural control of IT users has an association with the actual green IT behaviour

1.7 Research Questions

Below are the research questions that guided the current study.

1.7.1 Main Question

Are IT users concerned with regard to green IT issues?

1.7.2 Sub-Questions

- What is the main factor associated with the beliefs or intent of IT users to practise green IT?
- What is the main factor associated with IT users' actual behaviour to behave in ways consistent with green IT?
- Are the main factors associated with IT users' beliefs or intent and actual behaviour the same when practising green IT?

1.8 Research Design and Methodology

The research paradigm, sampling methods and data analysis are set out below.

1.8.1 Description of inquiry strategy and the broad research design

Research Paradigm

A mixed research method was used as this research paradigm combines aspects from both interpretive and positivist research approaches. The researcher made use of the interpretive research paradigm for the following reasons: Interpretive research relies on the assumption that knowledge of reality can be influenced by social constructs, including language,

consciousness and shared meaning (Klein and Myers, 1999:71; De Villiers, 2012:239; Walsham, 1995:376). On the other hand, the positivist view promotes the belief in the existence of a real world that can be measured objectively (Knox, 2004:121). Even though interpretivism is associated mainly with qualitative studies, the current research study also involved positivism which is mainly associated with quantitative studies (Hayes, 2000:6). An analysis and understanding of this type of data could thus be achieved through a positivist approach using statistical methods. Additionally, the main evaluation method used in the study involved questionnaires for students and lecturers focusing on the use of green IT. This necessitated some form of reliability and validity tests which are features of positivism (Golafshani, 2003:597).

Quantitative

According to Kolb (2008:28), a survey is the standard tool used when conducting quantitative or qualitative research. A survey is conducted using questionnaires. It is economical in terms of design and rapid data collection (Creswell, 2009:146). A questionnaire was thus used to collect data from university students and lecturers.

Empirical

The study empirically examined the beliefs and behaviour of IT users in green IT in South Africa by first conducting a pilot study. The pilot study enabled the researcher to test the nature of the questions so that modifications to the questions could be made if required (Randall and Gibson, 1990:465).

Causal

Research questions that imply causal research, have a cause and effect (Pearl, 2000:675), for example, “Will a new promotion campaign using a celebrity increase purchases of computer books among IT experts?” This study sought to identify the main factors of beliefs, behaviour and demographic issues on actual green IT behaviour and intended beliefs and to determine whether one factor contributed more than others.

Explanatory

The study is also explanatory since it focused on analysing the causal relationship (De Vaus, 2001:2) among factors of IT users’ beliefs or intent and behaviour and demographic factors of green IT to enable effective and efficient use of IT resources. The model of green IT was used to obtain findings.

1.8.2 Method of sampling

Sampling

The target population used in the research consisted of university students and lecturers at the Tshwane University of Technology. More specifically, daily IT users (Information Technology students and lecturers) comprised the sample. Purposive sampling was used for this university study as the power of purposive sampling lies in selecting information-rich cases for in-depth analyses related to the central issues being studied (Foster and Ford, 2003:327). Moreover, purposive sampling can be used for both quantitative and qualitative studies (Tongco, 2007:147). Only students enrolled in IT or computer science studies, and lecturers involved with such courses were sampled for the purpose of the study because it was felt that they were familiar with the educational environment and usually have more knowledge of computers than the average user.

Source of data

The data was collected from 345 students and lecturers at the Tshwane University of Technology (TUT). Primary data from the university was used in the analysis process. Open-ended questions and questions with a Likert-type scale were used in the questionnaire. The survey was cross-sectional whereby data was collected at one point in time, although a follow-up study was conducted after three months.

Data analysis

Descriptive statistics were applied to analyse the data and determine the significance of the model using SPSS software. The data was captured and analysed for validity based on convergent validity using a scale factor analysis (Hu *et al*., 1999:100). The convergent validity test measures items for convergence or divergence on the decision variables with factor loading having a fixed value. The reliability of measurement items is tested using Cronbach's alpha for decision variables (Hu *et al.*, 1999:100). Cronbach's alpha was thus used by the researcher to assess the internal consistency of the proposed decision variables (Hu *et al.*, 1999:100). An analysis of variance (ANOVA) was used to identify the effects of demographic factors on a decision variable. A structural equation modelling (SEM) test was used to model latent variables under conditions of non-normality with small to medium size samples (Chin, Marcolin and Newsted, 2003:25) using reflective constructs. Hierarchical regression analysis was used to determine the dominant factors of beliefs and behaviour (Chow and Chen, 2009:139).

1.9 Assumptions, Limitations and Delineations

This study aimed to extract appropriate and significant information from the data which was obtained from the survey. However, certain assumptions, limitations and delineations need to be mentioned. While the specifics will emerge in subsequent chapters of the dissertation, the relevant ones are listed below:

1.9.1 Assumptions:

The following assumptions were made:

- The questionnaires were statistically reliable. It was assumed that the data under study was a good representation of the complete dataset of the population of TUT under consideration.
- Where analysis of the results led to recommendations and general comments, it was assumed that the data under study was a good representation of the complete data of the population of TUT under consideration.
- It was assumed that participants had an adequate understanding of the English language and that the answers provided via the questionnaires were accurate representations of what the user wished to communicate.

1.9.2 Limitations:

The main limitations and constraints of this study are as follows:

- The study was restricted to a specific site, selected by well-defined criteria to establish (in the case of the quantitative study) a representative sample, i.e. TUT in this instance.
- There are many demographic variables that affect beliefs and behaviour but the research design was limited to the level of study, age, employment status and gender.
- Students and lecturers were given limited time to answer the questions.
- Questionnaire data was limited to 345 IT students and lecturers from Tshwane University of Technology in South Africa.

1.9.3 Delineations:

The following delineations are applicable:

- It was not the purpose of this study to examine the beliefs and behaviour of IT users for the whole of South Africa.
- The study did not examine the beliefs and behaviour of IT vendors and businesses.

1.10 Definition of Key Terms

Triple bottom line captures an expanded spectrum of values and criteria for measuring organisational and social phenomena - economic, ecological and social.

Return on investment (ROI) is a performance measure used to evaluate the efficiency of an investment or to compare the efficiency of a number of different investments. To calculate ROI, the benefit (return) of an investment is divided by the cost of the investment; the result is expressed as a percentage or a ratio (From www.investopedia.com).

Environmental Protection Agency is an independent federal agency in the USA created in 1970 that sets and enforces rules and standards to protect the environment and control pollution.

Energy Star is the product of a joint venture between the USA Environmental Protection Agency (EPA) and the USA Department of Energy (DOE). Ultimately, this partnership helps individual consumers and businesses save money and protect the environment through energy-efficient products and practices.

A data centre is a facility used to house computer systems and huge databases with the associated components, such as telecommunications and storage systems. It generally includes redundant or backup power supplies, redundant data communications connections, environmental controls (e.g. air conditioning, fire suppression) and security devices.

1.11 Layout of the Dissertation

Chapter 1 - Introduction and Overview: Outlines the background of the main field of study in this dissertation. A brief introduction is given, including background and motivation of the study. The research problem is defined and the approach used to understand the proposed problem is explained. Next, the hypotheses, the research questions and the study objectives are given.

Chapter 2 - Literature Review: A comprehensive literature study is provided. Aspects covered in the literature review include definitions of key concepts of green IT, the use of renewable resources in data centres, recycling of IT resources, IT user-centred green IT practices including improvement in productivity focusing on energy consumption and computer design sustainability.

Chapter 3 - Theoretical Framework: The Research model and hypotheses are comprehensively discussed in terms of the theory of planned behaviour, theory of reasoned action and hypotheses used in the research.

Chapter 4 - Research Design and Methodology: The data collection, data presentation and data analysis procedures are described. It also covers questionnaire construction and assumptions, delineations and limitations of the study.

Chapter 5 - Data Analysis: This chapter focuses on the interpretation of the data. It discusses the research results with regard to the research questions and hypotheses. Findings supporting the literature review and theoretical framework are discussed and related to the literature review and theoretical framework. This includes a discussion based

on the significant factors that IT users believe are essential in green IT. This data analysis will enable green computing researchers and practitioners to gain a better understanding of IT users' beliefs and behaviour.

Chapter 6 - Conclusion and Future Research: The findings from the research are summarised and conclusions are drawn. The contribution of the study is explained followed by a brief discussion of the limitations of the study. Finally, suggestions for future research are made.

1.12 Summary

This chapter provides the background to the research and describes its importance. In the following chapter a literature review is presented which will sketch the necessary theoretical background for this study and examine the practice of green IT review in general.

Chapter 2: Literature Review

2.1 Introduction

Green IT is the study and systematic application of practices for using computer resources more efficiently while maintaining their overall performance (Loeser *et al*., 2011:2). A great deal of relevant research has been carried out in green IT, however, there has not been much research on green IT from the user's perspective. Green computing is important because of the role it plays in protecting the environment. Some green IT research has been conducted in countries such as Hong Kong relating to the behaviour of IT users. This gave the researcher the incentive to conduct research in green IT focusing on South African IT users and comparing the results with research done by Chow and Chen in Hong Kong (Chow and Chen, 2009).

This research study will examine the behaviour of university students and lecturers since they are frequent and daily users of IT resources. In the following sections the available literature is reviewed with regard to the situation in South Africa in terms of recycling and e-waste, the importance of green IT, an international scenario in recycling and electronic waste, methods for managing power consumption, telecommuting, virtualisation, data centres, designing green computers and power usage of CRT, LCD and LED displays.

2.2 The importance of Green IT

The concept of green computing originated almost two decades ago in the Environmental Protection Agency (EPA). In 1991 the EPA in the United States of America (USA) introduced the Green Lights programme to promote energy-efficient lighting (Harmon and Auseklis, 2009:1707). This was followed by the Energy Star programme in 1992, which established energy efficiency specifications for computers and other IT resources (Popescu, et.al., 2009:230). However, it is only during the last decade that green IT has become more prominent.

2.3 Environmental Impact

Information technology is increasingly viewed as having an important and growing impact on the environment, something that few people take note of (Espiner, 2007). The growing accumulation of greenhouse gases is affecting the world’s climate and weather patterns, creating droughts and subsequent famines in some countries and even leading to the destruction of infrastructure (Murugesan, 2008:25; Murugesan, 2010:4; Rana, 2010:46; Agarwal and Nath, 2011:688). The air we breathe, the water we drink, the food we eat and the soil on which we grow our food is contaminated with toxins that affect all living organisms (Rana, 2010:46; Kalogirou, nd). For example, people dispose of batteries but those batteries

release dangerous chemicals such as cadmium into the environment. The presence of cadmium and lead in the environment causes diseases such as lung cancer and damage to the kidneys and liver, and thus IT users need to be educated in this respect (Environmental Protection Agency, 2012; Rana, 2010:46; Dutta *et al.,* 2006:147).

High electricity consumption is one of the main causes of changes in weather patterns because the coal or oil that is used in the production of electricity pollutes the environment. These can cause asthma, acid rain, smog and global weather changes (Murugesan, 2008:25). Developed countries such as the USA and UK have a major task ahead in this regard. They have permitted large amounts of greenhouse emissions into the environment over the past 10 years (Sobotta *et al*., 2010:21). At the same time developing countries such as SA are still constructing plants that use coal, which are known to add to the high level of greenhouse gas emissions into the environment. In order to comply with international regulations to stabilise waste releases by 2020, developed countries need to reduce their emission of greenhouse gases considerably. Industrialised countries need to decrease their pollution by 25-40% prior to 2020 and developing countries must decrease their pollution by 10-30% (Sobotta *et al*., 2010:21).

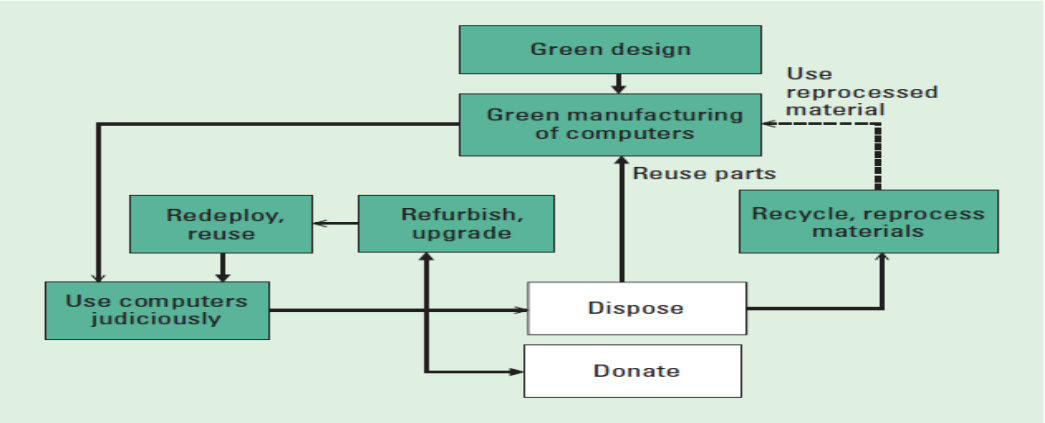
It is a little-known fact that ICT has a serious effect on biodiversity, for instance the East Lowland gorilla populations in the Democratic Republic of Congo have been nearly wiped out as their surroundings have been cleared to mine columbite and tantalite, a vital component in smart phones (Costanzo, 2006:15780). Various strategies thus need to be put in place to reduce the high rate of energy consumption. For instance, a renewable source of material for cell phone manufacturing needs to be found, as well as a renewable source of energy for data centres to ensure that further degradation of the environment is avoided.

2.3.1 International Scenario in Recycling and Electronic Waste

Recycling of organisational IT resources and electronic waste such as obsolete cathode ray tube (CRT) monitors and batteries is important (Williams and Curtis, 2008:12; Wilbanks, 2008:64). It is not always good practice, for example, for organisations to replace their old printers, mouse pads, batteries and monitors with new electronic devices which are energy efficient in an attempt to become more environmentally friendly. Wang (2008; as citied by Williams and Curtis, 2008) argues that this exercise might not at all times be the best ecological solution possible. Wang suggests that we look at the complete life cycle of an electronic device, i.e. take the whole picture of day-to-day business into consideration (see Figure 2.1). Murugesan (2010:4) supports the argument by stating that people need to change or discontinue several of their current habits. Furthermore, purchasing a new, more efficient electronic device might not always be the best solution (Kurp, 2008:13). Several

electronic producers are following a life-cycle point of view thereby creating an option of purchasing an original and energy-efficient electronic device (Kurp, 2008:13). In principle, purchasing new electronic, more energy-efficient devices are the way to go, but we must also look at ways of reusing parts of old electronic devices and dump used components at appropriate sites. By educating and training users in this regard, we can change their behaviour and beliefs, thus leading to more sustainable IT usage.

Figure 2.1 Greening a computer's entire lifecycle (Murugesan, 2008:27)



Organisations and business are following international standards, but more research needs be done to find alternative substances. Dell is speeding up its projects to reduce the use of hazardous materials in its electronic devices, and its original OptiPlex desktops are 50% more energy-efficient than a similar desktop produced in 2005 (Kurp, 2008:13). Moreover, new energy-efficient processors are being developed. Hewlett Packard (HP) publicised what it terms *"the greenest electronic device ever*", the HP rp5700 desktop personal computer (Kurp, 2008:13). The HP rp5700 surpasses U.S. Energy Star 4.0 standards, and has an accepted life span of at least five years; 90% of its materials are biodegradable and it meets the European Union's RoHS standards for the limitation of the usage of dangerous materials in electronic equipment. Furthermore, 25% of the HP rp5700's components are manufactured using biodegradable substances (Kurp, 2008:13).

Dell has launched a project where they recycle laptops and smart phones irrespective of the manufacturer (Murugesan, 2008:27). When a user visits the Dell website and fills out a form, a Dell agent will come and collect the old laptops or printers. According to Murugesan (2008) HP recycles any producer's electronic devices for a price ranging from $40 to $120. Moreover, HP has also put in place battery-recycling schemes for numerous computer products. Gateway pays for old electronic devices on producing evidence of the purchase of a new Gateway machine (Murugesan, 2008:27). Thus organisations such as these are taking important steps to reduce electronic waste. However, the problem of electronic waste

is not restricted to laptops only. PCs, batteries, PDAs and mobile phones all pose challenges to the environment. Several municipalities, government organisations and drug suppliers provide battery-recycling facilities. However, in some cases, industries and organisations still dump computer products in landfills mainly due to ignorance on their part. The representatives of Dell and HP could make an important contribution by visiting developing countries to educate users about the importance of recycling and how this can be achieved.

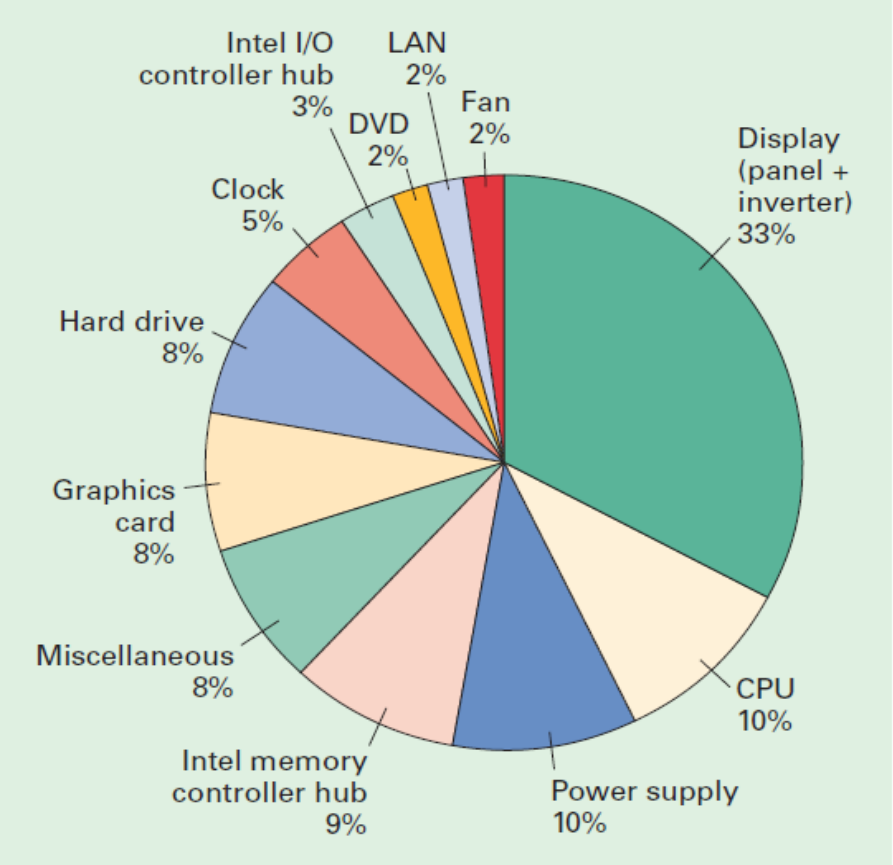
Table 2.1: List of companies that recycle e-waste (Sarrel, 2006)

Manufacturers	**Service Providers**	**Retailers**
Apple	Cellular One	Best Buy
Canon	Ingram Micro	Office Depot
Dell	RIM (Blackerry)	Staples
Epson	Sprint / Nextel	
Gateway	T-Mobile	
Hewlett-Packard	Verizon Wireless	
IBM		
Intel		
Lexmark		

Power management has always been a significant priority for laptop producers, as they strive to control weight versus battery life issues as shown in figure 2.2. Powerful laptops, tablets, desktop computers and smart phones with high definition video monitors require more costly battery technology to acquire a balance between the weight and the battery life (Williams and Curtis, 2008:14). Longer battery life always comes with a price, i.e. heavier batteries or more expensive battery technologies for every additional minute of battery life. High quality video displays and a cheaper battery come at the cost of a lower performance machine. Even if the weight or price is reduced, energy-starving devices could waste energy (Williams and Curtis, 2008:14). An algorithm for balancing battery life, performance and the cost price of laptops which are affordable and energy-efficient should be designed to decrease the impact on the environment. The architecture of laptops could also be redesigned to be in line with the rapid development of technology.

Electronic waste poses a dilemma which is increasing around the globe. Generally, when the public thinks of toxic waste, they do not think of computers and smart phones. As new smart technology is flooding the market place, the removal of obsolete computer equipment is rapidly becoming a serious ecological issue (Berthon *et al*., 2010). Electronic devices such as monitors and motherboards contain poisonous substances and end up in landfills when, in many instances, they could have been recycled (Berthon *et al*., 2010).

Figure 2.2: Power consumption in a standard laptop (Agarwal and Nath, 2011)



Recycling computing devices can keep dangerous substances such as lead, cadmium, chromium and mercury out of landfills (Agarwal and Nath, 2011:692). Moreover, the manufacturing of electronic devices also utilises energy, chemicals and water, and produces dangerous waste, leaking mercury and lead into the soil (Murugesan, 2010:4; Kaestner, 2009:19). Electronic equipment misuse is rising worldwide as millions of computers are disposed into landfills (Agarwal and Nath, 2011:691). According to Murugesan (2010), two-thirds of the approximately 870 million PCs produced internationally in the next five years will end up in landfills (Murugesan, 2008:30).

Some 20 to 50 million tons of electronic waste are produced each year, the majority of which ends up in developing countries (Serial, 2006). These numbers will keep on increasing unless organisations and society put into place more efficient technologies and tough recycling policies in order to reduce toxic waste (Kaestner, 2009:19).

The growth in the number of computers and mobile devices, and their replacement, is a formula for a major environmental disaster (Murugesan, 2010:4). Well-manufactured devices would last longer than cheaper but more fragile devices that have a shorter life span. Unfortunately, the majority of the public, as well as some IT experts, are not aware that an

electronic device with a longer life span is more environmentally friendly (Murugesan, 2010:4). Moreover, computer devices that have a longer lifespan than expected can be donated to educational institutions and non-profitable organisations. Various old computers and other hardware devices which contain toxic material are usually disposed of within two to three years after being purchased, and end up in landfills, spoiling the environment and polluting water systems (Murugesan, 2008:30). The recycling regulations exist in only a few countries, e.g. Australia and New Zealand (Lane *et al*., 2009:796). Numerous organisations enforce minimum system requirements for donating devices and penalise organisations responsible for emissions into the environment (Lane *et al*., 2009:796). Furthermore, parts of obsolete systems might be retrieved and recycled through private recycling businesses (Agarwal and Nath, 2011:692; Murugesan, 2010:4). One way of reducing electronic waste is to re-use some of the components of an old computer when upgrading (Agarwal and Nath, 2011:691).

In this section the recycling of organisational IT resources and electronic waste such as obsolete cathode ray tubes (CRTs) monitors, mouse pads and batteries has been discussed. Purchasing new electronic devices is encouraged, but few people re-use parts of old electronic devices or dump used components at an appropriate site. Green IT practices can be achieved through educating and training the public in general, as well as employees in IT organisations which will help to change their behaviour and beliefs. Organisations and business often adhere to international standards, but more research needs to be done on strategies for educating them regarding the use of renewable sources of energy. It is thus important that the behaviour and beliefs of IT users are considered in order to make users more aware of sustainable IT resources that are not harmful to the environment. In addition, governmental and organisational recycling initiatives can assist in reducing carbon dioxide emissions and waste products in corporate South Africa by implementing appropriate policies and regulations.

In the next section user-centred green IT practices, virtualisation, data centres and computer design sustainability are discussed.

2.3.2 Computer design sustainability

Designing green computers

Green IT design intends to reduce the ecological impact of electronic devices such as personal computers and tablets by adapting to recent technologies and implementing the latest methods and devices while balancing ecological compatibility with financial performance and viability. Green design is rapidly turning into a key industry due to the need

for more ecologically-friendly solutions. The majority of electronic IT industries is now trying to create green electronic devices using nontoxic substances that utilise less electricity and are easy to recycle. Highly upgradable current electronic devices such as PCs and smart phones have a long useful lifespan (Agarwal and Nath, 2011:689). The shift from single core to multiple core processors is leading to a conservation of energy while at the same time escalating processing performance (Vajda, 2011). In the past, the performance of microchips was improved by raising the frequency of the microprocessor's clock, leading to increased heat production and energy use. According to Murugesan (2008:31), a 15% drop in frequency could conserve up to 50% energy.

Initiatives, such as separating the cache memory into sectors that are only power-driven when necessary and navigating to a 45 manometer design, also reduces energy use (Murugesan, 2008:31). Producers are also using power-driven reduction methods in tablets and laptops, for instance screens that lighten the display palette as well as darken the backlight, flash memory caches for hard disks and enterprise servers. It is thus important to convey the latest developments to the public so that they can make use of the green products that are available. With increased knowledge, behaviour and beliefs can change and thus aid in building a more sustainable and ecologically-friendly environment, which includes the IT environment.

The IT industry is investing a great deal of capital into green programmes, for instance by introducing power-efficient and effective server warehouses, innovative electronic equipment and design alternatives. Currently, companies such as Dell and Apple are developing ecological solutions to ensure a longer, and thus greener, lifespan of their electronic devices and smart phones. Companies such as Dell are putting into place a zero carbon initiative by fully using the energy efficiency of Dell commodities, and reducing their carbon footprint (Murugesan, 2008:31). Suppliers are now also required to report their carbon footprint emissions (Muyot, 2010). IBM, Apple and HP announced that they would reduce or abolish toxic components in their new electronic devices (Muyot, 2010). Organisations are initiating innovative equipment, standards, and electronic device registration to assist clients to select the most appropriate ecological features of tablets, smart phones, notebooks, and other electronic devices. Energy Star 4.0 Standards, Electronic Product Environmental Assessment Tool (Epeat), and the Restriction of Hazardous Substances (RoHS) Directive are just a few of the regulations and tools that are aimed at reducing the ecological impact of the new technology.

Power usage CRT, LCD and LED displays

Light emitting diode (LED) and liquid crystal display (LCD) monitors are far more power efficient than the old cathode ray tube (CRT) monitors (Lane *et al*., 2009:798). Some of the latest monitors make use of a group of LEDs in place of the fluorescent bulb, which reduces the amount of electricity used by the LCD display. LCD monitors use three times less energy than CRTs when active, and ten times less power when in sleep mode. For instance, by comparison, a 17" CRT monitor typically consumes 66-90 Watts while a 17" LCD typically consumes 35 Watts of power (Lane *et al*., 2009:798). LCDs are 66% more energy efficient than CRTs. The most recent LCD monitors consume 40-60 Watts maximum in a modest 19", 20", or 22" unit (Shaik, 2012:653). That figure increases to 85 W or 100 W maximum for a 24" unit. It is thus good practice to put monitors into standby mode or turn them off completely when not using them in order to reduce power consumption. According to Petzer *et al.* (2011), even though there are important issues such as cost reduction and sustainability rewards involved in the use of LCD and LED monitors, only three out of seven businesses attempt to replace their CRT monitors with LED or LCD monitors (Petzer *et al.*, 2011:332). Moreover, the majority of contributors confirmed they no longer bought CRT monitors, but replaced them with LED and LCDs when the old monitor becomes malfunctional (Petzer *et al*., 2011:332).

It is thus clear that the public needs to be educated about the benefits of using LED and LCD instead of CRT monitors and to be made aware of the configurations as this is fairly novel technology being introduced into the market. Organic light emitting diodes represent the latest technological developments. LCDs and LEDs consume less energy and are more portable compared to CRT monitors. Furthermore, LCD and LED material have less effect on the pollution of the environment. Therefore, there is a need to develop material to further reduce the energy consumption of IT resources.

2.4 Virtualisation and Data Centres

2.4.1 Virtualisation

According to Gartner (2012), half of the data centres in the world have insufficient energy to meet the demands of its optimum usage. Gartner estimates that this will increase to 60% by the year 2020 taking into account the current rate of the consumption of energy by data centres (Gartner, 2012). Gas emissions need to be dealt with before the deadline of 2020 set by the UN through the efficient and effective use of data centres (Sobotta et al., 2010:21). Virtualisation was acknowledged by Gartner as one of the ten tactical technologies for the year 2009 and years to come (Cearly, 2008). Virtualisation refers to the concept of IT

resource minimisation. Virtualisation permits several operating systems to run simultaneously on a number of virtual machines in a single physical computer, dynamically sharing and partitioning the available physical resources such as memory and central processing unit devices (VMware, 2007:2). The energy load of data centres can be reduced by the appropriate sizing of the computer resources through the dynamic management and consolidation of the computing energy rate (VMware, 2007:10). According to VMware (2007:13) data centre virtualisation is still in the embryonic stage of adoption which permits the following concepts:

- **Data centre consolidation**

Data centre virtualisation permits the consolidation of devices which consist of several different virtual servers running on one physical server. It can decrease the quantity of servers at a ratio of 15 to 1; reducing server sprawl and trimming costs (see Figure 2.3).

- **Reduction of energy utilisation**

Every virtualised data centre saves 7 000 kWh of electricity annually which amount to approximately five hundred euros in energy costs.

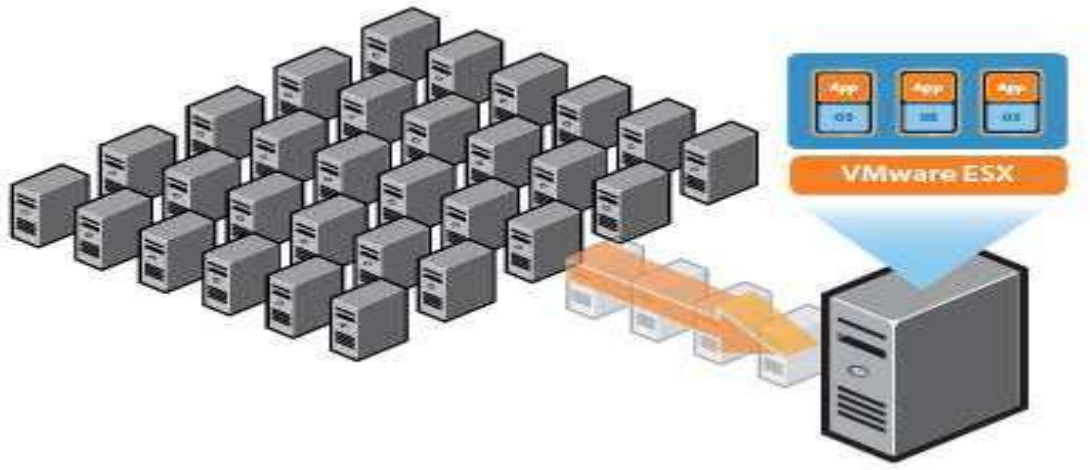
- **Raising the utilisation of IT devices**

The ratios of data centre utilisation have improved from 5-15% to 60-80%. Fewer data centres but increased utilisation of IT equipment free up power and space.

- **Reduction of of carbon dioxide emission**

There is a reduction of roughly four tons of carbon dioxide emission for the virtualisation of each data centre, which is equal to removing 1.5 cars off the street.

Figure 2.3: Server consolidation (VMware, 2009).



Virtualisation is already having a positive effect on the environment. According to the predictions of Gartner (Stevens, 2008), in 2007 one million workloads operating in VMware virtual equipment represent a cumulative energy savings of approximately 8 500 kWh.

Furthermore, OpenNebula is an open source option in the formation of a virtual technology that allows active operation and transfer of virtual equipment for a set of substantial resources (OpenNebula.org). OpenNebula broadens the paybacks of virtualisation platforms from a single physical device to a set of many, decoupling the data centre not only from the physical device, but also from its sizable location. Virtualisation is a better option than simply replacing old electronic devices with new ones. Hence the savings involved in virtualisation are substantial compared to each PC in use which produces about a ton of carbon dioxide every year. To illustrate this point, one respondent in Petzer's research mentioned that "they had reduced the total amount of servers from 74 to 13 over the past 10 years" (Petzer *et al.,* 2011:332).

Developing countries need to start incorporating virtualisation in order to support green IT and protect the environment. Training and education in this respect is thus urgently required so that virtualisation can be implemented.

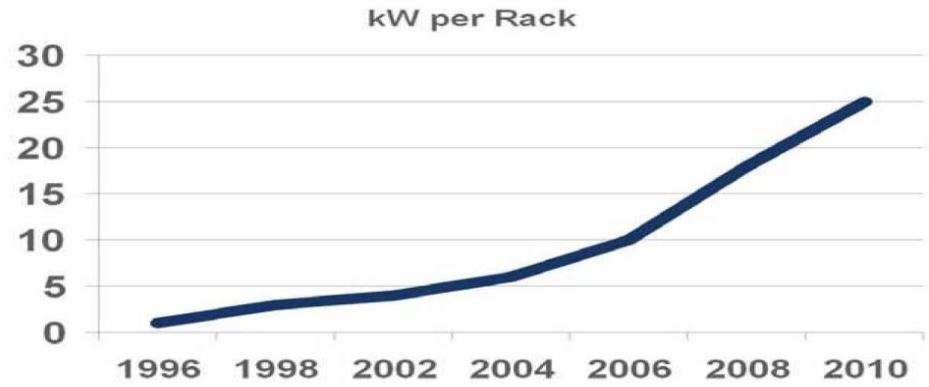
2.4.2 Data Centres

Data centres need to be moved to locations where there are renewable energy resources so that there is a minimum consumption of polluting energy (Kurp, 2008:11; Omer, 2012). For example, Facebook opened new data centres in Prineville and Oregon that use electrical distribution systems to reduce energy loss; this avoids the need for a central uninterrupted power supply, and components in the servers are removed that are inefficient (Heilliger, 2011). In addition, an electrical distribution system is used to reduce downtime and assist in dealing with power faults in the cabinets of data centres to reduce energy consumption (Heilliger, 2011). Clearly the utilisation of renewable energy has a great impact on the environment, even though the practical implementation is expensive and requires a great deal of investment, especially in developing countries.

The implementation of a green computing policy in an organisation can lead to a reduction in energy expenses as advanced technological methods are used (Sobotta *et al*., 2010:33). Energy consumption may be reduced through the efficient use of end user power management, more energy-efficient use of data centres, effective cooling management practices in servers, and virtualisation of data servers (Sobotta *et al*., 2010:29; Popescu *et al*., 2009:230). There are thus technological ways to implement changes to decrease carbon emissions and IT expenses by improving a server's operation and computing performance. The main task of a server is to manage the applications that are used by individual computers (Da Silva, 2009:31). There are a number of different ways to save server warehouse energy such as data centre consolidation, virtualisation and building data centre close to dams and rivers where the water temperature is low throughout the year to reduce

energy for cooling purposes (Sullivan, 2009). Muirhead (2006:32; as cited by Hogan, 2011) states that a reasonable sized data centre in a server warehouse of a huge economic services business has about the same annual carbon footprint as a gas-guzzling family SUV motor car reaching 15 miles per gallon. Moreover, more power is utilised per square meter in the server than in any other division of an office environment (Sullivan, 2009). Server warehouses continue to consume more and more energy (Da Silva, 2009:1) (see Figure 2.3). As the energy utilisation rises, so does the carbon trace produced by servers in kW per rack in the data centre.

Figure 2.4: Increase of energy consumption in data centres (VMware, 2009)



Recently the focal point in green IT has been on moving server warehouses. The SUVs of the tech world have been attacked for their abundant use of energy (Kurp, 2008:11). According to Curtis (2006; as citied by Kurp, 2008), roughly 6 000 server warehouses in the United States used about 61 billion kWh of energy in 2006 (Kurp, 2008:11). Furthermore, the total expense of that energy, i.e., $4.5 billion, was more than the expense of electricity consumed by all the colour televisions in the US in 2006. Server warehouses consumed 1.5% of all energy in the US in 2006 according to the report of the Department of Energy (DOE), and their energy rate demand is increasing by 12% per annum (Kurp, 2008:11). If the use of server warehouses increases, they will use more than 100 billion kWh of energy at a yearly charge of $7.4 billion by 2014 (Williams and Curtis, 2008). The USA central administration required the energy use of server warehouses to be reduced by at least 10% before 2014. It could not be established whether this target was met. Every sector in the IT industry specifically needs to participate in the reduction of the rate of the consumption of energy in order to ensure the sustainability of the environment.

David Scheffler, EMC's director of data centre operations and global infrastructure support, has pointed out that EMC is experiencing a yearly rise of around 70% in the number of the server warehouses (Pepper, 2008). It should also be noted that the carbon dioxide

emissions from server warehouses are close to those released by the steel plant industry and airline businesses (Sobotta *et al*., 2010:31).

Sobotta *et al*. (2010:150) also note that by 2020 the utilisation of power by server warehouses and the resultant greenhouse effect are likely to be greater than that of air transport. Furthermore, high server energy utilisation is not only due to the fact that they are switched on 24 hours a day, seven days a week, but they also produce a lot of heat and thus need huge cooling machines for the servers to continue functioning (Sullivan, 2009). In addition, server warehouses need to be more energy efficient and ecologically friendly. According to the Climate Group (2008:21; as citied by Sullivan, 2009), there will be an increase of servers in the world from 18 million to 122 million in 2020. As of 2006, the electricity utilisation used by servers and server warehouse in the United States was approximately 61 billion kWh (Sobotta *et al*., 2010:32). As the price of oil increases and continues to rise, the price linked with providing electricity to server warehouses will rise accordingly (Muirhead, 2006:32; as cited by Hogan, 2011).

In an endeavour to diminish electricity consumption and ultimately decrease carbon emissions, an IBM IT infrastructure supplier is using a huge collection of solar plates on the roof of the data centre for power efficiency (Sullivan, 2009). IBM has the operational knowledge to build affordable and more efficient solar cells, in addition to having several other solutions to ensure a sustainable form of green IT. The thousands of input and output server warehouses are power-driven in part by eleven acre solar plate roofs that produce 4.5 mega Watts of electricity (Sobotta *et al*., 2010:220). According to Muirhead (2006; as cited by Hogan, 2011), in 2005 the Climate Group found that 43 companies saved $11.6 billion by decreasing the effects of greenhouse gases and making use of energy-efficient techniques. Out of 43 companies, four companies (Bayer, BT, DuPont and Norske Canada) were able to reduce their greenhouse gas emissions by more than 60% while saving $4 billion in energy expenses (The Climate Group, 2006:29; as citied by Sullivan, 2009). Furthermore, 21 of the 43 companies accomplished greenhouse gas reductions of 25%. One of the 21 companies reduced their carbon dioxide emissions by 22%, mainly due to energy-efficiency methods, while increasing their yearly income by 27% (The Climate Group, 2006:3; as citied by Sullivan, 2009). It is important, however, that even though there is a large improvement when using solar panels, the material which is used to manufacture solar panel systems may not be environmentally-friendly.

Andy Hooper predicts that in years to come, the global consumers of electronic energy such as computers will be determined by server warehouses being tactically situated close to resources of renewable energy for instance, wind, water and solar ranches that control them

(Kurp, 2008:11). In addition, energy resources could be placed anywhere in the world, wherever high sources of energy is available for server warehouses. The current methods used are mostly uneconomical (Hopper**,** 2008; as cited by Kurp, 2008). With regard to server warehouses, it is recognised that the functional costs associated with the utilisation of a server have exceeded the capital costs of the hardware (Sobotta *et al*., 2010:194). The world is losing power by depending on state-run grids (Hopper, 2008; as citied by Kurp, 2008). Hopper has suggested a system (moving data centres to sources of renewable energy that supply them) that is more effective, efficient, much less costly, and that could have an instant impact on the world's power consumption. Government and business in SA have an opportunity to provide alternative energy sources by looking at what has been done in developed countries and also studying the policies in place in those countries in order to reduce energy consumption.

In order to deal with weather changes and power consumption, Google believes that companies need to provide clean, low cost and renewable energy quickly (Sobotta *et al*., 2010:182). Furthermore, Google believes that the manufacturing of electricity from renewable sources does not currently make a significant difference because coal is less costly than electricity from renewable sources (Sobotta *et al*., 2010:182). Thus, in 2007 Google started a scheme called RE<C, which aspires to generate an effective scale of renewable energy that is less costly than coal. Google thus formed an in-house development investigation group with dedicated experts that aim to renew the power of technology. As a result, Google's philanthropic branch and Google.org invested over $30 million in renewable energy technologies such as solar and wind technologies. Currently Google has put up solar panels in the staff's car park as shown in the Figure 2.5.

Figure 2.5: Google, carport solar panels (Sobotta *et al*., 2010)

Google uses modified evaporative cooling to significantly reduce its server warehouse energy consumption (Google, 2011; as citied by Sobotta *et al.,*2010). Recently, Microsoft and other organisations have constructed server warehouses in central Washington that benefit from the use of the hydroelectric power generated by two dams in the area. Microsoft's data centre that consumes up to 27 MW of energy every minute is power-driven by hydroelectricity. Moreover, the Microsoft server warehouse in Dublin (Ireland), which was set up in 2009, is also in operation. The data centre covers 51 000 square meters that are air-cooled, making it 50% more energy-efficient than other similar-sized server warehouses. Originally, the data centre covered 303,000 sq ft.

Several companies such as Google and Yahoo are starting to show interest in reducing their energy consumption, but developing countries are reluctant to invest in new technologies due to financial constraints. According to Weihl, Google has been aiming to be carbon neutral since 2007 (Kurp, 2008:12). Carbon emission is measured internationally and takes account of straight fuel utilised in industrial, transportation, as well as construction and industrialised data centres around the globe. According to Google, its server warehouses use half the industry's mean quantity of energy consumption (Kurp, 2008:12). Google points out that they have modified enhanced energy practices to suit their own needs. Yahoo, also decided to ensure that its server warehouse would be carbon neutral by 2015. Furthermore, Google and Yahoo have started to use sewage water for cooling and biogas as an energy source to further reduce their energy consumption.

The relocation of data centres to locations where there are convenient renewable energy resources can result in an optimal consumption of energy (Kurp, 2008:11; Omer, 2012). Solving the source of the problem in this way has always been the ultimate objective, but implementation of this as the solution still remains challenging (Sobotta *et al*., 2010:219). Several sources of energy, such as the sun, water and wind, need the best possible conditions to function optimally. Large amounts of investment are required to build a data centre which would include provisions for future expansion. Since such data centres need complex equipment, additional financial support from the government may be needed. Thus a large investment and future plans need to be put into place in order to sustain the growth in the use of data centres. IT industrial companies can solve the situation by working together with the community and government.

Countries such as Australia and China are of the highest consumers of electricity per capita (Sobotta *et al*., 2010:219). Their national governments provide business with the option of generating a certain fraction of the electricity and sending it back to the grid from alternative

sources of energy, should a corporation or an individual choose to participate in a renewable energy programme.

Energy-efficient technology might be costly now, but in time the price will drop. For instance, IBM desktop computers were retailing at US$20 000 in 1975 but 37 years of investment in technology has seen the price drop to $1 000 in 2013. The same can be said of laptop computers and smart phones. Energy providers require investment in infrastructure and technology in order to adapt to new technologies and this can initially be costly.

2.5 User-centred Green IT Practices

The table below presents a list of user-centred green practices.

Table 2.2: Main focus area

User-centred green IT practices	
1.	Electronic waste
2.	Recycling
3.	Energy saving
4.	Screen saver
5.	Monitor sleep mode
6.	Hard disk sleep mode
7.	System standby
8.	Hibernate
9.	Phantom loads
10.	Telecommuting

2.5.1 Electronic waste

There is a limited amount of information available regarding waste disposal at landfills for recyclability in South Africa (Republic of South Africa Department of Environmental Affairs and Tourism, 2005:I). Several recycling programmes have been established on an informal basis and are financed by private organisations, with little contribution from individuals in authority in the industry.

There are no authorised businesses involved in dealing with e-waste in SA even though several companies are trying to initiate e-waste disposal sites (Republic of South Africa Department of Environmental Affairs and Tourism, 2005:9). As a result, large amounts of electronic waste are being dumped on landfill sites. This has lead to informal salvage businesses spreading across the country and impacting negatively on the environment. This state of affairs has lead to serious health and security risks for the salvagers, and is also affecting the operations of the landfill employees. The recycling initiatives are long-term and continuous projects that require constant checks and monitoring, as well as a change in behaviour by the public. Continuous campaigns are aimed at educating the public in order to bring about awareness of the impact of electronic waste and to take responsibility for their actions when disposing of electronic waste.

Every person should have a sense of accountability for their actions in this regard, and everyone in the chain should be considered when governments engage in electronic waste administration planning in order to bring about a holistic e-waste plan. The Polokwane Declaration represents an important programme in South Africa that is especially relevant to the waste management sector (Republic of South Africa Department of Environmental Affairs and Tourism, 2002). The Declaration aims to increase the recycling business by 50% by 2015. This is not an easy objective to reach. South Africa has initiated several declarations such as the Polokwane Declaration, which works together with the National Waste Management Strategy Implementation (NWMSI) scheme.

Several approaches to waste management, such as a shift from the traditional approach are being implemented (Republic of South Africa Department of Environmental Affairs and Tourism, 2000). Moreover, polices such as the Waste Management Policy and Strategy are reviewed annually to ensure that they are in line with environmentally sustainable objectives (Republic of South Africa Department of Environmental Affairs and Tourism, 1999). Ultimately, policies need to be implemented practically and thus require a high level of strategic plans and actions. In SA a waste hierarchy approach is used whereby waste treatment is the first line of defence, followed by waste minimisation, and then waste reuse. However, the policies in SA are so broad that companies are slow to implement them. Focusing the policies would enable better adoption and would have a greater impact on the environment.

2.5.2 Recycling

There are a number of ways whereby electronic components can also be recycled by IT users. Paper, for example, is a product that is being recycled. Paper recycling is the most often used activity in green IT practice aimed at protecting the environment. In 2006, the US recycled about 53% of used documents (www.paperrecycles.org). In 2007, each person on average recycled 1.5 pounds of paper per day. Recycling paper reduces the total waste that is burned or taken to landfills. However, recycling paper also has harmful ecological effects. Recycling paper products involve the use of energy, and toxic waste (carbon dioxide) is produced in the process of recycling the paper (www.paperrecycles.org). Nevertheless, the cost of recycling paper is much less than the ecological costs Appropriate benefits and weaknesses should be disclosed regarding the international standards to educate and train the public on the importance of recycling.

Furthermore, recycling also reduces transport costs. The CUTCO's main recycling work resulted in a 26% cut in garbage from all amenities (Berthon *et al*., 2010). Organisations in the US use approximately 215 million tons of paper per year (Underwood, 2008). In San

Francisco, for instance, the public are encouraged to use less paper and recycle it, and if possible, not to use paper at all. These types of strategies can also have a positive effect on the bottom line of governments, municipalities and organisations (Thibodeau, 2008). San Francisco's municipality uses approximately 215 million pages of paper per year, which amounts to a cost of $946,000 for paper alone (Thibodeau, 2008). To meet its aim of a 20% reduction in paper usage, San Francisco's municipality organised a file management system that permits the electronic construction and sharing of different text documents (Thibodeau, 2008).

Recycling does not stop at recycling paper. In 2010 Ernst & Young, for instance, started an initiative to reduce throwaway cups by 54%. CUTCO encourages workers to use reusable products such as plates and drinking glasses for holiday parties (Berthon *et al*., 2010). Only two bags of rubbish were collected at the end of one 75-employee holiday luncheon (Berthon *et al.,* 2010). Each year, thousands of ink cartridges up in landfills. Many, if not all, ink producers provide an extra cartridge in the box for users to pack the used cartridge and send it off for recycling. Recycling thus not only benefits green IT, organisations and entire sectors of business, but also the public in general.

Recycling thus plays an important role in reducing waste material and thereby supports green IT and helps to protect our environment. Even though energy is used in recycling, its impact is less as a result of using renewable energy. In order for green IT to be successful, targets need to be set by organisations and government, and incentives need to be put in place to encourage organisations to achieve the set targets. Setting targets and providing incentives will encourage the public to participate in green computing.

2.5.3 Method for managing power consumption

It is important to understand how energy consumption impacts on the environment, especially that of the various technologies including IT technology. Only by understanding these issues can we reduce energy consumption. There are a number of methods for monitoring energy consumption which are standard on most electronic devices in the marketplace. These methods include alternating the settings that manage the performance, and therefore energy utilisation, of many hardware and software constituents.

- **Energy saving**

One of the points of this research is to create an awareness of computer energy consumption and how to reduce it in practice. Behaviour and beliefs in this regard can be changed through education and training, which will eventually help individuals to select more

efficient IT devices. Efficiency of current IT devices can be extensively enhanced without affecting usability by following some of the international standard guidelines.

The University of Colorado in Boulder issued a document to their faculty, students and staff which are designed to increase awareness of green IT and energy efficiency, and reduce computing electronic waste (The University of Colorado Boulder, 2004). At that stage, the university had approximately 18 000 PCs on site (The University of Colorado Boulder, 2004) which consume about $550 000 worth of energy per year. The amount of $550 000 is the round figure for only the direct electricity costs to power the computers. This cost does not include the costs of cooling the buildings which are needed due to the heat produced by the laptops and PCs. This cost increased to about $700 000 when the cost of cooling the building was taken into account. Therefore the university implemented policies to be followed by students and staff by employing a group of IT specialist to educate and train them every week. One year later, their total cost of energy per year was reduced to $3000 000 and $500 000 for cooling the building.

The financial implications regarding IT device power utilisation are clear, but there is also an ecological concern. Carbon dioxide gas and other impurities are emitted into the environment by plants that produce electrical energy (Bradsher and Barboza, 2006:1). Carbon dioxide is thought to be a significant contributor to global warming. Pollutants such as mercury, zinc and other impurities produced by these plants pollute our surroundings (Joumaa and kadry, 2012:1058). Thus, if electrical consumption can be reduced, the quantity of dangerous contamination produced by energy plants will also drop.

According to the University of Boulder, a typical desktop PC system consists of a mouse, computer, printer and a monitor (The University of Colorado Boulder, 2004). A typical desktop PC with a 17-inch flat-panel LCD monitor requires approximately 65-100 watts of electrical power (Gupta and Singh, 2012:58), and a 15-17 inch CRT monitor requires 50-150W. A conventional laser printer uses approximately 100W or more while printing and also uses energy when in idle mode. An ink jet printer uses approximately 12W while printing and 5W while in idle mode. Businesses have recently embarked on exchanging conventional laser printers for inkjet printers, and are making use of double-sided printing (Petzer *et al.,* 2011:332; Popescu *et al.,* 2009:233). According to the Environmental Protection Agency, approximately 30 to 40% of computers are left on after office hours and during the weekend and approximately 90% of those personal computers are in idle mode (Soomro and Sarwar, 2012:538).

A single laptop or personal computer may use approximately 35 watts of power while in idle mode (energystar.org). Furthermore, laptops do not need a separate monitor because they have a built-in display. A single desktop computer, on the other hand, may use 100 watts in idle mode, but may use additional power if the monitor is left on. Table 2.3 lists some estimated typical IT energy expenditures. The current cost of electricity in SA is around 60 cents per kWh, according to the chief financial officer at Eskom (Eskom, 2013).

By shutting down a PC when it is not in use, significant financial and energy savings can be accomplished. Over the course of a year, energy to the amount of approximately R225 can be saved when turning off the computer or the monitor only on the weekend, and approximately R601 is saved when turning off the computer or the monitor on weekends and on weekdays when the computer is not in use. Furthermore, most significant savings can be achieved when using energy saving strategies such putting the PC into hibernate or standby modes, in addition to turning off the computer after work each day. When comparing a job accomplished on a stand-alone laptop to a job done on a desktop PC there is a significant difference in energy utilisation. For instance, even if a computer is left on for 24 hours a day, 365 days per year, a saving of approximately R604 per annum can be achieved by using a laptop rather than a desktop PC and following the same utilisation pattern. The laptop in our research studies used about six times less electricity than a desktop PC and its monitor.

Table 2.3: Comparison of electricity costs of a laptop and desktop configuration with altered usage patterns (Eskom, 2013)

Set-up	**Desktop PC 100 Watts, 19" LCD 50 Watts**	**Laptop PC 35 Watts**
Worst Situation 24 hours per day use, 365 days per annum	150 watts/hour * 8760 hours * 1kiloWatt/1000 Watts * R0.60/ kiloWatt (K) = **R788.40 total cost per annum of utilisation**	35 watts/hour 8 760 hours * 1kiloWatt/1000 Watts * R0.60/kiloWatt = **R183.96 Total cost per an annum of utilisation**
24 hours per day, then turned off over weekends	150 watts/hour *6264 hours *1kiloWatt/ 1000 Watts * R0.60/kiloWatt = **R563.76 total cost per an annum of utilisation**	35 watts/hour *6264 hours * 1kiloWatt/1000 Watts * R0.60/kiloWatt = **R131.54 Total cost per an annum of utilisation**
8 hours per day, turned off when not in use	150 watts/hour * 2080 hours * 1kiloWatt/1000 Watts * R0.60/kiloWatt = **R187.20 total cost per an annum of utilisation**	35 watts/hour *2080 hours * 1kiloWatt/1000 Watts* R0.60/kiloWatt = **R43.68 Total cost per an annum of utilisation**

Note: Rand values used are for 2013

- **Screen savers**

Screen savers are a misnomer in green IT. A common misunderstanding is that screen savers use less electricity. This is in fact far from the truth. Screen savers use more or as much energy as when your laptop or electrical device is in idle mode (Justin, 2008). Often a complex screen saver may consume more power than your desktop PC when in idle mode (Gupta and Singh, 2012:58). Moreover, screen savers can stop the CPU and displays from going to "sleep" which can waste a large amount of energy (Justin, 2008). In other words,

screen savers do not place the laptop in a power saving mode. One common idea concerning screen savers is that they were made to keep displays from “burning in” (Justin, 2008). “Burn in” happens to a display when the same image is shown on the screen for a long period of time (Justin, 2008). “Burn in” has a slight impact on current LCD displays (Justin, 2008). Plasma television (TV) screens for instance can suffer from “burn in” but they are usually not used together with a laptop. As a rule of thumb, screen savers should be deactivated. It is better to permit the monitor to fall “asleep” rather than to turn on the screen saver after a fixed period of being in idle mode (energystar.org).

- **Monitor sleep mode**

Permitting the monitor or display to sleep after idling for a fixed time period is a good way of improving power efficiency (Microsoft Corporation, 2006). (A display or monitor falling asleep or entering standby mode usually means the same thing). In this mode the display screen will go blank and thus no light will emanate from the screen. There is generally a green light on the display or monitor that tells the IT user that the display or monitor is turned on. When the display or monitor is in sleep mode, the green light generally turns to amber or red. The experiments carried out for this research study have shown that a Dell 20 inch widescreen monitor LCD uses around 55 watts when turned on. When the LCD is in sleep mode, the energy use drops to approximately 3 watts resulting in important power savings. Moreover, the sleep mode on the monitor can lead to a decrease in carbon dioxide emission (Microsoft Corporation, 2006). This state can be altered in the operating system energy rate selection control panel. Main operating systems such as Mac OS X, Linux, and Microsoft Windows have energy rate selections which permit IT users to alter the monitor sleep characteristic over and above other energy saving features. Thus, one can set the system so that it mechanically turns off certain components, for instance hard drives and the monitor, after a fixed time of inactivity. Although putting a monitor into sleep mode after 15 minutes of idleness will not usually impact significantly on IT users, it will nevertheless reduce energy consumption. It is thus important to educate the public on these issues in order to help save our environment.

- **Hard disk sleep mode**

The hard disk sleep mode is similar to the monitor sleep mode - a laptop can place its hard disk drives in sleep mode when they are not being used (Cocktail**,** 2010). Furthermore, hard drives on desktop computers can use 10 watts or more when in user mode (Karabuto, 2005). Hard drives on desktop computers use more energy than laptop computers. Moreover, the power savings for a laptop computer might be even more especially when the laptop is operating via battery energy. Many servers, laptops, and workstations have multiple

hard drives. Thus, hard drives that are not in use can be placed into standby mode and hard drives that are being used can be left turned on. The operating system in Microsoft Windows Ultimate for instance controls this without the intervention of the user. Putting the hard drive into sleep mode after 15 minutes of idle mode will not usually impact on IT users, but will make a difference to energy consumption. The Energy Star website offers a useful statistics page where IT users can establish how much energy and power a known product uses in sleep mode and off mode.

- **System standby**

System standby is among the most helpful energy savers found in laptops and desktop computers. After a fixed time period of idle mode, laptops, smart phones and computers will shut down most of its functions (Stevens, 2008), thereby ensuring important energy savings. The memory is not affected when the laptop or computer wakes up from standby mode. The desktop computer, tested in this research study used more than 100 watts when in idle mode and as little as 5 watts when in standby mode. That is more than 20 times less than the electricity used in idle mode. One more benefit of standby mode is that the laptop or personal computer can wake up within a few seconds. This is much quicker than shutting down a laptop or personal computer totally and booting it back up again. Since the laptop's state is saved in the memory chip which still uses some energy in standby mode, the laptop or personal computer will wake up with all the tasks the IT user was using before going into standby mode (Stevens, 2008).

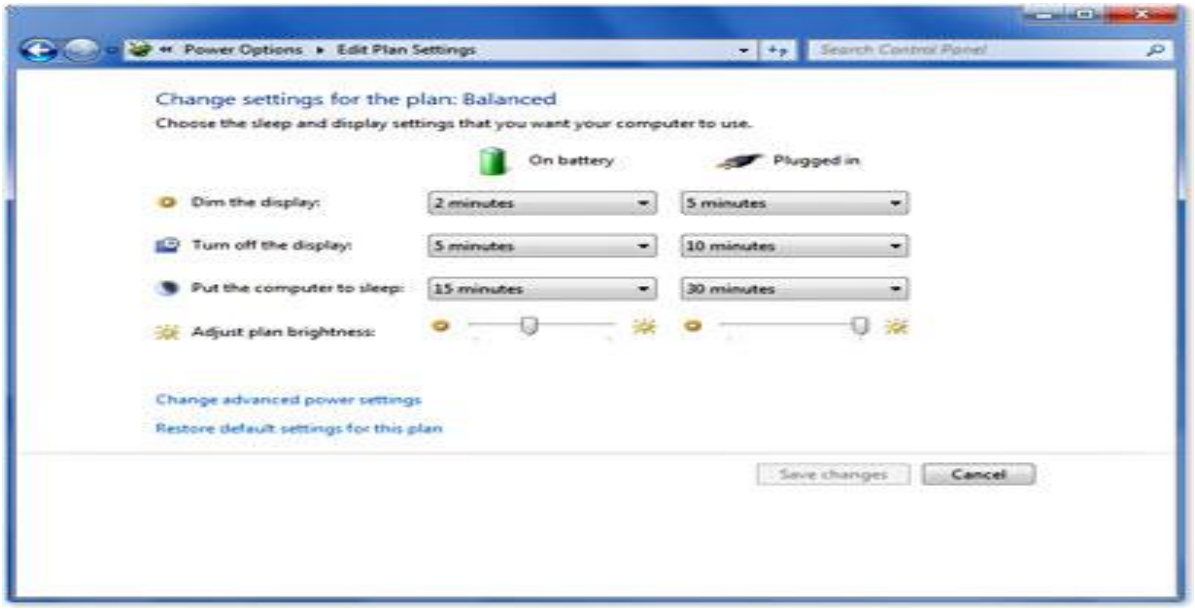
An additional feature of using standby mode is to configure the laptop's energy rate button to send the laptop or personal computer into standby mode as a substitute for shutting it down. This will permit the IT user to allow the machine to go into standby instantly, rather than waiting for a fixed time in idle mode before it mechanically goes into standby mode. Configuring a laptop's energy rate button to operate as a standby button can be done by altering the laptop's or personal computer’s energy rate selections in the control panel. Putting the system into standby mode after 30 minutes will not affect IT users, but will make a difference in energy consumption.

- **Hibernate**

The hibernate function is different from the system standby mode. The hibernate function can be enabled via the interface shown in Figure 2.6. In hibernation mode the processor is totally turned off (Lane *et al*., 2009:802). Prior to turn-off, the hibernation mode will save the memory state onto the hard drive and the power to the peripherals is shut down (Lane *et al*., 2009:802; Stevens, 2008). When the computer comes out of hibernation mode, it will access the memory file which it stored on a persistent file on the hard disk before hibernating and

copy it back into memory. The desktop computers tested used approximately 3 watts in the hibernate mode in comparison to 5 watts in the standby mode (Stevens, 2008). The question that arises is, why do computers use 3 watts if the hibernate mode turns the personal computer totally off? The reason can be found in phantom loads, which will be discussed in the next section. One of the drawbacks of the hibernating mode is that it takes a little longer for the computer to hibernate or wake up than when it goes into standby mode or wakes up from standby mode (Stevens, 2008). This is because it takes some seconds to load or save the memory's state onto the hard disk drive.

Figure 2.6: Power options in windows 7



- **Phantom loads**

Phantom loads occur when electrical equipment is turned off but electricity from a wall socket is still drawn (OpenNebula.org). Some electrical equipment that do not include a physical shut-off control that splits the electrical linkage to a wall outlet will continue using energy when plugged in to the wall socket (OpenNebula.org). Computers, for instance, use small amounts of energy, usually approximately 1-3 watts, because of the wake-up function embedded in a local area network (LAN), and thus energy is constantly drawn from direct current or alternating current adapters. A LAN permits wake-up on a totally shut-off computer to be switched on remotely from an electronic device on its network. Electronic devices that are shut off use a small amount of energy so that they can pick up a wake-up indicator on their network card. Phantom loads can be costly when left without being checked. If a user has 20 electrical appliances that use only a small amount, for instance 3 watts, when turned off, the following amount of power is used per annum:

Formula 1: Electrical power wasted for equipment

(20 appliances * 3W * 24 hr * 365 days * 1 Kw/1000 watt) = 526 KwH.

Using a rate of R0.60 per kW/hr, this adds up to approximately R315 per annum. The numbers in Formula 1 show the electrical power wasted for equipment that is not being used. A solution to dealing with phantom loads is to reduce the energy consumption of plugs when the electrical appliance is not in use (OpenNebula.org). If phantom loads cause an inconvenience, the machines that generate phantom loads can be linked to a power strip. The power strip can be switched off when the appliances are not in use. An example of this unnecessary consumption of energy is cell phones that are plugged in all night in order to charge them. There is thus a need to change the beliefs of IT users and their behaviour which can be done through educating them about unnecessary power consumption.

- **Telecommuting**

Telecommuting refers to an operational agreement during which a worker carries out a task from a distant site and thereby eliminates the need for a worker to travel to the main site of work. Telecommuting includes working at a satellite office, at home, or at a telework centre, and communicating by electronic means between a distant site and a worker's main location of work. Telecommuting can be a valuable tool for the worker, the company, and society as a whole. The worker profits by shortening the time used to travel to the main work station, and thereby stress levels as well as travelling costs are reduced (Wilbanks, 2008:63). Society profits as the number of cars on the road is reduced and the air quality is improved due to fewer gas emissions into the environment (Martin, 1991; Shaik, 2012:654; Popescu *et al.,* 2009:234).

The Climate Group predicts that greenhouse gases released due to internet business will rise to about 1.3 giga tonnes of carbon dioxide, and that the joint effect of smart logistics, smart buildings, smart grids, and video conferencing can lessen emissions by about 7.8 tonnes (Popescu *et al.,* 2009:234). There is thus an urgent need to educate businesses, students and the general public about the importance of telecommuting even though people may lose personal contact with others in the process.

2.6 Green IT in the South African Context

There is not a lot of literature that deals with the question of whether IT users are concerned about green IT, especially for South Africa (Petzer *et al.,* 2011:330). Chow and Chen (2009) report on some of the studies conducted in Hong Kong. As such studies were conducted outside South Africa, the results cannot be generalised to South Africa because each country, developed or not, has different belief systems and behaviour patterns. Furthermore,

behaviour and beliefs change over time. It is thus important that research on this topic be conducted in South Africa.

South Africa is one of the largest emitters of carbon dioxide in Africa, ranking in the top 20 in the world (Odhiambo, 2011:75). Most of South Africa's carbon footprint (about 47.6%) is produced by the electricity sector (Department of National Treasury, 2010:17).

The electricity sector mainly relies on low-cost, coal-based electricity generation (Mwakasonda, 2007:2). Relying on fossil fuels is a major cause of pollution. There is already a high level of greenhouse effects in SA which is expected to increase as the economy grows. The average temperature has increased over the past 50 years at a rate of 0.2 degree Celsius per year, largely as a result of human activity (Department of National Treasury, 2010:4). For example, 2005 was the warmest year on record, and one of the ten warmest years since 1980. It is expected that the atmospheric concentration of gases could reach 550 ppm of carbon dioxide and this figure might double by early 2035 (Department of National Treasury, 2010:4). In SA, the situation is even more severe since policies to reduce greenhouse gases have not been implemented, despite the fact that, if the SA economy continues to grow without restrictions, greenhouse emissions will multiply fourfold by 2050 (Winkler *et al*., 2011:5819).

South Africa is still in the embryonic stage when it comes to implementing green IT practices. Moreover, corporations in South Africa are slow to consider environmental sustainability as a strategic issue (Petzer *et al*., 2011:330). According to the UN, by 2020 e-waste from old laptops and desktop computers will rise by 200% to 400% from 2007 levels in South Africa and China (Budde, 2010). IT resources in general, including tablets, laptops, the internet, smart phones, and data centres specifically are major contributors to the endangerment of a green environment (Lamb, 2009: XXIII). Technology is largely responsible for the increased energy consumption, carbon dioxide emissions, landfill pollution and the loss of biodiversity (Petzer *et al*., 2011:330).

2.7 Summary

There is an urgent need to educate students, lecturers and IT professionals about green computing and its implications. Several senior IT executives and professionals are not aware of the existence of green computing, and if they are, they are not sure how to make full use of green computing (Lamb, 2009: XXIII). In addition, there are different levels of understanding among IT users, IT professionals and general business people regarding green computing. A small group of training organisations and universities have started offering green computing courses, for example Leeds Metropolitan University in the UK.

It is clear that, the electronic device energy consumption of IT's overall resources must be reduced and the efficient utilisation of energy in the manufacture, operation, and disposal of computing devices should be maximised. In addition, renewable energy sources could be implemented even though the process may be lengthy since it is expensive. The IT sector and society as a whole would benefit from green computing and thus it is the responsibility of every individual to create a more sustainable environment. The government could also play a vital role in creating green awareness among businesses, IT specialists and the general public by helping to build societies, supporting education or training, engaging groups in participatory decision-making, and green advocacy campaigns. Tools such as blogs, environmental web portals and interactive simulations of the environment could be used to great advantage to promote an awareness of the benefits of using green technology.

The next chapter gives a comprehensive description of the theoretical framework, research model and hypotheses.

Chapter 3:Theoretical Framework, Research Model and Hypotheses

3.1 Introduction

This chapter discusses the theoretical framework underpinning the research model for the study. Hypotheses are then formulated from the research model. The chapter first presents the theoretical background and the details of the theory of reasoned action (TRA) and those of the theory of planned behaviour (TPB), both of which form part of the main theoretical framework for this research. This is followed by a detailed discussion on actual behaviour and intended beliefs in green IT. The literature on TPB is also discussed.

The next sections review the two main theories, namely TRA (Ajzen and Fishbein, 1980) and TPB (Ajzen, 1985).

3.2 Theoretical Background

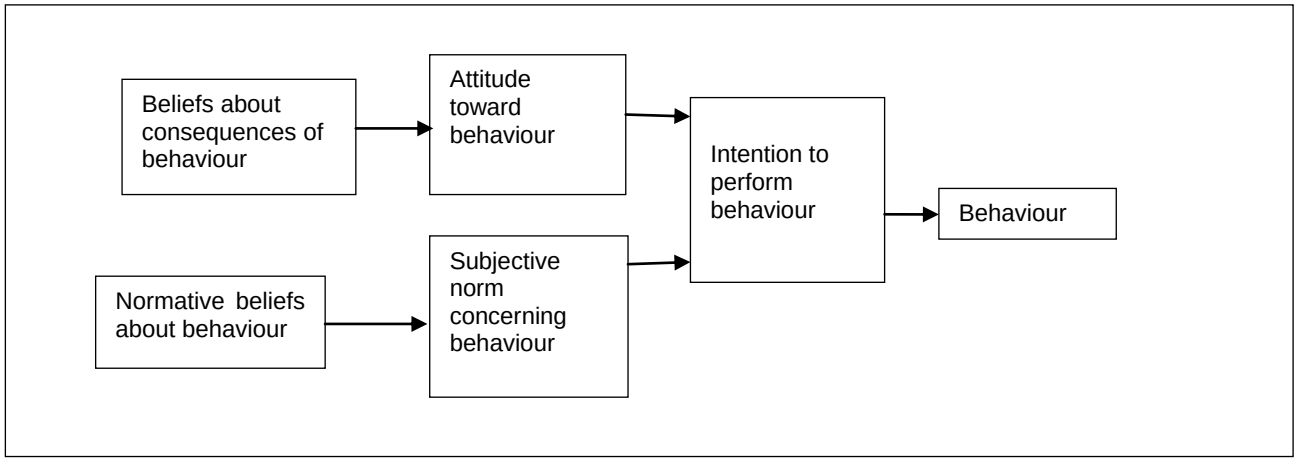
The research model is based on the theory of planned behaviour and the theory of reasoned action (Ajzen and Fishbein, 1975; Davis, 1989; Davis and Venkatesh, 1996). TRA is the pillar upon which TBP was formulated. An extension of TRA is used in this study. TRA is among the most commonly used behavioural and belief models. According to TRA, an individual's volitional beliefs and behaviour are determined by his or her intention to perform any given action. This intention is furthermore determined by two predictors: attitude toward the behaviour and the subjective norm (Khalifa and Shen, 2008). Attitude towards the behaviour pertains to an individual's feeling of the unfavourableness or favourableness of a specific behaviour. The subjective norm is explained as an individual's perception that the majority of individuals who are important to the person think he/she should or should not perform the behaviour in question. Thus, behavioural intention is "a measure of the degree to which a person is willing to perform a specified behaviour" (Ajzen, 1991:188).

TPB expands on TRA by adding the factor of perceived behavioural control. Perceived behavioural control refers to beliefs about the presence of factors that may facilitate or impede the performance of the individual's behaviour and the perceived strength of the control beliefs. TPB explains the following two behavioural phenomena: firstly, the more favourable the attitude of an individual to a behaviour, the greater the subjective norm, and consequently the stronger the intention of the individual to engage in such a behaviour will be; secondly, the stronger such an intention, the more likely it will be that the individual will perform the action.

3.3 Theory of Reasoned Action

The theory of reasoned action has been used by various information system (IS) researchers in order to explain user behaviour (Davis, 1989; Davis and Venkatesh, 1996). TRA was developed by Ajzen and Fishbein (1980; 1975) to predict human behaviour. The theory is based on the intention, behaviour, subjective norm and attitude of individuals. TRA assumes that a person's belief regarding a specific behaviour will affect the person's attitude. Ajzen and Fishbein (1977:888) found that human attitude toward intention has a greater effect than attitude toward the actual behaviour. TRA defines attitude as a person's general favourable or unfavourable feelings about a particular behaviour. Moreover, attitude determines the comparative strength of the person's intention to carry out that behaviour. A person is more likely to carry out that behaviour if that person has a higher degree of intention. In addition, TRA argues that the intention to carry out a specific behaviour is influenced by subjective norms and attitudes. Furthermore, subjective norms are affected by the normative beliefs concerning that specific behaviour. Subjective norms can be seen as a person's perception of the significance of the behaviour that must be carried out, taking the person's social environment into account. Moreover, Fishbein and Ajzen (1975:189) categorise subjective norm as the "perception that most people who are important to him, think he should or should not perform the behaviour in question". TRA's construct model is illustrated in Figure 3.1.

Figure 3.1: Theory of reasoned action (Ajzen and Fishbein, 1975)



TRA is extensively used by psychologists to predict and explain human behaviour in particular circumstances. A study by Greene *et al.* (2002) showed that TRA has been validated by numerous researchers in the field of health, as well as in IS behaviour (Greene *et al.,* 1997; Sparks *et al.* ,1995). Several researchers have commented that TRA has been used successfully in the domain of consumer behaviour to forecast users' behaviour and intention (Sheppard et al., 1988). Accordng to Sheppard *et al*. (1988), the intention might be

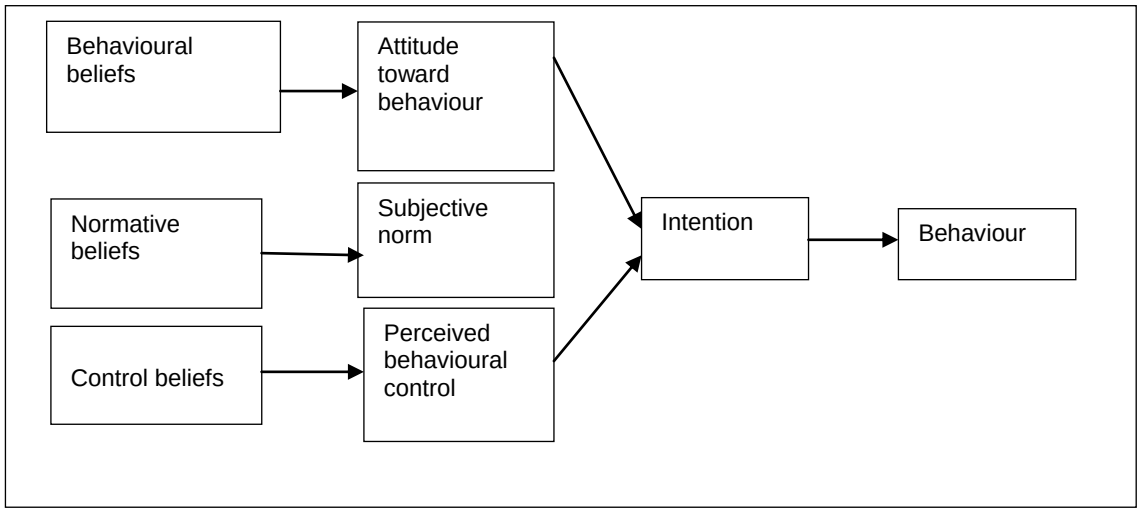
affected by a change of activities, time and other external factors that are not linked to the behaviour before a person performs an act. Davis (1989) and Yeaman (1988) also argued irrelevance of subjective norms when using TRA in the field of IS (the research is not focused on the irrelevant of subjective norms). Furthermore, scientists have discovered that the behaviour used in TRA is restricted to the behaviour with individual volitional beliefs (Ajzen, 1985; 1991:181; Greene *et al*., 2002; Sheppard *et al*., 1988). Thus, a person will normally perform a given action when they have the intention to do so. Nevertheless, there are a number of instances where the behaviour is out of the person's control or may even be unconscious. For instance, behaviour might be involuntary or habitual and the behaviour might need skills and resources that the person does not possess.

3.4 Theory of Planned Behaviour

The theory of planned behaviour was formulated by Ajzen in 1985 as an extension of Ajzen and Fishbein's TRA (1980; 1975). TPB added the factor of perceived behavioural control known as the factor of self-efficiency as a further determinant of an individuals' actual behaviour and behavioural intent (Madden *et al*., 1992). Focusing on the constructs of TRA, TPB posits that a person's behaviour is determined by the intention to carry out the behaviour and that the intention is influenced by the person's subjective norms and attitude toward the behaviour. Nevertheless, as mentioned above, one of the restrictions concerning TRA is that behaviour is not under a person's volitional control or beliefs. Furthermore, Ajzen (1985) found that some other factors concerning specific behaviour, such as skills, financial status and time, also affect behaviour. Moreover, researchers such as Adams *et al*. (1977) and Adams *et al*. (1980) found that a person's confidence concerning their capability to carry out a specific behaviour will directly affect actual behaviour.

To address the volitional concerns toward the behaviour, Ajzen (1985) adopted all constructs from TRA and proposed perceived behavioural control as an additional determinant of a person's intention. Control beliefs refer to a person's beliefs concerning the availability of factors such as skills, money and time that correspond to specific behaviours. Perceived behavioural control refers to a person's evaluation of the degree of easiness of carrying out a specific act of behaviour focusing on control beliefs (Ajzen, 1991:183). According to Ajzen and Madden (1986), perceived behavioural control signifies the absence or presence of all mandatory resources and opportunities that are essential to perform an act. The idea of perceived behavioural control arose from Bandura's concept of self-efficacy (Ajzen, 1991:184; Bandura, 1978; 1982; 1986).

Figure 3.2 Theory of planned behaviour (Ajzen and Fishbein, 1980)



Bandura (1997) proposed self-efficacy focusing on social cognitive theory, which concerns judgments of how well one can carry out courses of action needed to deal with prospective circumstances (Bandura, 1997:122). TPB is one of the most commonly used theories to understand the reasons for a person's belief toward their behaviours (see Figure 3.2). According to meta-analysis research which was conducted using TPB, the constructs of TPB offer explanations for human behaviour (Ajzen, 1991:186; Armitage and Conner, 2001; Godin and Kok, 1996; Hausenblas *et al.,* 1997). Mathieson *et al*. (2001:88) suggest that TPB could be implemented to predict a broad spectrum of behaviour.

However, there are also counterarguments that speak against TPB. For instance, Ogden (2003 as cited by Ajzen and Fishbein, 2003) discovered contradictory positions in the constructs of perceived behavioural control, subjective norm and attitude when reviewing the literature concerning TPB. Furthermore, Ajzen and Fishbein (2003) investigated Ogden's concerns and noted that the significance of constructs might differ or might even not be essentially based on changing circumstances, behaviour and populations. In addition, according to Mathieson *et al*. (2001), modified instruments are required when implementing TPB research in different contexts. According to Sharma (2007), TPB might be unsuitable for studies that concentrate on behavioural change since the constructs of TPB do not provide the reasons for behavioural modification over time.

3.5 Utilisation of TPB and TRA in Empirical Studies in Hong Kong

Chow and Chen (2009) examined IT users' intended beliefs and actual green IT behaviour in an empirical study which was conducted in Hong Kong in 2009. TRA and TPB were used to develop the model as shown in Figures 3.1, 3.2 and 3.3.

The literature mostly explains findings based on the important factors of TRA and TPB. The research by Chow and Chen (2009) mainly identifies the critical factor of TPB.

The following findings were made by Chow and Chen (2009): The research was done in Hong Kong at a tertiary institution. The targeted group consisted of students only and the sample size consisted of 267 sudents. The research was mainly focusing on quantitative rather than qualitative data. After the research the researcher obtained the following results:

Government and communities in Hong Kong have launched several campaigns to promote green IT such as placing recycling boxes on campuses that allow students to deposit unwanted computing resources such as CDs and DVDs, printed output, inkjet/laser cartridges and used computer batteries.Over the a six months period IT users had used fewer IT resources such as printing paper (approximately 88%) and read-only CD/DVD devices (approximately 68%). Moreover, 87% of the users used read/write DVD devices or memory sticks, 84% powered off the PC when not using it and 75% dimmed the PC brightness. It was also found that the intention to practise green IT was highly dependent on the promotion of individual pleasure and awareness, inclusive of their enjoyment, convenience, and a sense of feeling good about themselves by engaging in green IT activities.

The results showed that the attitude, subjective norms and perceived behavioural control all have direct effects on the intention to practise green IT and actual green IT behaviour (De Vries *et al*., 1998; Chow and Chen, 2009). Attitude has an indirect effect on actual behaviour. Even though the attitude towards green IT has no significance for actual behaviour, it should not be neglected. According to Chow and Chen (2009:140) and De Vries *et al*. (1998), the intention of an act has a higher influencing role than the factor of self-efficacy in predicting actual behaviour. The factor of self-efficacy in the model has a similar interpretation of PBC in TPB. Thus, IT users will practise green IT if they have total control over the means of doing so. Subjective norm has a slightly higher effect on actual behaviour than intention which implies that IT users try to live up to the expectations of their peers and people they respect when engaged in green IT activities. PBC thus remains the main factor dictating IT users' commitment to green IT. By means of a hierarchical regression analysis, it was found that the results of De Vries *et al*. (1988) were similar to the results obtained by Chow and Chen (2009).

These results show that the dominant factors in an individuals' beliefs and behaviour in green computing are different. An individual's beliefs have higher contributing decision variable values compared to their behaviour in order to perform an act (Chow 2001). To

promote the commitment of individuals to green computing resulting in actual behaviour, an environment needs to be designed that enables IT users to adopt green computing behaviour. Chow and Chen's study had a few natural restrictions. The researchers only considered the main influencing factors of TPB and TRA. Other factors such as social capital factors might have affected the outcomes. Moreover, the research in the Hong Kong sample consisted only of university students. According to Chow and Chen (2009), most of the literature in this regard applies the TRA and TPB concepts but few researchers discuss their results using hierarchical regression analysis and structural equation modelling. The reason for this is that hierarchical regression and structural equation modelling generalise statistical data which may be difficult to analyse without a mathematical background. Furthermore, the theory which Chow and Chen (2009) used did not include the bi-directional influence of attitude, subjective norm and perceived behavioural towards green IT.

3.6 Research Model and Hypotheses

3.6.1 Derivation of the research model

The research model is based on the theory of reasoned action (TRA) and the theory of planned behaviour (TPB) (Ajzen and Fishbein, 1980; Ajzen and Fishbein , 1975). The TPB model used for this study was derived from Chow and Chen (2009). It involves the following five decision variables:

- Attitude toward green IT (ATT)
- Subjective norm toward green IT (SN)
- Perceived behavioural control toward green IT (PBC)
- Intention to carry out green IT behaviour (INT)
- Actual green IT behaviour (ACT)

The decision variables listed above were taken from TPB and TRA and are used in this study to form the research model for comparing the Hong Kong results with those of the South African study.

3.6.2 Formulation **of hypotheses for the study**

The primary research question addressed in the study is as follows:

Are IT users concerned about green IT issues?

The secondary questions addressed in the study are as follows:

- What is the main factor associated with the beliefs or intent of IT users to practise green IT?
- What is the main factor associated with IT users' actual behaviour to behave in ways consistent with green IT?

- Are the main factors associated with IT users' beliefs or intent and actual behaviour as stated above the same when practising green IT?

Using the decision variables from TBP as listed in Section 3.6.1, the actual behaviour and intended beliefs of green IT as discussed in this chapter are determined by the hypothesised model (see Figures 3.1 and 3.2). This will enable the researcher to answer the primary and secondary questions based on the research model.

The following hypotheses based on the model developed by Chow and Chen (2009) were formulated (see Figure 3.2):

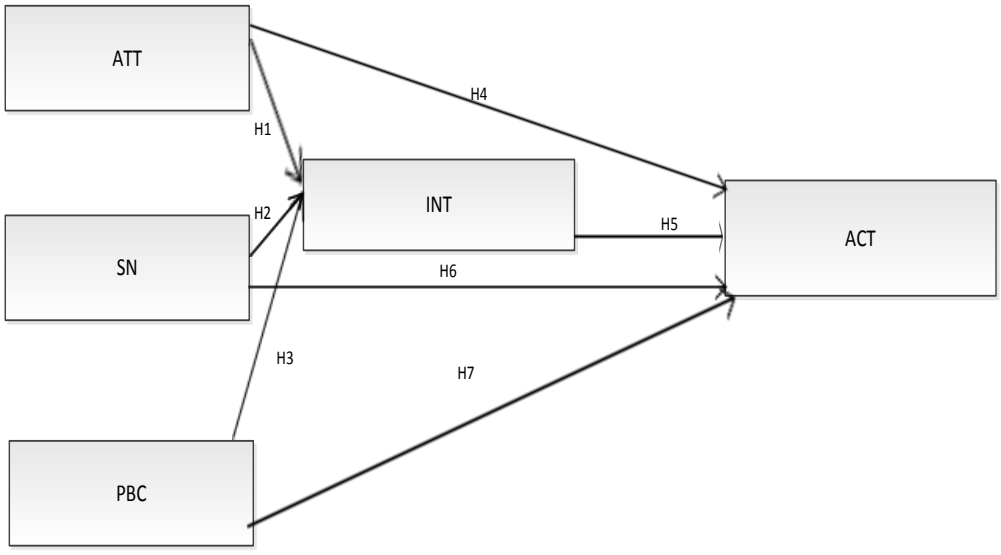
H1: Attitude has a direct influence on the intention to practise green IT.

Individual attitude toward the beliefs are an important interpreter of the intention to engage in that intention and beliefs to commit to green IT are determined by an individual's attitude towards a green IT act (Ajzen and Fishbein, 1975).

H2: Subjective norm has a direct influence on the intention to practise green IT.

The subjective norm influences IT user's intention toward green IT; that is, individuals practise green IT by seeing what other people do (Ajzen and Fishbein, 1975).

Figure 3.3: Research hypothesis model (Chow and Chen, 2009) (see Section 4.7.2)



H3: Perceived behavioural control has a direct influence on the intention to practise green IT.

The person's perceived control of actions will influence their intention to practise green IT and detailed beliefs influence general perceptions toward green IT (Ajzen 1991; Khalifa and Shen, 2008).

H4: Attitude has a direct influence on the actual behaviour to practise green IT.

In terms of the TBP model, the enjoyment element of individuals plays an important role in the actual performance of the act (De Vries *et al*.,1988; Thompson *et al*., 1991).

H5: Intention has a direct influence on the actual behaviour to practise green IT.

TRA sugests that the intention influences the actual behaviour regarding green IT directly (Ajzen and Fishbein, 1980).

H6: Subjective norm has a direct influence on the actual behaviour to practise green IT.

Social norms play a major role in relation to the behaviour of individuals regarding a novel act (Cheung *et al*., 2000; Triandis, 1988). Subjective norms have a constructive influence on actual behaviour.

H7: Perceived behavioural control has a direct influence on the actual behaviour to practise green IT.

In terms of the TPB model, perceived individual control directly influences the users' actions with regard to practicing green IT (De Vries *et al*., 1988; Mathieson, 1991).

General research objective

To determine the most significant factors associated with the (supporting or non-supporting) beliefs and (supporting or non-supporting) actual behaviour of IT users.

Specific research objectives

- To promote the commitment of individuals to behave in a sustainable way to promote green IT
- To determine the main demographic factors that influence decision variables pertaining to green IT
- To identify the gap between literature trends and existing practices in green IT
- To determine whether the attitude of IT users is associated with the intention to exercise green IT
- To determine whether the subjective norm of IT users is associated with the intention to exercise green IT
- To determine whether perceived behavioural control of IT users is associated with the intention to exercise green IT
- To determine whether the attitude of IT users is associated with actual green IT behaviour

- To determine whether intention of IT users is associated with actual green IT behaviour behaviour
- To determine whether the subjective norm of IT users is associated with actual green IT behaviour
- To determine whether perceived behavioural control of IT users is associated with actual green IT behaviour

3.7 Conclusion

In this chapter the theoretical framework that forms the basis for this study was discussed and hypotheses were formulated from the research model. Actual behaviour and intended beliefs as determined by TPB developed by Chow and Chen (2009) were used to construct the research model for this study. The research by Chow and Chen was conducted in Hong Kong using TPB, and the researcher replicated the study in South Africa with a selection of added decision variables. The research model will thus enable us to answer the research questions.

In the next chapter the research design and methodology, the conceptualisation and operationalisation of constructs, and variables and the data collection method for this study are examined.

4 Research Design and Methodology

4.1 Introduction

In order to create scientific knowledge using objective methods and procedures, the research process should involve the application of various methods and techniques (Welman and Kruger, 2001). The purpose of this chapter is to present the methods and techniques applied to satisfy the objectives of this research. The chapter begins with a discussion of the paradigm, context, research design and process. Then the mixed methodologies (triangulation) approach used in the study is discussed. A description is also given of the sample selected for the study, the sampling procedures, qualitative and quantitative instruments used and the data collection methods used. Finally, the data analysis process is described.

The chapter is organised as follows: Section 4.2 deals with the paradigm chosen for the research and Section 4.3 examines the context of the research. Section 4.4 discusses the research design and Section 4.5 deals with the research methods and methodology. Section 4.6 looks at the purpose of the research. Section 4.7 discusses the conceptualisation and operationalisation of constructs relevant to this study. Section 4.8 deals with the design of the survey questionnaire, Section 4.9 describes the data-gathering techniques, the research techniques are explained in detail in Section 4.10, and in Section 4.11 the validity of the measurement instrument and the reliability of the results are discussed. Finally, some ethical considerations are discussed.

4.2 Paradigm

According to Galliers (1991), positivism and interpretivism are major research paradigms. These research paradigms provide a theoretical framework for choosing an appropriate research methodology. According to Burrell and Morgan (1979:24), in order to choose a particular paradigm, the target population must view the world in a specific systematic way. Many research paradigms rely on different philosophical concepts and foundations of reality by associating methodological strategies and approaches (De Villiers, 2007).

The positivist paradigm views scientific knowledge in its purest form, depending on pure observation that is free of environmental impacts (Howe, 1988). The positivist paradigm depends on quantitative methods for data analysis and interpretation. According to De Villiers (2007), the positivist paradigm focuses on knowledge that is objective and absolute, leading to a single objective which involves the existence of reality. The interpretivist paradigm is characterised by a subjectively-based reality and the influences of the environment. Interpretivism is in disagreement with the positivist view of pure observations,

recognising the desirability and inevitability of environmental influences on observation. The fundamental assumption and delimitation of interpretivism is that almost every situation needs to be studied in order to fully understand a phenomenon. As a result, qualitative methods of analysis and their interpretation highly favour interpretivist research. Howe (1988) suggests that investigations need to focus on the broad-based comprehension of interpretivism, compared to the narrower objective of prediction, explanation and control that is characterised by positivist research.

A mixed research method was used as the paradigm that combines aspects from both interpretive and positivist research approaches. The researcher conducted a survey in the form of a questionnaire at TUT and used quantitative methods to analyse the data. This represented an application of the positivist research approach and necessitated some form of reliability and validity features of positivism through the use of SPSS for analysing statistical data (Golafshani, 2003:597). Using qualitative methods, the researcher also analysed the observation, i.e. how IT users actually practise green IT three months after having completed the questionnaire. This analysis resulted in the interpretation of observed differences between quantitative and qualitative data. Such qualitative data analysis and interpretation represented an application of the interpretivist research paradigm.

4.3 The Context

Research always takes place in a specific context. The manner in which the researcher views the context will depend on the research paradigm. Positivist research deals mainly with quantitative and experimental data in order to manipulate and control the context of the study. In addition, interpretivists consider the context, of their own and that of the object of their study, as having an impact on research. Hence, interpretivists take the ecological impact on the investigation into account in their research designs.

This research was conducted in the general context of the green computing discipline. It thus plays an important role in the study of investigating the actual behaviour and the intended beliefs in practising green computing. The empirical work was carried out in a lecture hall at TUT. The reason for choosing TUT was its ease of access and the population size which was deemed suitable for the study. Another reason was that most IT students and lecturers at TUT have access to computers every day of the week. The sample of IT users was drawn from students and lecturers in different departments of TUT.

4.4 Research Design

According to Nieuwenhuis (2010:70), a research design is “a plan or strategy which moves from underlying philosophical assumptions to specifying the selection of respondents, the

data gathering techniques to be used and the data analysis to be done". Hofstee (2006:113) also proposes that the research design section needs to include a discussion of the techniques that are used to test the thesis statement. In his view of a research design as a plan, Babbie (2001:91) believes that a scientific observation comprises "making observations and interpreting what you have observed". Consequently, the researcher has to formulate a plan, which is the research design, i.e. a design which involves what is to be observed or collected and analysed and explain the how and why. Nieuwenhuis (2010:71) suggests a number of research designs from which researchers can select. These include historical research, conceptual studies, case study research, action research, grounded theory and ethnography research. McMillan and Schumacher (2010:24) propose analytical research designs which involve concept analysis, analytical studies, policy analysis and historical analysis. Analytical studies examine events and concepts through an analysis of documents. Therefore, as illustrated in Figure 4.1, research design assists the researcher to plan and answer the research questions clearly by monitoring factors that might restrict the validity and reliability of the findings.

There are three key attributes of a research design as discussed by Bhattacherjee, (2012):

- **External validity:** Refers to the observed association that may be generalised from the selected sample to the whole population or to other populations, contexts, organisations or times.
- **Internal validity:** Determines whether the observed variation in a dependent variable is actually caused by the matching variation in a hypothetical independent variable and not by variables unrelated to the research context.
- **Statistical conclusion validity:** Determines whether the conclusion drawn through the use of statistical software packages, e.g. SPSS, is valid, by checking that the correct statistical method is used for hypothesis testing and by checking that the variables implemented meet statistical assumptions and delimitations.

4.4.1 Time dimension

The time attribute of a research study plays an important part in the design and execution of a research study (Babbie, 2001). The time attribute has two dimensions: a longitudinal and a cross–sectional dimension.

A longitudinal study focuses on the unit of analysis which is observed over a long period of time (Cooper and Schindler, 2003; Babbie, 2005). Furthermore, longitudinal studies allow modifications to be introduced over a period of time. Therefore, it is difficult to consider longitudinal research because of its large scale survey in the research study (Babbie, 2001).

Longitudinal research frequently involves a large cost in terms of money and time. It is for this reason that it is avoided by many researchers.

On the other hand, cross-sectional research involves the unit of analysis whereby the study is observed at one point in time (Babbie, 2001). Cooper and Schindler (2008) agree that cross-sectional research is conducted once only and represents snapshots at one time. Subsequent to the “snapshot”, the relationships between variables are analysed and examined.

In this research study, the cross-sectional dimensions were deemed the most appropriate and suitable as the study involved a fairly large-scale survey focusing on TUT and was conducted once only.

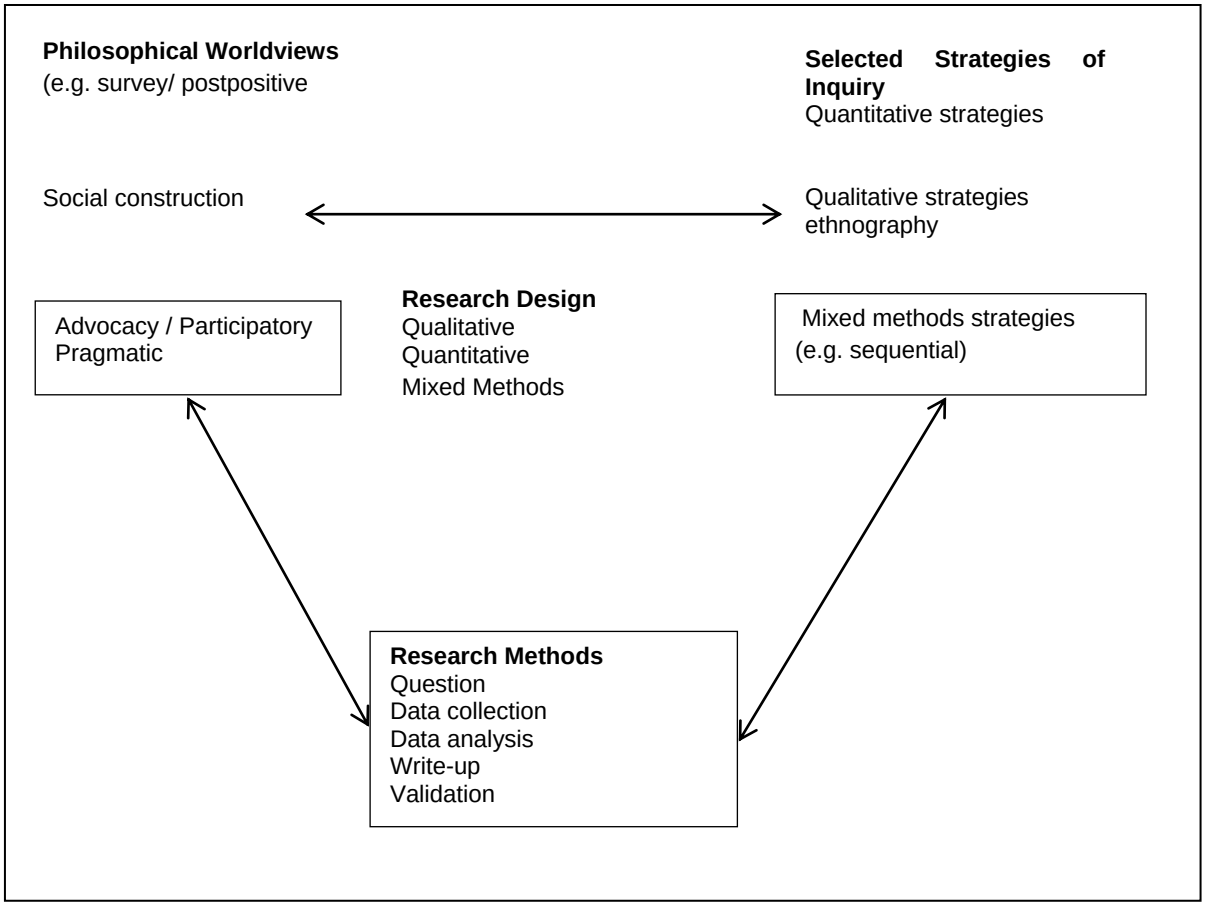
4.4.2 Research design and process

The research model on which this study was based is presented in Figure 4.1 and contains the following fundamental aspects:

Philosophical worldviews

Philosophical worldviews are explained as being advocacy or participatory, as well as pragmatic in nature. This study is of an advocacy or a participatory nature in that there are matters concerning social integrity that need to be dealt with, e.g. beliefs and actual behaviour in terms of the efficient and effective use of energy consumption of IT resources at TUT as the selected population. This corresponds with Creswell's explanation of research that consists of an action agenda for improvement that might amend the way of living of the respondents, the institution or the world in which IT users live or work and also the researcher's way of living (Creswell, 2009:9). The social issues of beliefs and actual behaviour regarding green IT at a tertiary institution within South Africa was dealt with and the worldview regarding the commitment of individuals to behave in a sustainable way was taken into account to determine the social integrity that affects green IT (see Appendix E). This enabled us to answer the main research question, “Are IT users concerned about green IT issues?” The answer might ultimately lead IT users to find ways of reducing energy consumption. There was also a pragmatic focus, because the research results might impact on the users’ future actions and situations, due to the fact that the research accentuated the research problem (high consumption of energy of IT resources). By making use of a mixed-methods approach, all approaches depicted in Figure 4.1 were used to understand the research problem (Creswell, 2009:10).

Figure 4.1: The research design (Creswell 2009:5)



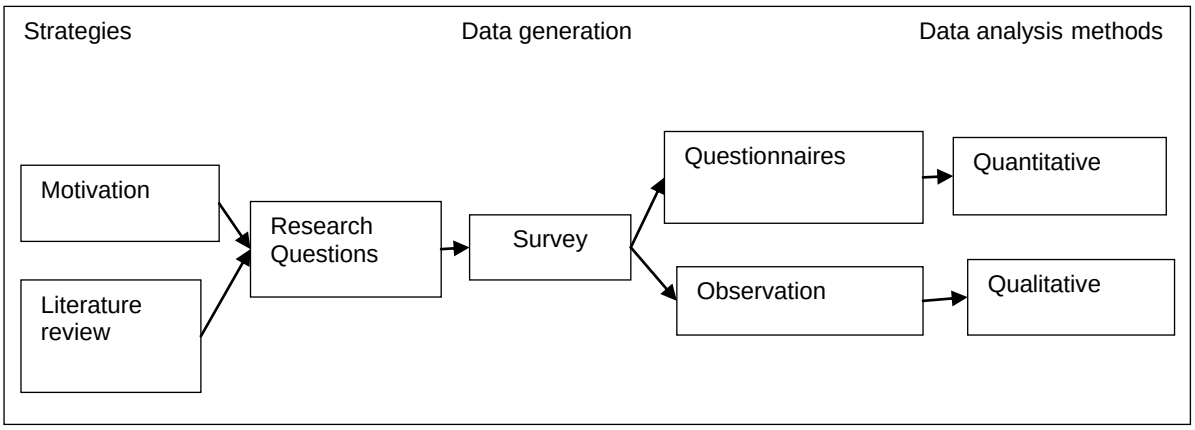
Selected strategy of enquiry

The selected strategy of enquiry is a mixed-methods approach, consisting of both quantitative and qualitative strategies. The details of the quantitative component (questionnaire) and the qualitative component (observation) are discussed. The mixed-methods strategy is an approach in which the research converges or merges quantitative and qualitative data in order to provide a comprehensive analysis of the research problem by collecting both quantitative and qualitative data at the same period (three months in the current research study). This enables the researcher to integrate the information in the interpretation of the overall results.

Research methods

The research methods constitute the research question formulation, data collection methods that include a questionnaire and observation in a natural setting, data analysis, interpretation of results and discussions, the validation of results and the documentation of the thesis. The research process is shown in Figure 4.2 and illustrates the individual stages involved.

Figure 4.2: The research process (adapted from Oates, 2006:33)



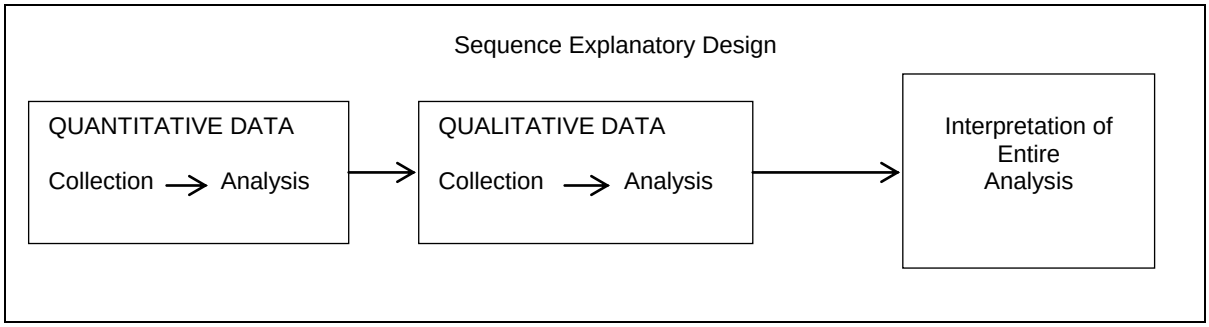
According to Oates (2006:35), a survey concentrates on obtaining similar data from a group of individuals in a systematic and standardised way. Therefore, patterns in the data were analysed using statistical methods in order to be able to generalise to a bigger population than the group we targeted in the study. A quantitative research approach was implemented in this research study, whereby a questionnaire was used to obtain the survey data which was collected from a group of IT users in a systematic and standardised way whilst observing the behaviour of IT students and lecturers.

4.5 Research Methods and Methodology Overview

As mentioned above, this research study used a mixed-methods approach consisting of both quantitative and qualitative methods to arrive at conclusions about the subject of interest (Creswell, 2009). Creswell describes quantitative research as a method for testing theories by studying and examining the relationships among decision variables. The decision variables may be measured or calculated, usually by means of a particular measuring tool, so that numerical data can be analysed using statistical methods. Qualitative research, on the other hand, refers to ways of exploring and understanding the meaning that individuals or groups assign to some social or human situation (Creswell, 2009:4). The research study was mainly quantitative, with successive qualitative methods being used to maintain and enrich the quantitative methods (see Figure 4.3).

Computing research can have a philosophical, social or technical goal. Research with a social objective is mostly likely to be carried out by experiments or surveys, and literature reviews, while research with a technical goal most likely involves literature surveys, languages, models or mathematical evidence (Olivier, 2004:12). The primary research goal in this study involved social issues, i.e. determining relationships between IT users' beliefs and behaviour, and the usage of IT resources contributing to the actual behaviour.

Figure 4.3: Mixed-methods, sequential design (Creswell, 2009)



Moreover, the study included significant technical secondary objectives to attain the primary goal. These involved the design of the environment that enables IT users to adapt by focusing on the main contributing factors of TPB when using electrical devices. According to Oates (2006), the main research strategies used in computing and information systems (IS) are surveys, case studies, experiments, ethnography and action research, while the main data-generation methods involve questionnaires, interviews, observation and documents. Using Olivier's and Oates' concepts, Table 4.1 below shows the relationship between different research methods employed in this study.

Table 4.1: Appropriate research methods for research goals (adapted from Olivier, 2004).

	Research Method	Data	Technical	Social	Philosophical
Primary Goal (determine relationships between IT users' beliefs and behaviour in practising green IT)	Literature Survey	Secondary	X	X	
	Observations Questionnaires	Qualitative and quantitative		X	

4.6 The Purpose of the Research

In describing the purpose of a particular study, the author needs to stipulate what or who the objects of evaluation were and what approach was used in studying them (Durrheim, 1999). (A description of the purpose was provided in Section 1.3 in chapter 1.)

4.6.1 Objective

The objective of the study was to evaluate the beliefs and actual behaviour of IT users regarding green IT at a tertiary institution in South Africa through a survey, completed by university students and staff at the Tshwane University of Technology (TUT).

4.6.2 The research approach

According to Terre Blanche and Kelly (1999) and Babbie (2001; 2005), research can be categorised into different approaches as set out in Table 4.2 below:

Table 4.2: Research approach

Explanatory research: This is described as research carried out in a systematic way to discover relationships among different traits of the phenomenon under study in the research. Explanatory research focuses on analysing the causal relationship (De Vaus, 2001:2) among various factors. The utilisation of this design helps to capture and explain the different intended beliefs and behaviours.
Descriptive research: This is conducted to describe the precise measurements and reporting of the characteristics or features of the population or phenomenon under study. Burns and Grove (2003) describe this research approach as one that provides a picture of the problem as it naturally occurs in the environment.
Exploratory research: This is undertaken to develop an initial understanding of the phenomenon being studied. Furthermore, exploratory research investigates the nature of the phenomenon and other factors that are related to it.

This study followed an explanatory research approach, whereby the factors regarding IT users' beliefs or intent and behaviour where examined. Moreover, the demographic factors of green IT were taken into account and it was hoped that ultimately the findings would lead to more effective and efficient uses of IT resources. The researcher decided to use this approach as it is a scientific method that focuses on "why" questions and develops causal explanations which could help to explain the intended beliefs and behaviours of participants (De Vaus, 2001:2).

Basic research

The research was basic as it sought to understand dominant factors that contribute to intention to practise green IT and actual behaviour towards green IT. Basic research generates new theories, principles, models and ideas which might not be immediately used, even though they are the pillar of modern progress and development in diverse fields in a real-world setting and application (Lane and Meissne, 2008:782). It stimulates new insights that have the capability to naturally improve the way in which practitioners or experts in the research deal with a particular problem. The research thus evaluated the reasons why users contribute to an increase in the consumption of energy, especially through the use of IT resources. The researcher was specifically interested in IT users' actual behaviour and intended beliefs regarding green computing. A quantitative research design and methodology was therefore selected as the main method for analysing the data through a questionnaire. The data was analysed in terms of the participants' intended beliefs and actual behaviour in practising green IT.

Quantitative and qualitative research

Quantitative and qualitative research aims to help researchers comprehend new ideas, improve their way of thinking and gather insights from analysing data. This study is quantitative due to the numerical data which was collected and analysed. In addition, quantitative research is a form of conclusive research involving sampling, and involves a structured or unstructured data collection procedure (Struwig and Stead, 2001:4). According to Grix (2004:117), quantitative research is categorised into three main phases: finding

variables for concepts, operationalising them in the research study, and quantifying them. Therefore, quantitative research is utilised to answer questions about relationships among measured variables with the aim or purpose of predicting, explaining and controlling the real situation of the study (Leedy and Ormrod, 2005:94). A quantitative study often concludes with either disconfirmation or confirmation of the hypotheses of the model being tested. According to Durrheim (1999), qualitative methods are inductive, holistic and natural. This leads to the investigation of the relationships that exist in nature, with the purpose of coming up with significant meanings. A quantitative study, such as this research, aims to produce further research questions that may then be answered through qualitative research. Nevertheless, before the data can be effectively used, a variety of sub-processes need to take place.

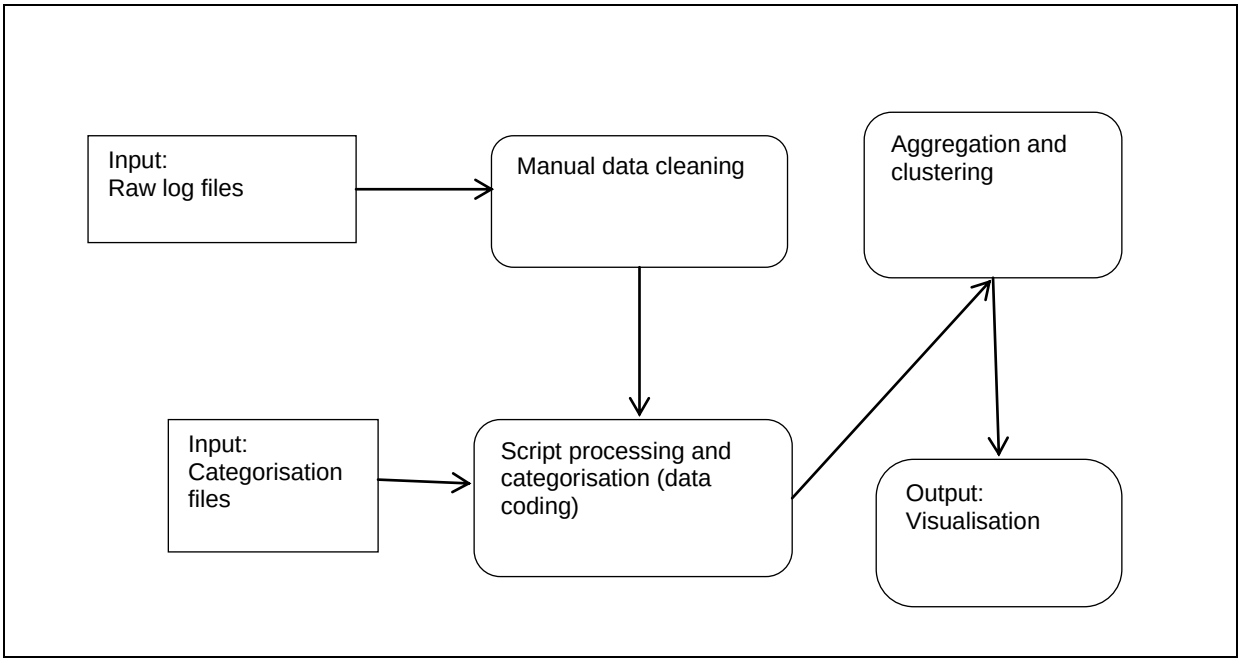
The main steps in the data collection and analysis processes were as follows:

- Design a questionnaire to systematically collect raw data and extract salient as well as direct information about intended beliefs and actual behaviour for engaging in green IT.
- Categorise and combine data elements.
- Identify the site with quantities of usable data for the pilot study or pre-test.
- Narrow site selection down to one site (TUT in this case).
- Retrieve all available raw data on IT users' beliefs and behaviour from the questionnaire focusing on the hypothesised model.
- Do data cleaning.
- Analyse data obtained from TUT.
- Perform statistical analysis where appropriate.
- Visualise significant relationships between categorised data.

Figure 4.4 depicts the main steps in moving from large amounts of raw data to meaningful visualisation. Data-processing tools are used to categorise, filter, combine and analyse data.

According to Rubin and Babbie (2001), qualitative research gives a deeper and richer understanding of a situation or question being investigated, which usually leads to improved understanding of human knowledge. Furthermore, according to Crotty (1998), research methods can either be quantitative, qualitative or both. In this research study, qualitative research was conducted for triangulation purposes. Triangulation is viewed as a significant methodological process in qualitative and naturalistic approaches to evaluating the target population. Therefore it can be used to monitor bias and to create valid propositions in the study. Traditional scientific techniques are sometimes lacking in this regard (Golafshani, 2003).

Figure 4.4: Process from raw data to visualisation



4.7 Conceptualisation and Operationalisation of Constructs

According to Dista (2003), it is important for the researcher to identify the key concepts related to the problem before any conceptualisation of the constructs and operationalisation of variables can be started.

The researcher developed the measurement items in the questionnaire for the decision variables of attitude towards green IT (ATT), subject norm towards green IT (SN), perceived behaviour control towards green IT (PBC), intention to green IT (INT) and actual green IT behaviour (ACT) by adopting the measures proposed and validated by Ajzen (2002), and modifying them to fit the green IT context. The conceptual framework of this study consists of five constructs as presented in the research model in chapter 3. These constructs are referred to as ATT, SN, PBC, INT and ACT.

4.7.1 Definition of key terms

Concepts - are described by Babbie (2005) as constructs derived by mutual agreement from psychological concepts. Babbie argues that concepts summarise related observations and experiences. Nachmias and Nachmias (2008) define a concept as an abstract that represents an object and serves as a foundation in the relevant study.

Conceptualisation - deals with imprecision, vagueness and ambiguity which are sometimes inherent in many social constructs. Conceptualising is the process of specifying the ambiguous conceptual description of a concept and sorting out the kinds of observations and measurements that would be appropriate for the study. According to Babbie (2009),

conceptualisation involves defining the boundaries which surround relevant terms to make them more physically tangible. In addition, conceptualisation assists in linking theory with research.

Theories - according to Hofstee (2006:130), theories create new ideas of understanding the environment that surrounds us by creating order out of chaos and giving meaning to the observations of the intended study. Moreover, theories provide frameworks for the researchers' specific hypothesised model of development (Babbie, 2005).

Attribute - this is described as a characteristic or quality of an object or concept, for example an IT student's behaviour towards green IT.

Variable - is the item that one is interested in studying regarding the object or concept and can also be described as a logical set of attributes such as gender and sex (Babbie, 2009). Bhattacherjee (2012) describes a variable as a measurable illustration of an abstract construct. Abstract constructs cannot be measured directly and therefore alternative measures called variables are used. According to Babbie (2009), all variables should have two relevant qualities:

- The attributes composing it should be exhaustive.
- Attributes should be mutually exclusive.

Furthermore, he argues that the process of operationalisation and conceptualisation is a specification of the variables and their attributes. According to Cooper and Emory (1995), scientists, practitioners and researchers use the term "variable" as a synonym for the construct or the property being studied in the research.

4.7.2 Measurements of variables

Operationalisation

Operationalisation is described as the process of developing indicators for measuring the recognised variables. Babbie (2009) defines operationalisation as the development of specific research procedures or techniques that might result in empirical observations regarding concepts in the real world. Operationalisation variables, as described by Davis (1989), Dillion and Morris (1996) and Venkatesh *et al*. (2003), were used for this research. A 5-point Likert scale was used to measure the variables.

Sections in the questionnaire (Ajzen, 2002)

The constructs of the theory of planned behaviour consists of the following decision variables: subjective norms, attitude, perceived behavioural, intention and actual behaviour as explained below. The decision variables are analysed in chapter 5.

Subjective norms

These revolve around an individual's perception of social pressures or other relevant beliefs, for instance the belief of a person that they should not participate in green computing.

Attitude toward behaviour

An individual's positive or negative evaluation of self-performance of practicing green computing.

Perceived behavioural control

An individual's opinion about something or someone that makes it easy or difficult to perform a particular behaviour.

Behavioural intention

An indication of an individual's readiness to perform a given behaviour.

Behavioural belief strength

An individual's belief about practising green computing (e.g. the belief that practising green computing is comfortable).

Control belief strength

Beliefs of IT students and lecturers about the presence of factors that may facilitate or impede the intention to practise green computing.

Normative beliefs

An individual's perception of practising green computing which is influenced by the judgment of significant others (e.g. parents, spouse, friends, IT experts).

Behavioural outcome evaluation

This refers to items formulated to assess the strength of the evaluation of the outcome of the study.

Injunctive normative referent

This refers to items formulated to assess the strength of the motivation to comply with the referent individual or group in the research.

Power of control factors

These refer to items formulated to assess the probability that the factor will be present and the factor's power to facilitate or impede the performance of the behaviour (Ajzen, 2002).

Direct measures

The questionnaire includes direct measures developed on the basis of the pilot study to assess intention and actual behaviour through the use of perceived behavioural control, attitude and subjective norm (Ajzen, 2002).

Other measures consist of a questionnaire section of demographic and background information.

Behaviour

Three months after answering the main questionnaire participants were contacted again, to report whether they had practised green IT.

4.8 Questionnaire Design

According to Hannum *et al*. (2010:66), a questionnaire is a list of structured questions for collecting reliable feedback from a selected sample, with the aim of finding out what a selected group of participants do, think or feel. According to Leedy and Ormrod (2005:185), questionnaires have two major advantages:

- They are relatively inexpensive, as they reduce the researcher's travel costs and telephone expenses.
- Questionnaires offer respondents anonymity, assuring greater confidence in the correctness of the results.

Leedy and Ormrod (2005:185) point out two disadvantages of questionnaires:

- They have a low return rate owing to the general apathy of participants to take the time to answer a questionnaire.
- The participants' answers might be inconsistent due to the fact that there is the possibility of misinterpreting some questions.

To deal with the possible disadvantages, Leedy and Ormrod (2005:190) suggest guidelines for the development of a questionnaire. These guidelines are not discussed here as they are beyond the scope of this research.

Questionnaires can be used for descriptive, exploratory and explanatory research. A questionnaire is an instrument particularly designed to elicit information with a meaning that will be useful for analysis and conclusions (Babbie, 2005:239). In order for a questionnaire to elicit the anticipated information, there are specific guidelines that should be followed in the design process. Cooper and Schindler (2003) suggest two main accessible options that researchers can make use of when formulating questions for a questionnaire:

- **Open-ended questions**

In this case, the participants are asked to provide their own comments to the questions. Hofstee (2006) suggests that it is advisable to avoid these kinds of questions because the willingness and ability of the participants to provide answers differ, and the responses may be difficult to analyse and interpret. Nevertheless, a few questions could assist to put the participants at ease, and to let them express themselves in their own words, which will provide in-depth answers where required.

- **Closed-ended questions**

The participants are asked to choose a response from a list of options provided. Cooper and Schindler (2003) and Babbie (2005) propose that closed-ended questions are common in survey research due to their ability to provide uniformity of responses that are more easily processed.

Open-ended questions need to be coded before a computer analysis can be done. The process requires the interpretation of the meaning of responses which may lead to misunderstanding and bias. Both open-ended and closed-ended questions were used in this research. Note: Open-ended questions were used to construct the closed-ended questions.

4.8.1 The design of the survey questionnaire

A self-administered questionnaire was used for the collection of the data as the respondents were literate and were thus able to complete the questionnaire (Mouton, 2001:258). The draft questionnaire was designed based on the constructs and variables selected from the TPB model described in the model development section in chapter 3.

Table 4.3.The 16 sections of the questionnaire

Stage	Section	
1	A:	Biographical information
2	B:	Attitude towards behaviour
	C:	Subjective norms
	D:	Perceived behavioural control
	E:	Behavioural intention
	F:	Behavioural outcome evaluation
	G:	Behavioural belief strength
	H:	Injunctive normative referent
	I:	Normative beliefs
	J:	Power of control factors
	K:	Control belief strength
	L:	Actual behaviour
3	O,M,N and P	Open-ended questions

A cover letter was included which provided a general description of the study (see Appendix A). A brief description and definitions were provided at the beginning of each section of the questionnaire so that the participants would understand what was being asked. The participants were instructed to place a cross in the appropriate box next to the answer that

best represented their opinion. A section requiring personal information was included at the end of the questionnaire. This was done to help participants to start responding to the questions related to the main purpose of the survey (Dillman, 2000; Babbie, 2005)

4.9 Data Gathering Techniques

According to Zikmund (2003:189), there are four types of survey methods:

Table 4.4: Data gathering techniques (Zikmund, 2003:189)

Personal interviews: Personal interviews are a research technique for gathering information through face-to-face contact with individuals or a group of people.
Door-to-door interviews: The survey questionnaire is administered by interviewing the participants in a face-to-face encounter.
Telephone interviews: The survey questionnaire is read over the telephone by the instructor to the participants and receives verbal responses to the questions.
Self-administered surveys: The participants are given questionnaires to complete in their own time and space. The most common form of self-administered questionnaires are mailed surveys.

According to Babbie (2001), mail surveys are appropriate for collecting precise data but are less effective and efficient when it comes to collecting sensitive and complex data. Face-to-face interviews and telephone surveys provide high quality information but the cost is higher when compared to mail surveys. Mail surveys might be the most appropriate method available to collect original data from a sample population that may be difficult to observe directly or indirectly due to geographic distance, for example. Hence, selecting a particular method is based on financial resources and the specific context of the study (Kerlinger, 1986). A self-administered survey was used in this study.

Self-administered survey

A self-administered questionnaire involves a data-collection technique whereby the participants read the questions and record their own response mostly without the presence of trained instructors (Hair *et al*., 2000:261). A self-administered questionnaire is the same as a drop-off questionnaire. Some advantages of drop-off questionnaires are as follows:

- The availability of an individual to screen participants and spur interest in completing the questionnaire and general questions.
- The questionnaire can be sent electronically to the participants to save costs and time, and the participants can complete the whole questionnaire in their own time.

The main drawbacks of mail surveys are:

- Response rates are generally low.
- There is a lack of control over the survey administration.
- One cannot examine unclear responses from the participants (Dillman, 2000).
- Participants might skip questions and therefore participants may not fully express their thoughts (Leong and Austin, 2006:115).

Nevertheless, there are also advantages that outweigh the disadvantages of mail surveys. For instance, it is easy to administer a mail survey to a large sample of the target population and to assure participants of anonymity for honest responses. Furthermore, questionnaires are tangible, reliable and uniform, and can be filled in at a convenient time (Dillman, 2000). The response rates for mail surveys are generally low due to the return requirement. This weakness was overcome in this research by hand-delivering the questionnaire to the IT students and emailing the questionnaires to the IT lecturers.

4.10 The Research Techniques

A description of the research methodology includes the following three elements: Sampling, data collection and data analysis (Durrheim, 1999).

4.10.1 Sampling

Target population

A target population is the entire group under study as specified by the research (Bradley, 2007:170). The target population of this study consisted of IT students and lecturers based at TUT who have been at least one year on campus.

Sample

Sampling is the process of choosing units (for instance organisations or people) from a specific population of interest so that, by studying the sample, we can generalise the results to the target population from which they were chosen (Nieuwenhuis, 2007:79; Puttergill, 2000; Trochim, 2006; McMillan and Schumacher, 2010:138). According to Mouton (2001), a sample consists of elements chosen with the intention of finding out something about the entire population from which they are taken. The aim of scientific research is to describe and explain the nature of a population, a class or group of subjects, concepts, variables and phenomena. In most circumstances, however, the whole population cannot be included due to resource and time constraints (Bradley, 2007:519). The usual steps to be followed in these instances are thus to take a representative sample from the population (in this research from TUT).

Sampling method

There are many different methods of sampling and these can be categorised into non-probability and probability sampling techniques. Probability sampling is a sampling technique whereby all members of the target population have a non-zero probability of being chosen (Bradley, 2007:519). Probability sampling has the advantage that it is possible to calculate the sampling error, which is the degree to which a target population might differ from the whole population. On the other hand, non-probability sampling is a technique in which units

of the sampling are chosen based on convenience or personal judgement. In this research study non-probability sampling was used due to the fact that some units in the population were more likely to be selected than others (IT students at TUT rather than non-IT students).

The following are techniques of non-probability sampling:

- Convenience - also called haphazard or accidental sampling. The sampling procedure involves people, animals or units that are most conveniently available.
- Purposive sampling, also referred to as judgmental sampling. An experienced individual selects the sample based on his or her judgement about some appropriate characteristics required of the sample members.
- Quota sampling ensures that the various subgroups in a population are represented according to their characteristics, to the exact extent that the investigators desire.
- Snowball sampling has a variety of procedures, initial participants are chosen by non-probability methods and additional participants' information is obtained from the initial participants.

The type of sampling used in this study was purposive sampling for the following reasons: The participants included information-rich cases for in-depth study for the qualitative part of the study. The sample quantity was deemed representative which implied knowledgeable and informative responses on the phenomena being investigated (McMillan and Schumacher, 2010:326).

Purposive sampling is described as a type of non-probability sampling method which involves the sample being drawn from that part of the population which is close at hand (Tongco, 2008:151). It is thus a sample population that is selected because it is readily available and convenient. This type of sampling was chosen due to the accessibility and proximity of the participants. IT students and lecturers were chosen because they are daily users of IT and are the potential leaders in the IT industry. In addition, the participants of the pilot study were expected to cope well with the requirements of the questionnaire. IT students and lecturers were drawn from the Department of Information Technology at TUT. The reason for choosing TUT was that it was easily accessible and suitable for the population sample which was required for the study. Therefore the sampling method in this research study can be regarded as convenience sampling.

Sample size

The sample size is significant to consider in the research. According to Durrheim (1999), the size of a sample in any research relies on the type of study being carried out, although practical restrictions might have an influence. Hence, by involving specified inclusion criteria, the sample becomes homogeneous, which means that there is not much difference within the sample, permitting a smaller sample size (Durrheim, 1999; Patton, 2001). According to Bradley (2007:185), the best sample size depends on the following factors:

- Required precision of the study
- Budget, resources and time available
- Nature and size of the population under study
- Significance of the results

In this research the sample comprised 340 IT students and 5 IT lecturers.The study made use of the guidelines provided by Durrheim and Bradely as explained above.

4.10.2 Data collection methods

Participants

When conducting research it is significant to think carefully about how one would select the participants. The participants should have the capability to offer the information required. Also, the research needs the participants to have certain basic cognitive skills (Dumas and Redish, 1993), such as the following:

- Understanding of verbal and non-verbal material
- Maintaining a certain attention span
- Maintaining a memory capacity
- An understanding of certain symbols
- An understanding of conversation rules

According to Dumas and Redish (1993), choosing the participants for a study requires the following procedures:

- Deciding how many participants to include in the study
- Selecting subgroup(s) for the study
- Developing a user questionnaire
- Defining and quantifying characteristics for each subgroup

In this research, participants were IT students and IT lecturers since the research aimed at evaluating the intended beliefs and actual behaviour of IT users. Daily IT users who know

the technology system of the university were chosen because of their experience with computers. It was felt that IT students and lecturers with at least one year experience should be able to provide the required information for the study. Students at TUT come from different provinces in South Africa and also from a number of neighbouring countries such as Zimbabwe and Namibia. Consequently, different races and cultures of Southern Africa were included in the study. Primary data was used in the research. According to Zikmund (2003), primary data is data collected and joined together for a specific research study to provide meaningful information. Primary data can be gathered through observations, interviews and self-administered instruments. Primary data was collected through the use of self-administered questionnaires and observing the target population after the main study.

The study consisted of a pilot study and a main study.

Pilot study

A pilot study was conducted with 45 IT students and 5 lecturers at TUT. The purpose of the pilot study was to collect data to reduce uncertainty and risk. According to Olivier (2004), a pilot study is able to assist in removing frustrating problems which could arise during the main study. Therefore a pilot study checks the suitability of the research methods and research design, and enables the researcher to make alterations, if required, to the questionnaire, for instance by eliminating uncertainties highlighted in the pilot study. Based on the pilot study, a number of questions were redesigned. The researcher realised that the actual behaviour and beliefs of lecturers provided useful information and therefore decided to include the lecturers in the sample for the main study.

Main study

In the main study 340 IT students and 5 IT lecturers completed the questionnaire in a lecture hall used for the survey. The completion of the questionnaire involved three consecutive stages. In Stage 1 the participants were asked to complete the demographic questions aimed at obtaining information about their level of understanding green IT. In Stage 2, various questions on practising green IT were asked (see Appendix A). In Stage 3, open-ended questions were asked to determine the salient behaviour and beliefs of IT users and lecturers (see Appendix A).

The instruments used to collect data were the following:

Observation

The target population was carefully observed with regard to their behaviour and actions. Observation is a method that assists the researcher in studying the association between participants in a number of ways. For instance, non-verbal expression of feelings are observed, or the interactions among the target population are observed through communication and time spent using IT resources (Schmuck, 1997). An individual can focus on the following observable behaviour which may lead to the intended beliefs:

- Confident willingness to complete the questionnaire
- Readiness to listen to recommendations from other participants or friends
- Body language may be an indication of boredom or lack of enthusiasm through action or motion

According to Hanna *et al.* (1997), the researcher must evaluate the behavioural signs by observation. Behavioural signs such as leaving the computer without switching it off after the lecture period are more reliable than answering the questionnaire. They also recommend that, after the observations or after the entire questionnaire has been completed, the researcher visit the place where the research was conducted and make observations.

Observations are significant in qualitative studies due to the fact that they allow the researcher to witness specific patterns of behaviour and beliefs. The observation method used during the answering of the questionnaire was unobtrusive observation. The researcher concentrated on observing the actions of the participants and refrained as much as possible from influencing them.

The researcher's observations can be regarded as reliable because video recordings were used to authenticate the study. The benefit of a video recording is that it is durable (Grimshaw, 1982). This allows the researcher to continue to experience an event repeatedly by replaying the video. This allowed the researcher to alter his focus somewhat and see things that had not been noticed at the time of taping or on previous viewings of the video (Erickson, 1982; 1992). Replaying the event also allows the researcher more time to deliberate before drawing final conclusions. The researcher viewed the video recordings and transcribed them for analysis purposes, and then interpreted the results (Note: video recording will be used for further studies not included in this research).

Questionnaire

The study focused on two groups of people, namely IT students and their lecturers. Questions were adapted according to the feedback from participants in the pilot study and new information that emerged during the pilot study. The questionnaire comprised structured and semi-structured questions. The semi-structured sections enabled the participants to answer the questions by giving their own opinion (see Appendix A). A semi-structured questionnaire enables the participants to fully and freely express their views with regard to intended beliefs and actual behaviour of green IT.

The questionnaire was given to the participants at the start of the lecture. The instructor demonstrated how the questionnaire should be completed. This was done in order to clarify what was needed in the questionnaire through instructions from the researcher. IT students and lecturers answered the questionnaire themselves.

4.10.3 Data analysis

The goal of the data analysis was to structure the findings as an interpretation of IT users' beliefs and behaviour regarding green IT. By means of the data analysis, findings could be made and the challenges and successes could be identified. According to Thorne (2000), data analysis is the most complex of all the stages of a qualitative research study, and yet it receives the least attention in the literature. In order to arrive at findings that transform raw data into new knowledge, it is important to engage in proactive and in-depth analytic processing throughout all the stages of the study. Understanding processes is essential in qualitative research and for understanding, reading and interpreting results when used in the quantitative study.

Analysis methods

The data was analysed for validity based on convergent validity using a scale factor analysis (Hu *et al*., 1999:100). The convergent validity test measures items for convergence or divergence on the decision variables with factor loading having a fixed value. The reliability of measurement items was tested using Cronbach's alpha test for decision variables (Hu *et al*., 1999:100). Cronbach's alpha enabled the researcher to assess the internal consistency of the proposed decision variables (Hu *et al*., 1999:100). A structural equation modelling (SEM) test was used to model latent variables under conditions of non-normality with small to medium-sized samples (Chin *et al*., 2003). Descriptive statistics were applied to analyse the data and determine the significance of the model using SPSS software. The correlation between the decision variables of the participants with regard to practising green computing was tested to determine whether there was a significant association between decision

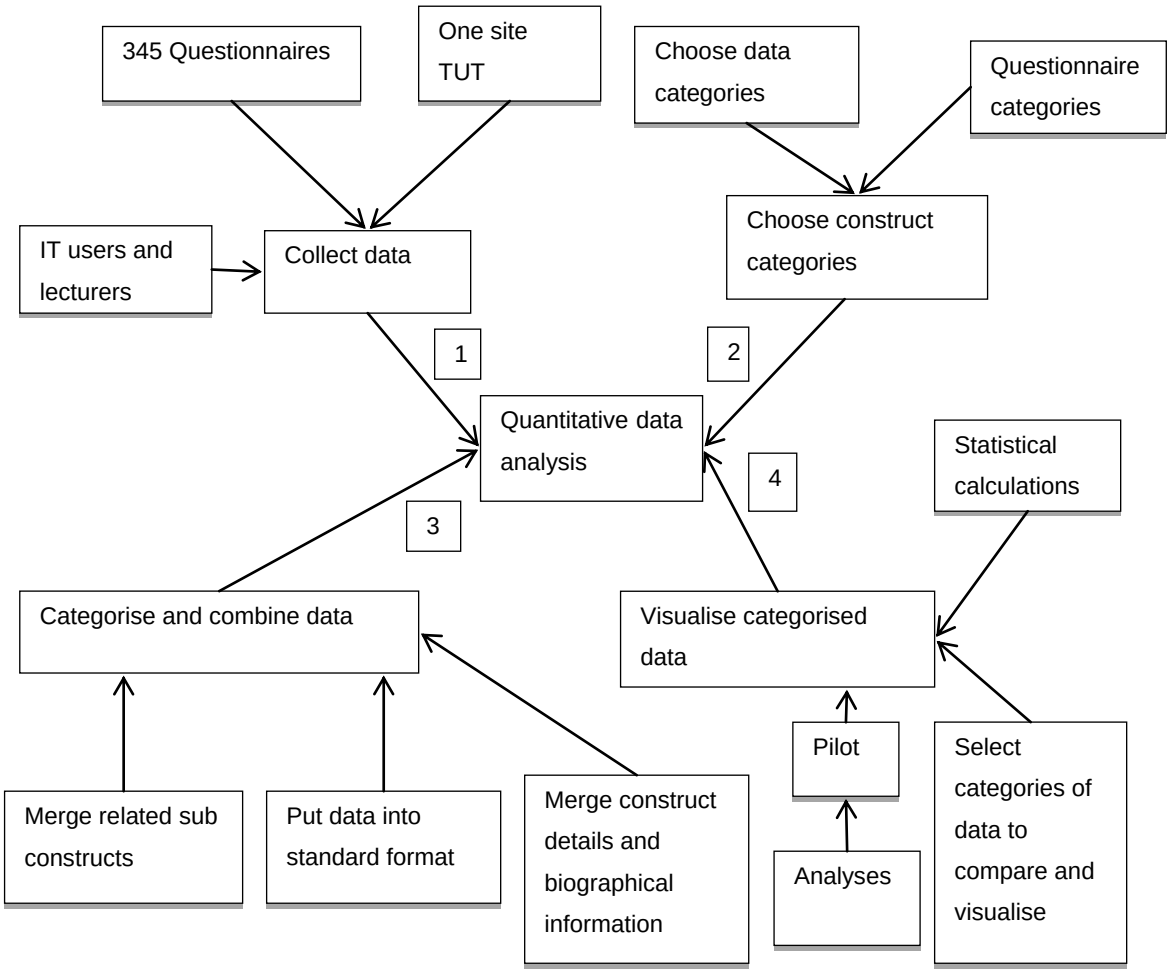
variables in South Africa. An independent sample test was carried out to test the difference between male and female respondents with regard to decision variables. A one-way analysis of variance (ANOVA) regarding age, current level of study and employment status results was also carried out. Hierarchical regression and structural equation modelling analysis was used to determine the dominant factors of beliefs and behaviour (Chow and Chen, 2009:139).

Overview of the quantitative data analysis

The key aspects of a quantitative data analysis process are as follows (Creswell, 2007:7) (see Figure 4.5):

- Collection of the raw data (1 below)
- Selection of appropriate construct categories (2 below)
- Integration of the raw data into manageable data sets and assignment of each data element to its appropriate category (3 below)
- Calculations and visualisation of categorised data within the data sets, inclusive of statistical analysis to determine the significance of the relationships (4 below)

Figure: 4.5: Components of quantitative data collection and analysis (Creswell 2007:7)



4.11 Validity and Reliability

Reliability and validity are significant in all research and address issues regarding the quality of data and the appropriateness of the method used. The researcher used both qualitative and quantitative research methods for triangulation purposes. Golafshani (2003:603) defines triangulation “as a strategy for improving the validity and reliability of research or evaluation of findings”.

4.11.1 Reliability

Reliability is the degree of consistency or stableness and the extent to which test scores are accurate (Struwig and Stead, 2001:130; Polit and Beck, 2004:730; Goddard and Melville, 2001:47). Leedy and Ormrod (2010:31) define reliability as the “consistency with which a measuring instrument yields a certain result when the entity being measured has not changed”. It thus follows that apart from delivering accurate results, the measuring instrument should deliver similar results which are consistent. Reliability may be assessed by conducting a pilot study with a small sample of people similar in characteristics to the target group. As mentioned earlier, 50 IT users, who were representative of the population of this study, were asked to participate in the pilot study. Their feedback was considered when the questionnaire was finalised. The reliability of the measurement items was tested using Cronbach’s alpha for decision variables (Hu *et al*., 1999:100). Cronbach’s alpha enabled the researcher to assess the internal consistency of the proposed decision variables as discussed in Sections 5.3 and 5.4 in chapter 5 (Hu *et al*., 1999:100).

According to Bhattacherjee (2012), measurements may be reliable but not necessarily valid which could lead to constantly measuring the wrong construct. Furthermore, measurements could be valid, but not reliable which could result in measuring the right construct, but leading to results which are inconsistent. In other words, reliability and validity are both required for assuring adequate measurement of the variables.

4.11.2 Validity

Validity is the degree to which a research instrument measures what it is intended to measure (Creswell, 2009; Joppe, 2011; Charles, 1995)**.** Struwig and Stead (2001:136) define validity as the extent to which a research design is scientifically sound and appropriately conducted. The validity of the test results can be enhanced by gathering data through using several evaluation methods and by collecting quantitative data with which statistical analysis can be performed (Holleran, 1991). Therefore validity provides an accurate measure of an attribute that is of interest and is relevant as shown below.

Zikmund (2003:302) suggests five forms of validity assessment methods:

i) Face validity which is the extent to which, on the surface, an instrument appears to be measuring a particular characteristic. An example would be when subjective agreement exists among professionals that a scale logically appears to reflect accurately what it intends to measure (obvious or common knowledge).

ii) Content validity which is the extent to which research instruments have the capability to reflect the findings in respect of a respective sample of the content area being measured. This involves parametric testing, i.e. it validates the claims that the analysis deems to measure.

iii) Criterion validity which reflects the success of the measure used for either estimation or prediction, or the degree to which a measure correlates with external variables. In the study limited external demographic factors were considered.

iv) Convergent validity which relates to other tests that are considered to measure the same or similar constructs. Convergent validity was used in this study to test constructs for convergence or divergence on the decision variables with factor loading having a fixed value.

v) Construct validity refers to how the scale measures or correlates with the construct that it attempts to measure, i.e. the hypotheses generated from a theory, based on the concepts. Construct validity implies that the empirical evidence generated by a measure is consistent with the theoretical logic of the concepts. When the researchers ask questions (or make statements) as a way of assessing an underlying construct, they should have obtained some kind of evidence that their approach does, in fact, measure the construct in question (Leedy and Ormrod, 2010:92).

Construct validity was ascertained by reviewing a sample of the output of the questionnaire used in the Hong Kong study. The researcher verified that it was an appropriate questionnaire to be used for the research at a tertiary institution within South Africa (see chapter 5). The validity process was done iteratively to improve the construct validity by changing the parameters through a pilot test as required in order to achieve the desired validity.

Both reliability and validity were used in the research to achieve the aim of the research (see chapter 5).

4.12 Ethical Considerations

According to Creswell (2009:87), “Researchers need to protect their research participants, develop trust with them, promote the integrity of research, guard against misconduct and

impropriety that might reflect on their organisations or institutions, and cope with new, challenging problems". It was the responsibility of the researcher to ensure that ethical standards were adhered to. Ethical clearance was obtained from the university to ensure that the study maintained research integrity embodying a range of good research practice and conduct, including intellectual honesty, accuracy, fairness and protection of human participants involved in conducting the research (Miles and Huberman, 1994).

4.12.1 Permission to conduct the study

The researcher obtained permission to conduct the study from the relevant authorities of the Tshwane University of Technology. The request for permission to conduct the study was forwarded to the University of South Africa (see Appendix C), and permission was granted (see Appendix D).

4.12.2 Informed consent forms

The ethical requirement of informed consent means that participation in the research study be voluntary (Leedy and Ormrod, 2001:107). Informed consent forms were thus sent to IT students and lecturers who participated in the research, to sign, stating that they agreed to participate at their own free will (see Appendix E). It was important for participants to understand that the study would be investigating the intended beliefs and actual behaviour of IT users regarding the practising of green IT. The ethical considerations included were the following:

- Making sure everything was ready before the participants arrived.
- Informing the participant about the state of the research (purpose of the study, the procedures, the risks and the benefits of the research, as well as the obligations of both the participants and the researchers) (Nielsen, 1994).

Potential participants were informed that they had the right to decide whether or not they wished to participate in the study.

4.12.3 Confidentiality, privacy and anonymity

Confidentiality was assured by restricting access to the gathered data to the researcher, statistician and supervisors. Moreover, information obtained from the participants would not be shared without their authorisation. Also, participant anonymity was guaranteed by not using the actual names of participants in the study (Dane, 1990:51). Privacy refers to the right that all information obtained in the course of the study would be safe-guarded against intruders or people (Polit and Hungler, 1999; Leedy and Ormrod, 2001:108; Melville, 2001:47). The completed questionnaires will be destroyed after ten years.

4.12.4 Justice and beneficence

Justice requires that people participating in the research should not be treated unfairly. The outcome of the questionnaire did not affect the academic lives of the students and lecturers (Creswell, 2009:89). The research will ultimately benefit IT students and lecturers and did not harm them. In other words, the research was advantageous rather than harmful. Moreover, the researcher did not foresee any potential harm or discomfort for the participants since their names or identities would not be disclosed. In fact, the study benefitted the participants directly in that it made IT students and lecturers aware of how to practise green IT more efficiently and thereby reduce their energy consumption.

4.13 Conclusion

This chapter focused on how data was collected, what research instruments were used, a description of the sample and finally an explanation of the empirical investigation that was followed. Appendix A provides details of the questionnaire.

The next chapter gives a comprehensive description of the data analysis and findings from the data collected through various data collection methods used.

Chapter 5: Data Analysis

5.1 Introduction

The aim of this chapter is firstly to discuss the statistical results of the green IT study and to integrate the empirical findings with the literature review and secondly, to compare the South African (SA) results with those of Hong Kong (HK). This chapter describes the analyses of the data obtained from the survey. The statistical analysis of the data was carried out with SPSS 21.

This chapter presents a report on the demographic variables of the frequency distribution in the South African sample. This is followed by a discussion of the validity and the reliability tests of the constructs of the measures used in the investigation in SA and HK. The factor loading measurements of the decision variables of green IT between the HK and SA studies are compared to determine whether there is a significant difference in the decision variables. The following decision variables were considered: Subjective norms, attitude, perceived behavioural control, intention and actual behaviour. The comparison of the reliability measurements of green IT between the HK study and the South African study is discussed to determine whether there is a significant difference between the Cronbach alphas, the mean and the standard deviation of each decision variable. The correlation between the decision variables of participants with regard to practising green computing is tested to determine whether there is a significant association between decision variables in the SA study. The independent sample test is discussed to test the difference between male and female participants with regard to decision variables.

A one-way analysis of variance (ANOVA) regarding age, current level of study and employment status results is also presented for the SA study. The results are analysed to determine whether there is a significant difference between “age and decision variables”, “level of study and decision variables” and “employment status and decision variables”. Multiple hierarchical regression analysis is used to determine the main factors towards intention and actual behaviour in practising green computing in SA. Structural equation modelling is used to investigate the main latent factors leading to actual behaviour and intended belief (testing the model) in green IT in SA.

The impact on the difference between the partial least square method of analysing data examined in HK and structural equation modelling used in SA is discussed. The major contributing factors towards intention and actual behaviour are also discussed.

The chapter concludes with a summary of the results.

5.2 Demographic Variables with the Frequency Distribution

A total of 380 questionnaires were distributed of which 345 were returned. All the questionnaires returned were suitable for analysis. The demographic information on the 345 participants is shown in Table 5.1. In terms of gender, 200 males account for 58% and 145 females account for 42% of the sample. Most of the participants (42.9%) fell into the age group of 21-25 years, followed by the 16-20 age group (31.3%) and those above 25 years accounted for 25.8% of the sample. There were no participants within the age range of 31-35 and above 40. The majority of the participants (96) were second-year students from the IT department (27.8%), followed by 86 third-year students (24.9%), 82 fourth-year students (23.8%) and 81 first-year students (23.5%). The majority of students were full-time students (77.4%). Marital status was considered insignificant, and therefore was not included as a factor in the analysis because only a few of the students were married.

Figures 5.1 to 5.4 provide a graphical illustration of the sample distribution by gender, age, current level of study and employment status.

Table 5.1: Demographic profile of the frequency distribution of the sample

Gender	**Frequency**	**Percentage**
Male	200	58.0
Female	145	42.0
Total	345	100.0
Age		
16-20	108	31.3
21-25	148	42.9
Above 25	89	25.8
Total	345	100.0
Level of study		
First Year	81	23.5
Second Year	96	27.8
Third Year	86	24.9
Fourth Year	82	23.8
Total	345	100.0
Employment status		
Unemployed	267	77.4
Part-time employed	18	5.2
Full-time employed	60	17.4
Total	345	100.0

Note: Fourth year students consists of 5 lecturers.

Figure 5.1: Sample distribution by gender

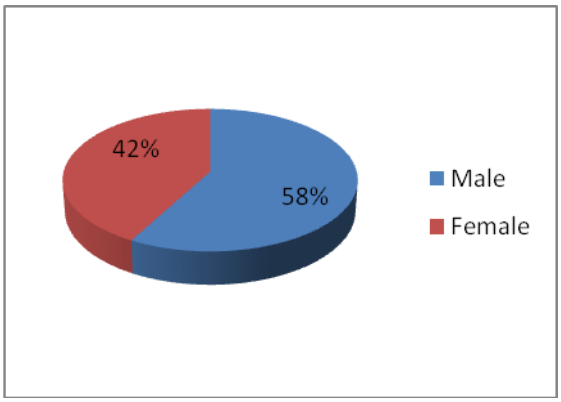


Figure 5 2: Sample distribution by age

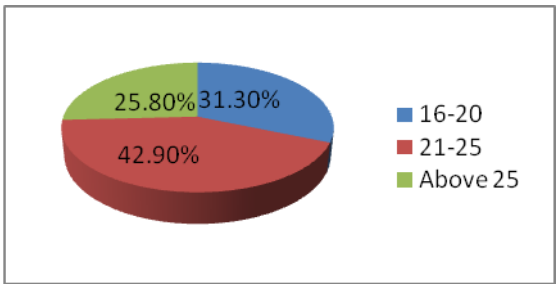


Figure 5.3: Sample distribution by current level of study

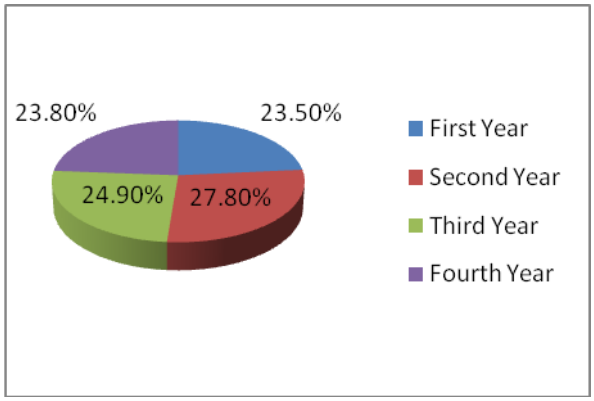
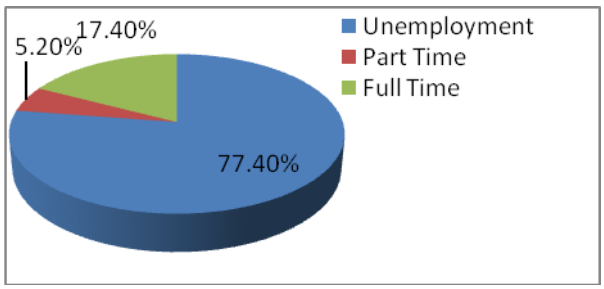


Figure 5.4: Sample distribution by employment status



5.3 Validity of the Sample

To test the convergent validity of all the dimensions in the questionnaire, a factor analysis was carried out to determine whether the individual questions contributed to their respective constructs as contained in the questionnaire. Factor analysis is a statistical method used to describe variability among observed variables in terms of unobserved variables called factors (Gerber and Finn, 1999:181).

There are two types of factor analysis: Exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) (Pallant, 2001:154). Only exploratory factor analysis was considered in this study. Exploratory factor analysis is used to identify the hidden dimensions or constructs which may or may not be apparent from direct analysis (Gerber and Finn, 1999:181). Consider the p-value of the Bartlett test: If the p-value is smaller than 0.05, the correlation structure of the construct is strong enough to conduct a factor analysis. A Kaiser-Meyer-Olkin (KMO) value towards 1 also implies a strong enough correlation structure and was also used within EFA (Pallant, 2001:154). An EFA yields one or more factors from the questions under consideration by applying the following steps to determine the number of factors:

• Determine the cumulative percentage explained by the factors 60% or greater.
• Identify eigenvalues = 1 or above 1 (also called the Kaiser Guttman rule).
• Look at a significant decline in the Scree plot (the shape of the curve changes direction and becomes horizontal).

5.3.1 The extraction and rotation method

Principal component analysis was used for extraction and rotation before the components or factors were calculated and chosen. There are two main rotation methods, namely orthogonal and oblique (Pallant, 2001:154). The orthogonal method ensures that the rotated components are not correlated with each other. The oblique method allows for correlation between the rotated components. The oblique method is preferred when the correlation between components needs to be explored. The most suitable orthogonal methods used for this study are the varimax method and the oblimin or quartimin oblique methods.

5.3.2 Bartlett's test for sphericity and the KMO

Table 5.2 shows the results of Bartlett's test for sphericity and the KMO value. The KMO of 0.835 and the magnitude ($p<0.05$) of Bartlett's test indicate that the correlation structure is significantly strong for performing a factor analysis of the items.

5.3.3 Communalities

The communalities indicate the extent to which an individual item correlates with the other items (Gerber and Finn, 1999:184). A value close to 1 indicates an item that correlates highly with the rest of the items. Items with low communalities (near 0.2) should be reconsidered. For the 19 items, communalities are reasonable as their extraction ranges from 0.549 to 0.732 (see Table 5.3). Note that items refer to components, factors and questions.

5.3.4 Rotated component matrix, factor loading and Scree plot

The rotated component matrix converged after 5 iterations and each construct excluding Q2.6, Q3.3, Q3.4, Q4.1 and Q4.2 fits well (see Table 5.5). Since the researcher selected principal component analysis as the method of extraction, the "Total", "% of Variance", and "Cummulative %" columns are identical to those of the first two components in the "Extraction Sums of squared Loadings" and "Rotation Sums of Squared Loadings" (see Tables 5.4a and 5.4b). After extraction and rotation, the factor loadings are produced as shown in Table 5.5. Factors are grouped as follows: factor 1 "Subjective Norm", factor 2 "Actual Behaviour", factor 3 "Attitude_1", factor 4 "Perceived Behaviour Control", factor 5 "Attitude_2" and factor 6 "Intention". The attitude was split into two factors, namely "Attitude 1" and "Attitude 2"; factor loadings of less than 0.50 were suppressed (Cooper and

Schindler, 2003). Questions (Qns) load to their respective group (see Table 5.5) and the "Total Variance Explained" is above 60% (see Table 5.4b). The significant decline in the Scree plot after 6 components is clearly illustrated in Figure 5.5.

Table 5.2: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.835
Bartlett's Test of Sphericity	Approx. Chi-Square	1933.601
	Df	171
	Sig.	0.000

Table 5.3: Cummunalite

Questions	Extraction	Questions	Extraction	Questions	Extraction
2.1	0.691	3.2	0.635	5.2	0.656
2.2	0.685	3.5	0.580	5.3	0.608
2.3	0.653	3.6	0.615	12.1	0.713
2.4	0.569	4.3	0.509	12.2	0.549
2.5	0.732	4.4	0.723	12.3	0.685
2.7	0.677	4.5	0.685		
3.1	0.622	5.1	0.670		

Table 5.4a: Extraction method - principal component analysis

Total Variance Explained			
Component	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
1	5.135	27.028	27.028
2	2.197	11.562	38.590
3	1.497	7.878	46.467
4	1.267	6.668	53.135
5	1.142	6.009	59.144
6	1.021	5.372	64.516
7	0.744	3.917	68.433
8	0.695	3.656	72.089
9	0.684	3.597	75.686
10	0.614	3.232	78.918
11	0.601	3.164	82.083
12	0.505	2.660	84.742
13	0.490	2.577	87.319
14	0.462	2.433	89.751
15	0.453	2.382	92.133
16	0.433	2.280	94.414
17	0.381	2.004	96.418
18	0.348	1.833	98.252
19	0.332	1.748	100.000

Table 5.4b: Extraction method - principal component analysis

Total Variance Explained					
Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
5.135	27.028	27.028	2.564	13.492	13.492
2.197	11.562	38.590	2.006	10.556	24.048
1.497	7.878	46.467	2.000	10.528	34.576
1.267	6.668	53.135	1.931	10.162	44.738
1.142	6.009	59.144	1.899	9.997	54.736
1.021	5.372	64.516	1.858	9.780	64.516

Figure 5.5: Scree Plot

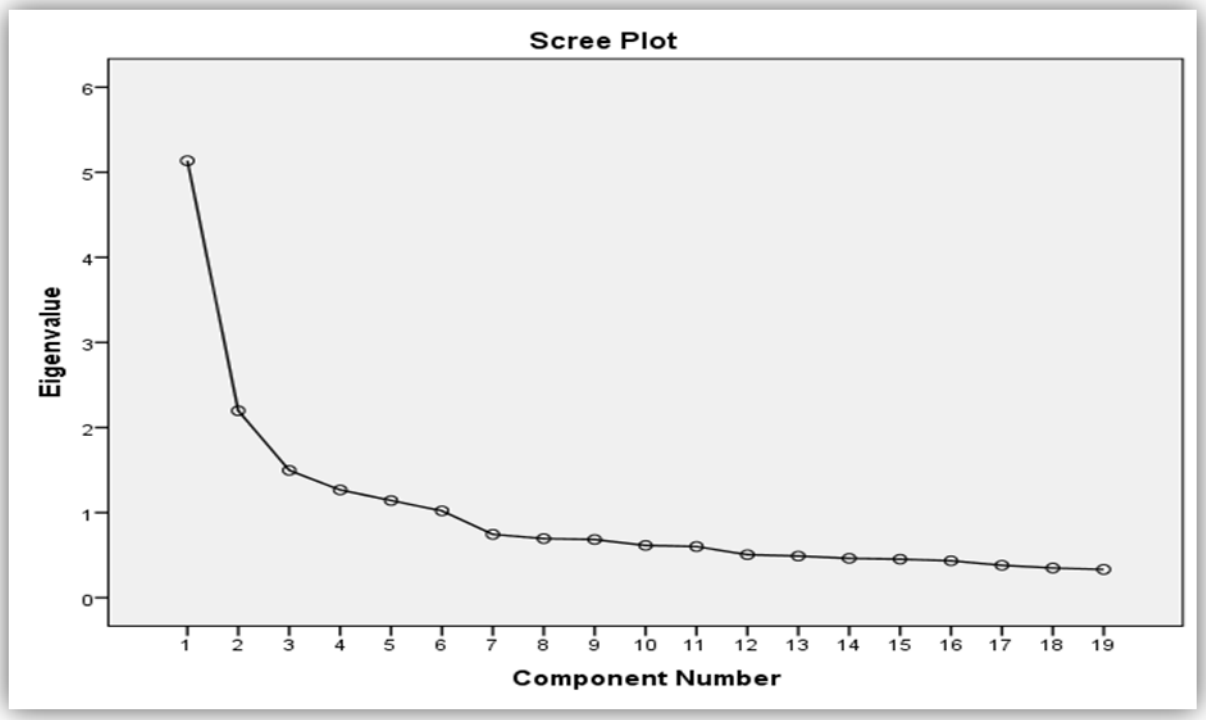


Table 5.5: Extraction method - principal component analysis rotation method-varimax with Kaiser normalisation

Rotated Component Matrix[a]							
Constructs	**Qns**	**Component**					
		1	2	3	4	5	6
Subjective Norm	3.2	0.755					
	3.6	0.745					
	3.1	0.731					
	3.5	0.689					
Actual Behaviour	12.3		0.801				
	12.1		0.784				
	12.2		0.699				
Attitude_1	2.1			0.825			
	2.2			0.824			
	2.3			0.730			
Perceived Behaviour Control	4.4				0.833		
	4.5				0.784		
	4.3				0.628		
Attitude_2	2.5					0.819	
	2.7					0.758	
	2.4					0.660	
Intention	5.2						0.757
	5.3						0.723
	5.1						0.680
	a. Rotation converged in 5 iterations.						

Table 5.6a: Comparison of factor loading of green IT between Hong Kong and South Africa

Constructs	Questions		Measurement Items	Factor Loading		Factor Loading Difference
	SA	HK		SA	HK	
Attitude (ATT)	Q2.1	Q2.1	For me, the idea of practising green computing on a regular basis is beneficial.	0.825	0.852	0.027
	Q2.2	Q2.2	For me, the idea of practising green computing on a regular basis is good.	0.824	0.846	0.022
	Q2.3	Q2.3	For me, the idea of practising green computing on a regular basis is valuable.	0.730	0.856	0.126
	Q2.4	Q2.4	For me, the idea of practising green computing on a regular basis is pleasant.	0.660	0.870	0.210
	Q2.5	Q2.5	For me, the idea of practising green computing on a regular basis is enjoyable.	0.819	0.787	-0.032
	Q2.7		For me the idea of practising green computing on a regular basis is interesting.	0.758		

Table 5.6b: Comparison of factor loading of green IT between Hong Kong and South Africa

Constructs	Questions		Measurement Items	Factor loading		Factor loading difference
	SA	HK		SA	HK	
Subjective Norm (SN)	Q3.1	Q3.1	Most people who are important to me think that I should practise green computing on a regular basis.	0.731	0.797	0.066
	Q3.2	Q3.2	Most people who are important to me practise green computing on a regular basis.	0.755	0.810	0.055
	Q3.5	Q3.5	Most people in my life whose opinions I value practise green computing on a regular basis.	0.689	0.797	0.108
	Q3.6	Q3.6	Most people like me because I practise green computing on a regular basis.	0.745	0.630	-0.115
		Q3.3	It is expected of me that I practise green computing.		0.630	
		Q3.4	The people in my life whose opinion I value would approve of me practising green computing.		0.676	
Perceived Behavioural Control (PBC)	Q4.3	Q4.3	I have total control to improve the practice of green computing.	0.628	0.778	0.150
	Q4.4	Q4.4	I can improve the practise of green computing in the forthcoming months.	0.833	0.855	0.022
	Q4.5	Q4.5	I could definitely improve the practice of green computing in the forthcoming months.	0.784	0.809	0.025
		Q4.2	It is mostly up to me whether or not I improve quality of green computing in the forthcoming months.		0.651	
Intention (INT)	Q5.1	Q5.1	I plan to practise green computing on a regular basis.	0.680	0.867	0.187
	Q5.2	Q5.2	I will make an effort to practise green computing on a regular basis.	0.757	0.878	0.121
	Q5.3	Q5.3	I intend to practise green computing on a regular basis.	0.723	0.651	0.073
Actual behaviour (ACT)	Q6.1	Q6.1	I am currently practising green computing on a regular basis.	0.784	0.921	0.137
	Q6.2	Q6.2	In the past I practised green computing on a regular basis.	0.699	0.921	0.222
	Q6.3		I sometimes practise green computing on a regular basis.	0.801		

Note: If the factor loading difference is greater than 0.05 there is significant difference (Tables 5.6a and 5.6b)

5.3.5 Comparison of difference in factor loading measurements of decision variables of green IT between Hong Kong and South Africa

Attitude

Attitude was measured by the following questions: Q2.1, Q2.2, Q2.3, Q2.4, Q2.5 and Q2.7 for SA and Q2.1, Q2.2, Q2.3, Q2.4 and Q2.5 for HK. The difference of the factor loading in SA and HK ranges from -0.032 to 0.210. All the questions about HK attitude have a higher factor loading except for Q2.5. Question 2.7 (Q2.7) was used for SA only. There was a significant difference of the factor loading with regard to attitude between SA and HK. Note: Attitude is split into two groups: attitude_1 and attitude_2 (see Table 5.6a and Section 5.3.4).

Subjective Norm

Subjective Norm was measured by the following questions: Q3.1, Q3.2, Q3.5 and Q3.6 for SA and Q3.1, Q3.2, Q3.5, Q3.6, Q3.3 and Q3.4 for HK. The difference of the factor loading in SA and HK ranges from -0.115 to 0.108. Questions about subjective norm have a higher factor loading except for Q3.6. Questions 3.3 and Q3.4 were used in HK only. There was a significant difference of the factor loading with regard to subjective norm between SA and HK (see Table 5.6b).

Perceived Behavioural Control

Perceived Behavioural Control was measured by the following questions: Q4.3, Q4.4 and Q4.5 for SA and Q4.3, Q4.4, Q4.5 and Q4.2 for HK. The difference of the factor loading in SA and HK ranges from 0.025 to 0.150. HK has perceived behavioural control with all of the questions having a higher factor loading. Question 4.2 was used in HK only. There was a significant difference of the factor loading with regard to perceived behavioural control between SA and HK (see Table 5.6b).

Intention

Intention was measured by the following questions: Q5.1, Q5.2, and Q5.3 for both SA and HK. The difference of the factor loading in SA and HK ranges from 0.073 to 0.187. Questions involving intention with regard to the HK sample have a higher factor loading except for Q5.3. There was a significant difference of the factor loading with regard to perceived behavioural control between SA and HK (see Table 5.6b).

Actual Behaviour

Actual behaviour was measured by the following questions: Q6.1, Q6.2, and Q6.3 for SA and Q6.1, and Q6.2 for HK. The difference of the factor loading in SA and HK ranges from 0.137 to 0.222. Questions about HK actual behaviour have a higher factor loading. Question

6.3 (Q6.3) was used in SA only. There was a significant difference of the factor loading with regard to actual behaviour between SA and HK.

The majority of the questions in the Hong Kong as well as in the SA studies are relevant as shown in Tables 5.6a and 5.6b. This shows that all measurement items converged on the decision variables, with each factor loading having a value not less than 0.6. Therefore the difference in the factor loadings between SA and HK was insignificant. Also the decision variables demonstrated unidimensionality. A comparison of factor loading is shown in Tables 5.6a and 5.6b. Questions Q3.3, Q3.4 and Q4.2 were not relevant in the SA study but were significant in the Hong Kong study. These questions were rejected from the rotated component matrix as a component which belongs to specific constructs in the model of TPB (see Tables 5.6a and 5.6b). Questions Q2.7, Q6.3 were added to the questionnaire of the SA study and are relevant in the study.

5.4 Reliability Test

A reliable measurement of scale is a benchmark against which the adequacy and accuracy of a measurement procedure are evaluated in scientific research since inappropriate reliability can lead to research bias and poor quality of the results (Gerber and Finn, 1999:188). Hence Cronbach's alpha coefficient is used for estimating the internal consistency measurements (Pallant, 2001:185). This is done by testing the reliability of the questionnaire; an item analysis is performed on the questions of each construct in the questionnaire to produce Cronbach's alpha values to ensure that all the questions of each construct are actually measuring the relevant construct. The Cronbach's alpha value is a significant measure of the reliability of a measuring instrument. Its value will usually increase when the correlations between the questions of the construct increase (Gerber and Finn, 1999:188).

The Cronbach's alpha coefficient is also known as the internal consistency of the test (Pallant, 2001:155). It can take values between negative infinity and 1 (even though only positive values are relevant). The Cronbach's alpha coefficient of the scale was above 0.7, which can be regarded as reliable for all constructs to be used (Churchill, 1979; Nunnally, 1978). Table 5.7 (individual constructs) shows the item-reliability and Cronbach coefficients in terms of the theory of planned behaviour for practising green computing. Item-analyses were conducted separately for attitude, subjective norm, perceived behavioural control, intention and actual behaviour on the current behaviour. Item analysis was conducted on an intention scale to establish construct reliability. Construct reliability is required to enable the researcher to compare the results of different evaluation scores. The scores were calculated as the mean of the individual item-scores within the construct.

Table 5.7: Descriptive statistics and internal consistency reliabilities for the theory of planned behaviour for individual constructs (SA study)

Item	N	Mean	SD	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted	Total Cronbach Alphas
Attitude_1						0.737
2.1	345	1.54	0.610	0.581	0.627	
2.2	345	1.51	0.586	0.558	0.656	
2.3	345	1.55	0.655	0.547	0.671	
Attitude_2						0.702
2.4	345	1.79	0.791	0.443	0.702	
2.5	345	1.91	0.848	0.576	0.535	
2.7	345	1.79	0.797	0.543	0.581	
Subjective Norm						0.780
3.1	345	2.38	1.197	0.576	0.731	
3.2	345	2.75	1.365	0.605	0.716	
3.5	345	2.38	1.151	0.575	0.732	
3.6	345	2.77	1.324	0.589	0.725	
Perceived Behavioural Control						0.707
4.3	345	1.90	0.928	0.454	0.699	
4.4	345	1.93	0.948	0.575	0.554	
4.5	345	2.03	1.034	0.551	0.583	
Intention						0.706
5.1	345	1.85	0.908	0.575	0.547	
5.2	345	1.63	0.832	0.516	0.625	
5.3	345	1.80	0.899	0.482	0.666	
Actual Behaviour						0.712
12.1	345	2.39	1.199	0.613	0.513	
12.2	345	2.75	1.273	0.490	0.694	
12.3	345	1.89	0.843	0.543	0.646	

5.4.1 Comparison of reliability measurements of decision variables of green IT

Table 5.8 shows the comparison of reliability measurements of decision variables of green IT in HK and SA respectively. The reliability of both SA and HK have Cronbach alphas above 0.7 and therefore were considered reliable. The mean and standard deviations (SD) of the decision variables were not similar, as shown in Table 5.8. Hence there was a significant difference between the mean, SD and Cronbach alphas. Even though Cronbach alphas were above 0.7 for the constructs in both SA and Hong Kong, SA has lower values. Note that Q2.4, Q2.5 and Q2.7 are not present in the HK study and were therefore are not compared to HK.

Note: The difference between Attitude_1 (ATT_1) and Attitude_1 (ATT_1) is that they are split constructs which .belong to attitude.

Table 5.8: Comparison of reliability measurements of decision variables of green IT in Hong Kong and South Africa

Constructs	Statistics					
	Alpha		Mean		Standard Deviation	
	SA	HK	SA	HK	SA	HK
Attitude_1 (ATT) (Q2.1,Q2.2 and Q2.3)	0.737	0.895	1.531	3.844	0.500	0.688
Attitude_2 (ATT) (Q2.4, Q2.5 and Q2.7)	0.702		1.833		0.6431	
Subjective Norm (SN)	0.780	0.833	2.570	3.234	0.979	0.656
Perceived Behavioural Control (PBC)	0.707	0.821	1.955	3.605	0.771	0.707
Intention (INT)	0.706	0.821	1.760	3.605	0.892	0.707
Actual behaviour (ACT)	0.712	0.821	2.342	3.605	0.892	0.707

5.5 Correlation

In probability theory and statistics, correlation (often measured in term of a correlation coefficient) indicates the strength and direction of a linear relationship between two random variables (Pallant, 2001:114). To assess the type of relationship, a regression analysis must be done to determine whether the correlation is significant. Because of the conventional dictum that correlation does not imply causation, these correlations cannot be validly used to infer a causal relationship between the variables (Pallant, 2001:116). The research in HK did not show a correlation between decision variables (Chow and Chen, 2009).

The following assumptions are considered in the correlation diagram in Table 5.9 (Pallant, 2001:116).

5.5.1 Assumptions of correlation

• The distributions of both variables related by the coefficient of correlation should be normal.

• The scatter-plots should be linear and homoscedastic (a sequence of random variables is homoscedastic if all random variables in the sequence have the same finite variance).

The assumption of correlation variables was suitable to infer a causal relationship between the variables (see Table 5.9).

5.5.2 Hypothesis testing

The Pearson product-moment correlation of continuous variables was considered. Other correlations exist for ordinal variables (Mukaka, 2012) but was not considered (Pallant, 2001:154). As illustrated in Table 5.9, the r-values range from 0.210 to 0.462. This indicates a reasonable relationship between decision variables. The r-value can range from -1 to 1. If the value of r is close to 1 there is a stronger relationship between decision variables. The p-values smaller than 0.05 indicate a significant correlation between decision variables. The other

correlations can also be obtained from Table 5.9 and all of them are positive. This leads to the following hypotheses which address some of the research questions posed in chapter 1:

Alternate Hypothesis H1: There is a significant correlation (association) between attitude (ATT_2) and intention (INT) to exercise green IT.

Alternate Hypothesis H2: There is a significant correlation (association) between subjective norm (SN) and intention (INT) to exercise green IT.

Alternate Hypothesis H3: There is a significant correlation (association) between perceived behavioural control (PBC) and intention (INT) to exercise green IT.

Alternate Hypothesis H4: There is a significant correlation (association) between attitude (ATT_2) and actual behaviour (ACT) to exercise green IT.

Alternate Hypothesis H5: There is a significant correlation (association) between intention (INT) and actual behaviour (ACT) to exercise green IT.

Alternate Hypothesis H6: There is a significant correlation (association) between subjective norm (SN) and actual behaviour (ACT) to exercise green IT.

Alternate Hypothesis H7: There is a significant correlation (association) between perceived behavioural control (PBC) and actual behaviour (ACT) to exercise green IT.

All the decision variables were significant and were therefore included for regression and structural equation modelling (SEM) (see Table 5.9). Note that ATT_2 refers to “Attitude_2”.

Table 5.9: Correlations

Constructs		**ATT_2**	**SN**	**PBC**	**INT**	**ACT**
ATT_2	Pearson’s Correlation (r)	1	0.379**	0.278**	0.369**	0.210**
	Sig. (2-tailed)(p)		0.000	0.000	0.000	0.000
	N	345	345	345	345	345
SN	Pearson’s Correlation (r)	0.379**	1	0.355**	0.462**	0.406**
	Sig. (2-tailed) (p)	0.000		0.000	0.000	0.000
	N	345	345	345	345	345
PBC	Pearson’s Correlation (r)	0.278**	0.355**	1	0.412**	.329**
	Sig. (2-tailed) (p)	0.000	0.000		0.000	0.000
	N	345	345	345	345	345
INT	Pearson’s Correlation (r)	0.369**	0.462**	0.412**	1	0.410**
	Sig. (2-tailed) (p)	0.000	0.000	0.000		0.000
	N	345	345	345	345	345
ACT	Pearson’s Correlation (r)	0.210**	0.406**	0.329**	0.410**	1
	Sig. (2-tailed) (p)	0.000	0.000	0.000	0.000	
	N	345	345	345	345	345
****** Correlation is significant at the 0.01 level (2-tailed)						

Note:

- Correlation, analysis of variance, multiple regression and structural equation modelling are examined using SPSS for SA only.
- N denotes the number of responses (see Table 5.9)

5.6 Additional Demographic Results with Constructs

The demonstration of the use of a t-test for comparing the means of two populations within the gender is shown in Tables 5.10 and 5.11. The analysis of variance which compares the mean of a larger number of populations (three or more) is shown in Tables 5.12 and 5.13 in order to ascertain whether there are significant differences between the constructs of the TPB model.

5.6.1 Independent samples test: Gender

The mean and standard deviations for attitude, subjective norm, perceived behavioural control, intention and actual behaviour clearly show that there are no significant differences with regard to gender (Tables 5.10 and 5.11).Their p-values (2-tailed Sig.) are greater than 0.05 indicating that there is no significant difference between the mean scores of males and females at a 95% level of confidence with the decision variables.

All the p-values for Levene's test for equality of variances are greater than 0.05 indicating that the variances are equal, therefore the first row p-value (equal variances assumed) needs to be used to test for significant differences (see Table 5.11).

Table 5.10: Independent Samples Test: Group Statistics

Constructs	1.1Gender	N	Mean	Std. Deviation	Std. Error Mean
ATT	Male	200	1.8517	0.63641	0.04500
	Female	145	1.8069	0.65342	0.05426
SN	Male	200	2.6313	0.99020	0.07002
	Female	145	2.4862	0.96140	0.07984
PBC	Male	200	1.9830	0.80740	0.05710
	Female	145	1.9150	0.7188o	0.05970
INT	Male	200	1.7417	0.70528	0.04987
	Female	145	1.7862	0.69018	0.05732
ACT	Male	200	2.3117	0.91521	0.06472
	Female	145	2.3839	0.86186	0.07157

5.6.2 Analysis of variance (ANOVA) among constructs

5.6.2.1 Age

One way ANOVA and Descriptives

The mean and standard deviations from the attitude, subjective norm, perceived behavioural control, intention and actual behaviour clearly illustrate that there are no significant differences with regard to age (Tables 5.12 to 5.15). The p-values of the F-Test with 0.940 (sig.) for attitude, 0.306 for subjective norm, 0.456 for perceived behavioural control, 0.160 for the intention and 0.333 for actual behaviour are all greater than 0.05 (see Table 5.14). Therefore there are no

significant differences between age and attitude, age and subjective norm, age and perceived behavioural control, age and intention, and age and actual behaviour with regard to different age groups. Note: “sig” refers to significant.

Table 5.11: Independent Samples Test for Constructs

Constructs	**Levene's Test for Equality of Variances**		**T-test for Equality of Means**				
	F	p-values	T	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
ATT	0.174	0.677	0.638	343	0.524	0.04477	0.07020
			0.635	305.590	0.526	0.04477	0.07050
SN	1.212	0.272	1.359	343	0.175	0.14504	0.10669
			1.366	315.593	0.173	0.14504	0.10619
PBC	1.701	0.193	0.813	343	0.417	0.06840	0.08410
			0.828	328.836	0.408	0.06840	0.08260
INT	0.081	0.776	-0.584	343	0.559	-0.04454	0.07624
			-0.586	314.240	0.558	-0.04454	0.07598
ACT	1.343	0.247	-0.742	343	0.459	-0.07224	0.09742
			-0.749	320.627	0.455	-0.07224	0.09649

Table 5.12: Descriptives (Age)

Constructs	**Age**	**N**	**Mean**	**Std. Deviation**	**Std. Error**
ATT	16-20	108	1.8148	0.62041	0.05970
	21-25	148	1.8423	0.64412	0.05295
	Above 25	89	1.8390	0.67441	0.07149
	Total	345	1.8329	0.64305	0.03462
SN	16-20	108	2.6157	0.90844	0.08741
	21-25	148	2.6199	1.02290	0.08408
	Above 25	89	2.4326	0.98624	0.10454
	Total	345	2.5703	0.97941	0.05273
PBC	16-20	108	1.9228	0.78221	0.07527
	21-25	148	2.0135	0.78427	0.06447
	Above 25	89	1.8951	0.73614	0.07803
	Total	345	1.9546	0.77104	0.04151
INT	16-20	108	1.6852	0.67876	0.06531
	21-25	148	1.8423	0.70998	0.05836
	Above 25	89	1.7154	0.69550	0.07372
	Total	345	1.7604	0.69831	0.03760
ACT	16-20	108	2.3858	0.86367	0.08311
	21-25	148	2.3829	0.94390	0.07759
	Above 25	89	2.2210	0.83627	0.08864
	Total	345	2.3420	0.89261	0.04806

Leven's Test for Homogeneity of Variances and Robust Test of Equality

Table 5.13 shows the Leven's test for homogeneity of variances. The p-values of 0.776, 0.424, 0.700, 0.746 and 0.227 are all greater than 0.05, indicating that the variances do not differ significantly and the assumption of equality of variances is satisfied. The values of the robust test of equality of means are greater than 0.05 (sig.) meaning there is no significant difference between the means of decision variables (Table 5.15).

Table 5.13: Test of Homogeneity of Variances (Age)

Constructs	Levene Statistic	df1	df2	Sig.
ATT	0.254	2	342	0.776
SN	0.861	2	342	0.424
PBC	0.357	2	342	0.700
INT	0.293	2	342	0.746
ACT	1.490	2	342	0.227

Table 5.14: One-way ANOVA (Age)

		Sum of Squares	df	Mean Square	F	Sig.
ATT	Between Groups	0.052	2	0.026	0.062	0.940
	Within Groups	142.198	342	0.416		
	Total	142.250	344			
SN	Between Groups	2.276	2	1.138	1.187	0.306
	Within Groups	327.707	342	0.958		
	Total	329.983	344			
PBC	Between Groups	0.937	2	0.469	0.787	0.456
	Within Groups	203.573	342	0.595		
	Total	204.511	344			
INT	Between Groups	1.785	2	0.893	1.840	0.160
	Within Groups	165.962	342	0.485		
	Total	167.748	344			
ACT	Between Groups	1.758	2	0.879	1.104	0.333
	Within Groups	272.327	342	0.796		
	Total	274.085	344			

Table 5.15: Robust Tests of Equality of Means (Age)

Constructs		Statistic[a]	df1	df2	Sig.
ATT	Welch	.065	2	205.353	0.937
SN	Welch	1.173	2	209.325	0.311
PBC	Welch	0.793	2	209.656	0.454
INT	Welch	1.827	2	208.275	0.163
ACT	Welch	1.200	2	212.763	0.303
a. Asymptotically F distributed.					

Welch is a method used to test unequal variance of the constructs.

5.6.2.2 Current level of study

One-way ANOVA and Descriptives

The mean and standard deviations from the attitude, subjective norm, perceived behavioural control, intention and actual behaviour clearly show that there are no significant differences with regard to the level of the study, except for perceived behavioural control (Tables 5.16 to 5.19). The p-values of the F-test with 0.688 (sig.) for attitude, 0.132 for subjective norm, 0.115 for the intention and 0.374 for actual behaviour are all greater than 0.05 (see Table 5.18). Therefore there are no significant differences between the level of the study and attitude, level of the study and subjective norm, and level of the study and intention, and level of the study and actual behaviour. Only perceived behavioural control has a sig. value of 0.001 which was less than 0.05 and was thus significant for the level of the study (see Table 5.18).

Table 5.16: Descriptives (Level of study)

		N	Mean	Std. Deviation	Std. Error
ATT	First Year	81	1.7654	0.61338	0.06815
	Second Year	96	1.8438	0.60205	0.06145
	Third Year	86	1.8333	0.67785	0.07309
	Fourth Year / B Tech or Hons	82	1.8862	0.68537	0.07569
	Total	345	1.8329	0.64305	0.03462
SN	First Year	81	2.5494	0.97582	0.10842
	Second Year	96	2.7578	1.03520	0.10566
	Third Year	86	2.5203	0.98236	0.10593
	Fourth Year / B Tech or Hons	82	2.4238	0.89295	0.09861
	Total	345	2.5703	0.97941	0.05273
PBC	First Year	81	1.7901	0.68200	0.07578
	Second Year	96	2.2083	0.89475	0.09132
	Third Year	86	1.8876	0.67565	0.07286
	Fourth Year / B Tech	82	1.8902	0.73153	0.08078
	Total	345	1.9546	0.77104	0.04151
INT	First Year	81	1.6955	0.67946	0.07550
	Second Year	96	1.8576	0.72183	0.07367
	Third Year	86	1.8295	0.70246	0.07575
	Fourth Year / B Tech	82	1.6382	0.67118	0.07412
	Total	345	1.7604	0.69831	0.03760
ACT	First Year	81	2.2757	0.75973	0.08441
	Second Year	96	2.4618	0.95436	0.09740
	Third Year	86	2.3605	0.94311	0.10170
	Fourth Year / B Tech	82	2.2480	0.88395	0.09762
	Total	345	2.3420	0.89261	0.04806

Leven's Test for Homogeneity of Variances and Robust Test of Equality

Table 5.17 shows Leven's test for homogeneity of variances. The p-values of 0.193, 0.372, 0.767 and 0.065 are all greater than 0.05, indicating that the variances do not differ significantly The assumption of equal variances is also satisfied except for perceived behavioural control which has a p-value of 0.012. This violates the assumption of equality variances (Table 5.17). As a result, its robust test of equality of means is significant with 0.005 (sig.) and was the only one which was considered. The other robust tests of equality of means are not significant with values of 0.685, 0.141, 0.117, and 0.391 respectively which are all greater than 0.05 (see Table 5.19).

Table 5.17: Test of Homogeneity of Variances (Level of study)

	Levene Statistic	**df1**	**df2**	**Sig.**
ATT	1.583	3	341	0.193
SN	1.046	3	341	0.372
PBC	3.726	3	341	0.012
INT	0.380	3	341	0.767
ACT	2.427	3	341	0.065

Table 5.18: One-way ANOVA (Level of study)

		Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
ATT	Between Groups	0.613	3	0.204	0.492	0.688
	Within Groups	141.637	341	0.415		
	Total	142.250	344			
SN	Between Groups	5.386	3	1.795	1.886	0.132
	Within Groups	324.597	341	0.952		
	Total	329.983	344			
PBC	Between Groups	9.098	3	3.033	5.292	0.001
	Within Groups	195.413	341	0.573		
	Total	204.511	344			
INT	Between Groups	2.884	3	0.961	1.988	0.115
	Within Groups	164.864	341	0.483		
	Total	167.748	344			
ACT	Between Groups	2.488	3	0.829	1.041	0.374
	Within Groups	271.597	341	0.796		
	Total	274.085	344			

Table 5.19: Robust Tests of Equality of Means (Level of study)

		Statistic[a]	**df1**	**df2**	**Sig.**
ATT	Welch	0.497	3	186.978	0.685
SN	Welch	1.841	3	188.583	0.141
PBC	Welch	4.382	3	189.001	0.005
INT	Welch	1.990	3	188.456	0.117
ACT	Welch	1.006	3	188.678	0.391
a. Asymptotically F distributed.					

5.6.2.3 Employment status

One-way ANOVA and Descriptives

The mean and standard deviations from the attitude, subjective norm, perceived behavioural control, intention and actual behaviour clearly show that there are no significant differences in the relationship between students and job status of staff in terms of decision variables (Tables 5.20 to 5.23). The p-values of the F-test with 0.431 (sig.) for attitude, 0.209 for subjective norm, 0.432 for perceived behavioural control, 0.248 for the intention and 0.514 for actual behaviour are all greater than 0.05 (see Table 5.23). Therefore there are no significant differences between the status and attitude of the students and staff, the status and subjective norm of the students and staff, the status and perceived behavioural control of the students and staff, the status and intention of the students and staff, and the status and actual behaviour of the students and staff with regard to the employment status of the students and staff.

Leven's Test for Homogeneity of Variances and Robust Test of Equality

Table 5.19 shows Leven's test for homogeneity of variances. The p-values of 0.832, 0.058, 0.644, 0.593 and 0.054 are all greater than 0.05, indicating that the variances do not differ significantly. The assumption of equal variances is also satisfied (see Table 5.21). The robust tests of equality of means are not significant with values of 0.387, 0.179, 0.385, 0.230 and 0.524 which are all greater than 0.05 (see Table 5.22).

Table 5.20 Descriptives (Employment)

Constructs		N	Mean	Std. Deviation	Std. Error
ATT	Unemployed	267	1.8489	0.64442	0.03944
	Part-time employed	18	1.6481	0.58825	.13865
	Full-time employed	60	1.8167	0.65362	0.08438
	Total	345	1.8329	0.64305	0.03462
SN	Unemployed	267	2.6199	1.00966	0.06179
	Part-time employed	18	2.3333	0.97769	0.23044
	Full-time employed	60	2.4208	0.81886	0.10571
	Total	345	2.5703	0.97941	0.05273
PBC	Unemployed	267	1.9763	0.78935	0.04831
	Part-time employed	18	2.0185	0.73629	0.17354
	Full-time employed	60	1.8389	0.69567	0.08981
	Total	345	1.9546	0.77104	0.04151
INT	Unemployed	267	1.7928	0.70171	0.04294
	Part-time employed	18	1.7222	0.78591	0.18524
	Full-time employed	60	1.6278	0.64976	0.08388
	Total	345	1.7604	0.69831	0.03760
ACT	Unemployed	267	2.3720	0.88320	0.05405
	Part-time employed	18	2.2407	1.17047	0.27588
	Full-time employed	60	2.2389	0.84615	0.10924
	Total	345	2.3420	0.89261	0.04806

Table5.21: Test of Homogeneity of Variances (Employment)

Constructs	Levene Statistic	df1	df2	Sig.
ATT	0.184	2	342	0.832
SN	2.872	2	342	0.058
PBC	0.441	2	342	0.644
INT	0.523	2	342	0.593
ACT	2.936	2	342	0.054

Table 5.22: Robust Tests of Equality of Means (Employment)

Constructs		Statistic[a]	df1	df2	Sig.
ATT	Welch	0.972	2	41.892	0.387
SN	Welch	1.790	2	42.288	0.179
PBC	Welch	0.976	2	42.229	0.385
INT	Welch	1.526	2	40.898	0.230
ACT	Welch	0.656	2	40.017	0.524
a. Asymptotically F distributed.					

Table 5.23: One-way ANOVA (Employment)

		Sum of Squares	df	Mean Square	F	Sig.
ATT	Between Groups	0.699	2	0.349	0.844	0.431
	Within Groups	141.551	342	0.414		
	Total	142.250	344			
SN	Between Groups	3.007	2	1.503	1.572	0.209
	Within Groups	326.976	342	0.956		
	Total	329.983	344			
PBC	Between Groups	1.002	2	0.501	0.842	0.432
	Within Groups	203.508	342	0.595		
	Total	204.511	344			
INT	Between Groups	1.361	2	0.681	1.399	0.248
	Within Groups	166.386	342	0.487		
	Total	167.748	344			
ACT	Between Groups	1.063	2	0.532	0.666	0.514
	Within Groups	273.022	342	0.798		
	Total	274.085	344			

5.7 Regression Analysis

Regression analysis is a collective name for methods that can be used for the modelling and analysis of numerical data consisting of values of a dependent variable (also called a response variable or measurement) and one or more independent variables (also known as explanatory variables or predictors). The dependent variable in the regression equation is modelled as a function of the independent variables, corresponding parameters ("constants") and an error term. Regression is used for hypothesis testing, and is also referred to as the modelling of causal relationships (Pallant, 2001). The use of regression analysis relies heavily on the underlying assumptions being satisfied. Multiple hierarchical regression analysis was used to model the relationship between one continuous dependent variable and other continuous independent variables.

The following assumptions of regression analysis were used in the research:

- The error is assumed to be a random variable with a mean of zero.
- The independent variables are error-free and the predictors are independent.
- The errors are uncorrelated, that is, the variance-covariance matrix of the errors is diagonal and each non-zero element is the variance of the error.
- The variance of the error is constant across observations (homoscedasticity).

When testing theoretical models, it is important to examine beta scores in order to determine the importance of each variable relative to changes in the dependent variable diversity. “The regression coefficient B and the standardised coefficient beta reflect the change in the dependent measure for each unit change in the independent variable. Comparison between regression coefficients allows for a relative assessment of each variable importance in the regression model” (Hair *et al*., 2006:238). Both B and beta measure similar concepts, where B is the unstandardised coefficient and beta is the value of the standardised regression coefficient calculated from standardised data. The standard error of the regression coefficient is an estimate of how much the regression coefficient will vary between samples of the same size taken from the same population. It is therefore more acceptable in statistical evaluations to look at the beta values for the estimate of the relative importance of each of the independent variables rather than B (Wingerchuk *et al*., 2006). The values for B and beta along with the standard error, t-test and significant results are presented in the Tables 5.26 and 5.29.

Multicollinearity refers to the interrelations of predictor variables (Pedhazur, 1982). High intercorrelation can lead to an increase in sensitivity to sampling and measurement errors (Ford, 2003). When multicollinearity increases, it complicates the interpretation due to the fact that it is more difficult to ascertain the effects of any single variable, because of the interrelationships between variables (Hair *et al*., 2006:557). Multicollinearity is problematic if the variables under examination are not discriminant. This in turn can cause inaccuracies in the multiple regression analysis.

The variance inflation factor (VIF) is the inverse of the tolerance value; instances of higher degrees of multicollinearity are reflected in lower tolerance values and consequently higher VIF values. The VIF translates the tolerance value, which directly expresses the degree of multicollinearity, into an impact on the estimation process: as the standard error increases, the confidence intervals around the estimated coefficients become larger, making it harder to demonstrate that the coefficient is significantly different from zero (Hair *et al*., 2006:227).

Tolerance scores range from 0 (perfect collinearity) to 1 (no collinearity) (Baten, 2006). Tolerance values in a range of 0 to 0.25 indicate a high degree of multicollinearity, and VIF levels equal to or greater than 4.0 indicate multicollinearity as well (Norusis, 2002).

The Durbin-Watson Test is a test for first-order serial correlation in the residuals of a time series regression. A value of 2.0 for the Durbin-Watson statistic indicates that there is no serial correlation (Greene *et al*., 1997). This is a significant condition that indicates the degree to which the independent variables are sufficiently isolated from each other so that the regression values truly measure the contribution of each variable separately without possible cross-variable contamination.

5.7.1 Multiple hierarchical regression analysis to determine actual behaviour

The output from the multiple regression analysis is shown in Tables 5.24 to 5.27. The overall multiple regression model is significant at a 95% level of confidence with a p-value smaller than 0.05. The R-square values are 0.041, 0.163, 0.197, and 0.235 respectively. This indicates the following percentages: 4.1%, 16.3%, 19.7%, and 23.5% of the variation in attitude, subjective norm, perceived behavioural control and intention declared for actual behaviour respectively (see Table 5.24). This is a statistically significant contribution as indicated by the Sig. F change value of (0.000) which is less than 0.05. The ANOVA table indicates that the model as a whole (which includes both blocks of variables) is significant ($F(4, 340) = 27.413$, $p<0.05$) (see Table 5.26). The coefficients show to what extent variables contribute to the model or equation (see Table 5.26). From the significance column, there are only three variables that make a statistically significant contribution (less than 0.05) (see Table 5.27). Attitude is not included since it has a p-value greater than 0.05. In order of importance is subjective norm (beta is 0.248), intention (beta is 0.240) and perceived behavioural control (beta is 0.145). The corresponding VIF scores range from 1.000 to 1.453 (see Table 5.26). This shows a low degree of multicollinearity.

The Durbin Watson score was 1.707, rounded up to 2.000, which is the “ideal” Durbin Watson measure of independence (Pouraghajan and Boroujerdi, 2013:440) (see Table 5.27). This indicates a high level of isolation among the independent variables of the model.

Table 5.24: Model Summary[e] (Actual Behaviour)

Model constructs	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change

1	0.210[a]	0.044	0.041	0.87395	0.044	15.853	1	343	0.000
2	0.410[b]	0.168	0.163	0.81648	0.124	50.978	1	342	0.000
3	0.452[c]	0.204	0.197	0.79977	0.036	15.445	1	341	0.000
4	0.494[d]	0.244	0.235	0.78074	0.040	17.827	1	340	0.000
a. Predictors: (Constant), ATT									
b. Predictors: (Constant), ATT, SN									
c. Predictors: (Constant), ATT, SN, PBC									
d. Predictors: (Constant), ATT, SN, PBC, INT									
e. Dependent Variable: ACT									
Note Durbin-Watson 1.707									

Table 5.25: One-way ANOVA[a] (Actual Behaviour)

Model constructs		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	12.108	1	12.108	15.853	0.000[b]
	Residual	261.977	343	0.764		
	Total	274.085	344			
2	Regression	46.092	2	23.046	34.570	0.000[c]
	Residual	227.993	342	0.667		
	Total	274.085	344			
3	Regression	55.972	3	18.657	29.169	0.000[d]
	Residual	218.113	341	0.640		
	Total	274.085	344			
4	Regression	66.838	4	16.709	27.413	0.000[e]
	Residual	207.247	340	0.610		
	Total	274.085	344			
a. Dependent Variable: ACT						
b. Predictors: (Constant), ATT						
c. Predictors: (Constant), ATT, SN						
d. Predictors: (Constant), ATT, SN, PBC						
e. Predictors: (Constant), ATT, SN, PBC, INT						

Table 5.26: Coefficients[a] (Actual Behaviour)

Model constructs		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	1.807	0.142		12.700	0.000		
	ATT	0.292	0.073	0.210	3.982	0.000	1.000	1.000
2	(Constant)	1.283	0.152		8.447	0.000		
	ATT	0.092	0.074	0.066	1.237	0.217	0.856	1.168
	SN	0.347	0.049	0.381	7.140	0.000	0.856	1.168
3	(Constant)	1.046	0.161		6.512	0.000		
	ATT	0.044	0.073	0.031	0.592	0.554	0.833	1.201
	SN	0.292	0.050	0.320	5.890	0.000	0.789	1.268
	PBC	0.238	0.061	0.206	3.930	0.000	0.850	1.177
4	(Constant)	0.925	0.159		5.809	0.000		
	ATT	-0.018	0.073	-0.013	-0.245	0.807	0.800	1.250
	SN	0.226	0.051	0.248	4.440	0.000	0.714	1.401
	PBC	0.168	0.062	0.145	2.734	0.007	0.787	1.270
	INT	0.307	0.073	0.240	4.222	0.000	0.688	1.453
a. Dependent Variable: ACT								

Table 5.27: Model Summary[d]: Multiple hierarchical regression analysis to determine intention

Model constructs	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	0.369[a]	0.136	0.134	0.64985	0.136	54.220	1	343	0.000
2	0.508[b]	0.258	0.253	0.60343	0.121	55.807	1	342	0.000
3	0.559[c]	0.312	0.306	0.58179	0.054	26.910	1	341	0.000
a. Predictors: (Constant), ATT									
b. Predictors: (Constant), ATT, SN									
c. Predictors: (Constant), ATT, SN, PBC									
d. Dependent Variable: INT									
Note: Durbin-Watson 2.087									

5.7.2 Multiple hierarchical regression analysis to determine intention

The output from the multiple regression analysis is shown in Tables 5.27 to 5.29. The overall multiple regression model is significant at a 95% level of confidence with a p-value smaller than 0.05. The R-square values are 0.136, 0.258 and 0.312 respectively. This indicates the following percentages: 13.6%, 25.8%, and 31.2% of the variation in attitude, subjective norm and perceived behavioural control declared for intention (see Table 5.27). This is a statistically significant contribution as indicated by the F change value of this line (0.000) which is less than 0.05. The ANOVA table indicates that the constructs in the model as a whole are significant ($F(3, 341) = 51.530$, $p < 0.05$) (see Table 5.28). The coefficient table shows how variables contribute to the model or equation. From the significance column, there are only three variables that make a statistically significant contribution (less than 0.05) (see Table 5.29). In order of

importance they are subjective norm (beta is 0.302), perceived behavioural control (beta is 0.253) and attitude (beta is 0.184). The corresponding VIF scores range from 1.000 to 1.268 (see Table 5.26).

The Durbin Watson score was 2.087, rounded to 2, which is the "ideal" Durbin Watson measure of independence (see Table 5.27). This indicates a high level of isolation among the independent variables of the model.

Table 5.28: One-way ANOVA[a] (Intention)

Model constructs		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	22.897	1	22.897	54.220	0.000[b]
	Residual	144.850	343	0.422		
	Total	167.748	344			
2	Regression	43.218	2	21.609	59.345	0.000[c]
	Residual	124.530	342	0.364		
	Total	167.748	344			
3	Regression	52.326	3	17.442	51.530	0.000[d]
	Residual	115.422	341	0.338		
	Total	167.748	344			
a. Dependent Variable: INT						
b. Predictors: (Constant), ATT						
c. Predictors: (Constant), ATT, SN						
d. Predictors: (Constant), ATT, SN, PBC						

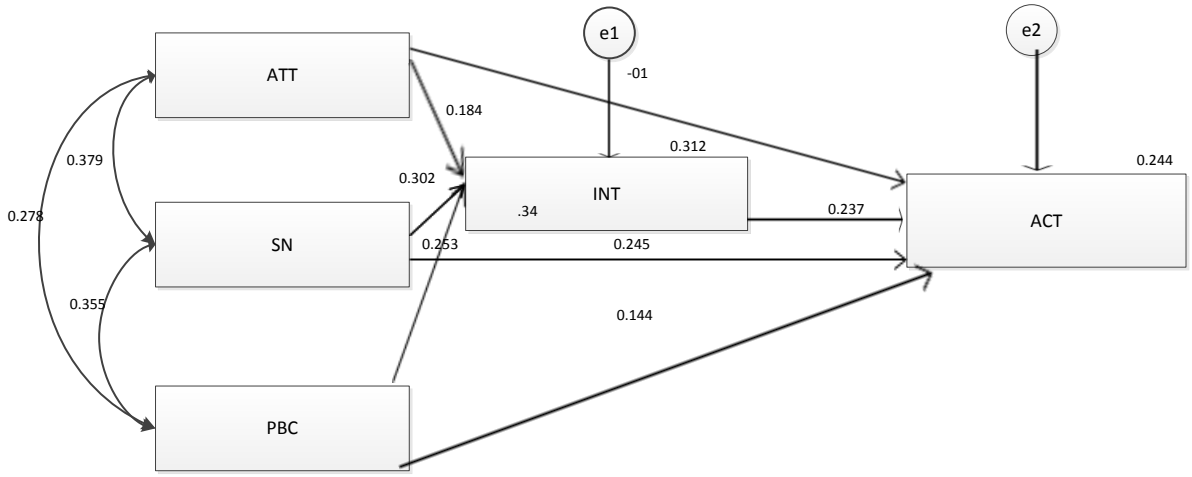
Table 5.29: Coefficients (Intention)

Model Constructs		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	1.025	0.106		9.687	0.000		
	ATT	0.401	0.054	0.369	7.363	0.000	1.000	1.000
2	(Constant)	0.620	0.112		5.519	0.000		
	ATT	0.246	0.055	0.227	4.506	0.000	0.856	1.168
	SN	0.268	0.036	0.376	7.470	0.000	0.856	1.168
3	(Constant)	0.392	0.117		3.353	0.001		
	ATT	0.200	0.053	0.184	3.747	0.000	0.833	1.201
	SN	0.216	0.036	0.302	5.977	0.000	0.789	1.268
	PBC	0.229	0.044	0.253	5.187	0.000	0.850	1.177
a. Dependent Variable: INT								

5.8 Structural Equation Modelling

Structural equation modelling (SEM) was used to determine the main factors leading to actual behaviour and intended belief in SA. SEM was used to estimate all coefficients in the model in order to evaluate the significance and strength of the relationships within the model. The independent variable in one relationship becomes a dependent model in other relationships in the model. Latent variables in structural equation modelling eliminate measurement errors leading to more valid coefficients being achieved as shown in Figure 5.6.The hypothesis test values are rounded to two decimal places and all discussions in Sections 5.8.1 to 5.8.5 focus on the model in Figure 5.6. Correlation shown on the left hand side in Figure 5.6 is discussed in Section 5.8.2.

Figure 5.6: Structural equation modelling



Note: For each indicator an error term was appended. The error terms were arbitrary names with a term ‘e’ and a numerical value. To indicate the relationships, double headed arrows were used to represent the covariance. The single headed arrows were used to represent the casual relationship between decision variables. Rectangle shape indicates the constructs.

5.8.1 Parameter summary and result

The parameter summary and results which constitute mean and intercepts have fixed, labelled and unlabelled values of 0. Weights, covariance and variance results are shown in Table 5.30.

Table 5.30: Parameter summary

	Weights	Co-variances	Variances	Total
Fixed	2	0	0	2
Labelled	0	0	0	0
Unlabelled	6	3	5	14
Total	8	3	5	16

Note: Mean and intercept columns have been removed.

Chi-square (χ^2) and degree of freedom (df)

The hypotheses are tested with χ^2. A perfect fit is where χ^2 = df (Dion, 2008:366). The estimated parameters of the model are shown in Table 5.30. When degrees of freedom (df) become larger, the model is rejected. The sample size interrelates with a lack of fit to produce a large χ^2. The χ^2 value is the measure of the difference between what the actual relationships in the sample are and what could be anticipated if the model was assumed to be correct (Dion, 2008:365). A large difference suggests that the model does not fit adequately. The χ^2 value must be interpreted in terms of its degrees of freedom. This is done by calculating a ratio of the χ^2/df. A model that represents the sample data well could yield a ratio close to 1 (a value above 1 is rejected). The measurement model test resulted in a good fit between the data and the proposed measurement model. The χ^2/df (0.061/1) was used in the model with a probability level of 0.805.

5.8.2 Maximum likelihood estimates

The parameters are estimated by maximum likelihood (ML) methods rather than by ordinary least square (OLS) methods (Dion, 2008:366). OLS methods minimise the squared deviations between the values of the criterion variable and those predicted by the model. ML (an iterative procedure) attempts to maximise the likelihood that obtained values of the criterion variable are correctly predicted.

Standardised regression weights

Table 5.31: Standardised regression weights

Estimate			
INT	←	SN	0.302
INT	←	PBC	0.253
INT	←	ATT	0.184
ACT	←	PBC	0.144
ACT	←	INT	0.237
ACT	←	SN	0.245

The path coefficients in Table 5.31 match those which are obtained from multiple regressions and are significant ($p<0.05$) even though there was a slight difference of 0.001 between direct effects of subjective norm (SN) toward actual behaviour (ACT).

Correlations

Table 5.32 shows the simple correlations between exogenous variables (predictor variables). All of them are significant ($p<0.05$), ranging from 0.278 to 0.379.The correlation between attitude and subjective norm has a higher value. For more details refer to Figure 5.6.

Table 5.32: Correlations

Estimate			
ATT	**<-->**	SN	0.379
PBC	**<-->**	SN	0.355
PBC	**<-->**	ATT	0.278

5.8.3 Squared multiple correlations

Table 5.33 shows the squared multiple correlation coefficients in the two multiple regressions. The squared multiple correlation coefficient gives the proportion of the variability in the item indicators which is due to the respective latent construct; each having 0.244 for intention and 0.3212 for actual behaviour. A high squared multiple correlations coefficient for an indicator implies that it is strongly related to the latent constructs identified by the other specified indicators. Furthermore, the squared multiple correlation coefficients for the latent constructs "actual behaviour" and "intention" indicate that about 56% of the variability is accounted for in the model.

Table 5.33: Squared multiple correlations (see Figure 5.6)

	Estimate
INT	0.312
ACT	0.244

The total effect of one variable on another can be divided into separate direct effects (no intervening variables involved) and separate indirect effects (one or more intervening variables). For example, consider the effect of PBC on ACT. The direct effect is 0.204 (the path coefficient from PBC to ACT) (see Table 5.34). The indirect effect, through "intention", is computed as the product of the path coefficient from PBC to INT and the path coefficient from INT to ACT, (0.253) (0.237) = 0.060 similar with standardised indirect effects of PBC (see Tables 5.34 and 5.36). The total effect is the sum of direct and indirect effects, 0.204 + 0.060 = 0.264 (see Tables 5.34 and 5.36).

The direct effect of ATT on ACT is 0.044. The indirect effect through "intention" is computed as the product of the path coefficient from ATT to INT and the path coefficient from INT to ACT, (0.184) (0.237) = 0.044, which is similar to the standardised indirect effects of ATT (see Table 5.36). The total effect is the sum of direct and indirect effects, 0.044 + 0.044 = 0.088 (see Tables 5.34 and 5.36).

The direct effect of SN on ACT is 0.316 and indirect effect through "intention" is computed as the product of the path coefficient from SN to INT and the path coefficient from INT to ACT, (0.302) (0.237) = 0.072 (see Table 5.36). The total effect is the sum of direct and indirect

effects, 0.316 + 0.072 = 0.388 (see Table 5.34). The standardised direct and indirect effects are significant (p<0.01) (see Tables 5.35 and 5.36).

Standardised total effects

Table 5.34: Standardised total effects

	SN	ATT	PBC	INT
INT	0.302	0.184	0.253	0.000
ACT	0.316	0.044	0.204	0.237

Standardised direct effects

Table 5.35: Standardised direct effects

	SN	ATT	PBC	INT
INT	0.302	0.184	0.253	0.000
ACT	0.245	0.000	0.144	0.237

Standardised indirect effects

Table 5.36: Standardised indirect effects

	SN	ATT	PBC	INT
INT	0.000	0.000	0.000	0.000
ACT	0.072	0.044	0.060	0.000

5.8.4 Model fit summary

CMIN

Table 5.37: CMIN

Model	NPAR	CMIN	DF	P	CMIN/DF
Default model	14	0.061	1	0.805	0.061
Saturated model	15	0.000	0		
Independence model	5	334.248	10	0.000	33.425

NPAR is the number of parameters in the model. In the saturated (just-identified) model there are 15 parameters: 5 variances (one for each variable) and 10 path coefficients. For our tested (default) model there are 14 parameters meaning that one was discarded which is attitude towards actual behaviour (see Table 5.37). For the independence model (one where all of the paths have been deleted) there are five parameters which represent the variances of the five variables. CMIN is χ^2 technique comparing the tested model and the independence model to the saturated model. CMIN/DF, the relative χ^2, is an index of how much the fit of data to model has been reduced by dropping one or more paths. One rule of thumb is not to drop too many paths so that the index does not exceed 2 or 3 (see Table 5.37).

RMR, GFI

RMR, the root mean square residual, is an index of the amount by which the estimated (the model) variances and covariances differ from the observed variances and covariances. There are smaller variances and covariances differences which are suitable for the estimated model. GFI (the goodness of fit index) shows what proportion of the variance in the sample variance-covariance matrix is accounted for by the model. This must exceed 0.9 for a good model (Bollen, 1989:274). AGFI (adjusted GFI) is an alternate GFI index in which the value of the index is adjusted for the number of parameters in the model. The fewer number of parameters in the model relative to the number of data points (variances and covariances in the sample variance-covariance matrix), the closer the AGFI would be to the GFI. The PGFI index is adjusted to support the model as well as to not support the model in which few path(s) have been deleted from the model (see Table 5.38).

Table 5.38: RMR and GFI

Model	RMR	GFI	AGFI	PGFI
Default model	0.002	1.000	0.999	0.067
Saturated model	0.000	1.000		
Independence model	0.196	0.649	0.474	0.433

Baseline comparisons

The goodness of fit indices (GFI) compare the model to the independence model rather than to the saturated model. The normed fit index (NFI) reflects the difference between the two models (χ^2 divided by the χ^2 for the independence model). For our data this amounts to (334.248-0.061) / 334.248= 1.000. Values of 0.9 or higher (some say 0.95 or higher) indicate a good fit (Dion, 2008:366). The comparative fit index (CFI) uses a similar approach (with a non-central χ^2) and is said to be a good index for use even with small samples. The acceptable range is from 0 to 1, similar to the NFI, and 0.95 (or 0.9 or higher) indicates a good fit. The incremental fit index (IFI) is also relatively insensitive to sample size. Values that exceed 0.90 are regarded as acceptable, although the index can exceed 1 (Dion, 2008:366). IFI is the ratio of difference between the χ^2 of the independence model in which variables are uncorrelated and the chi-square of the target model. The χ^2 of the target model is calculated by dividing the difference between the chi-square of the target model and the df for the target model. The TLI, sometimes referred to as NNFI, is similar to the NFI. TFL is relatively independent of sample size (Marsh, Balla and McDonald, 1988). The TFI and relative fit index *(*RFI) are usually lower than the GFI, but values over 0.90 or over 0.95 are considered acceptable (Hu and Bentler, 1999). TLI is greater than GFI and acceptable together with RFI (see Table 5.40).

Table 5.39: Baseline comparisons

Model	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI
Default model	1.000	.998	1.003	1.029	1.000
Saturated model	1.000		1.000		1.000
Independence model	0.000	0.000	0.000	0.000	0.000

Parsimony-adjusted measures

Parsimony-adjusted measures (PRATIO) refer to the ratio of how many paths were dropped to how many could have been dropped. The parsimony normed fit index (PNFI) is the product of NFI and PRATIO, and PCFI is the product of the CFI and PRATIO (1.000*0.100=0.100). The PNFI and PCFI are intended to reward those whose models are parsimonious (contain few paths) (see Table 5.40).

Table 5.40: Parsimony-adjusted measures

Model	PRATIO	PNFI	PCFI
Default model	0.100	0.100	0.100
Saturated model	0.000	0.000	0.000
Independence model	1.000	0.000	0.000

RMSEA

The root mean square error of approximation (RMSEA) estimates lack of fit compared to the saturated model. An RMSEA of 0.05 or less indicates a good fit, and 0.08 or less an adequate fit (Hair *et al*., 1995:656). LO 90 and HI 90 are the lower and upper limits of a 90% confidence interval for the estimate. PCLOSE is the p-value which tests whether the null hypothesis of the RMSEA is less than 0.05. The model has an RMSEA less than 0.05 and is a good fit (see Table 5.41).

Table 5.41: RMSEA

Model	RMSEA	LO 90	HI 90	PCLOSE
Default model	0.000	0.000	0.070	0.872
Independence model	0.307	0.279	0.336	0.000

5.8.5 HOELTER

Our sample size is smaller than the values shown in Table 5.42, therefore the researcher did not reject the null hypothesis (our model fits the data just as well as the saturated model). This is because the default model values are greater than the sample size in the SA study.

Table 5.42: HOELTER

Model	HOELTER 0.05	HOELTER 0.01
Default model	21771	37602
Independence model	19	24

5.9 Comparison of Results in SA and HK

The model fits the theory of planned behaviour well (see Figure 5.6). Most decision variables are significant except an attitude towards actual behaviour, similar to the Hong Kong study conducted in 2009. Multiple regression results are similar to structural equation and thus are treated similar in this research. The major contributing factors are not the same for SA and HK (see Table 5.43).

Table 5.43: Difference between results in Hong Kong and South Africa

Hong Kong	South Africa	Implications
1. The independent sample test was not used to compare the significant difference between gender and decision variables.	The independent sample test was not used to compare the difference between gender and decision variables.	There was no significant difference between gender and decision variables in SA.
2. ANOVA was not used to compare the significant difference between level of study and decision variables.	ANOVA was used to compare the difference between level of study and decision variables.	There was significant difference between level of study and PBC in SA.
3. Marital status was not considered.	Marital status was considered.	Data was not enough for marital status to be considered for analysis.
4. ANOVA was not used to compare the significant difference between employment status and decision variables.	ANOVA was used to compare the difference between employment status and decision variables.	There was no significant difference between employment status and decision variables.
5. PLS was used for analysis.	Used structural equation modelling AMOS 21.0 for the analysis.	PLS method is designed to maximise prediction rather than to fit as SEM.
6. Perceived behavioural control was the greatest factor contributing to the actual behaviour of practising green IT.	Subjective norm was the greatest factor contributing to the actual behaviour of practising green IT.	The main contributing factor in HK is different from SA.
7. Attitude was the greatest factor contributing to the intention of practising green IT.	Subjective norm was the greatest factor contributing to the intention of practising green IT.	The main contributing factor in HK is not the same for SA and HK.
8. University students made up the sample of the population.	IT students and staff made up the sample of the population.	Students who were also staff at TUT in SA enabled the researcher to understand more on resources being used by TUT lecturers.

The major contributing factor in SA is the subjective norm towards actual behaviour and intention. In HK it was perceived behaviour control towards actual behaviour and attitude towards intention. There was also a significant difference between the mean and standard deviation of the decision variables as shown in Table 5.7. The factor loadings in SA and HK were significant but SA has a lower factor loading than HK. Analysis of variance of demographic factors shows that there is a significant difference of the mean of perceived behavioural control with the current level of education but there is no significant difference between age and employment status with the decision variable. There was significant correlation among all

decision variables. The differences between the results in Hong Kong and South Africa are summarised in Table 5.43.

5.10 Results and Discussion

Table 5.44: Summary of the structural model with hierarchical regression analysis (N = 345) from chapter 5

Path	Hypothesis	$R^{2\#}$	$\Delta R^{2@}$	Path coefficient	t-value	Results
Prediction of intention						
ATT-INT	H1	0.136	0.136	0.184	3.747	Supported
SN-INT	H2	0.258	0.122	0.302	5.977	Supported
PBC-INT	H3	0.312	0.056	0.253	5.187	Supported
Prediction of actual behaviour						
ATT-ACT	H4	0.044	0.044	-0.013	-0.245	Not Supported
SN-ACT	H5	0.168	0.124	0.248	4.440	Supported
INT-ACT	H6	0.204	0.036	0.240	4.222	Supported
PBC-ACT	H7	0.244	0.040	0.145	2.734	Supported

5.10.1 Results of the structural model with hierarchical regression analysis

Table 5.44 shows the hypothesis testing of the model and Figure 5.6 shows the final diagram of SEM. $\Delta R^{2@}$ is the change in R^2, which represents the value leading to the final $R^{2\#}$ when a corresponding final decision is accepted. In column 3, $R^{2\#}$ is an accumulative value of $\Delta R^{2@.}$ Therefore a higher value of $R^{2@}$ represents a higher explanatory power which is regarded as the main factors.

The results show that H1, H2 and H3 are supported. This means that variables of attitude, subjective norm and perceived behavioural control all have direct effects on the intention to practise green IT. The path coefficients and $\Delta R^{2@}$ are 0.184, 0.302, 0.253, and 0.136, 0.122, 0.056 respectively. The explanatory power shown by $R^{2\#}$ is 0.312. Subjective norm is the dominant factor in each student's belief in green IT. Hypotheses H5, H6, and H7 are supported. ATT, SN and PBC have direct effects on ACT, therefore the path coefficient and $\Delta R^{2@}$ are 0.248, 0.240, 0.145 and 0.124, 0.036, 0.040 respectively. The explanatory power shown by R^{2a} is 0.244. Subjective norm is the dominant factor in each student's behaviour in green IT. Hypothesis H4 was not significant. However, attitude cannot be neglected as a decision variable for ATT-ACT. Attitude has an indirect effect on ACT through the path ATT-INT-ACT. The total indirect effect is 0.184*0.240=0.044.

5.10.2 Results of the model evaluation regarding overall fit measurement

The proposed model was evaluated using structural equation modelling (SEM). The data obtained was tested for reliability and validity using confirmatory factor analysis (CFA).

Table 5.45: Summary of the model evaluation regarding overall fit measurement

Measure	Recommended values	Value
Ratio χ^2 /df	<3	0.061
Root mean square residual (RMR)	<0.05	0.002
Goodness of fit index (GFI)	>0.9	1.000
Normed fit index (NFI)	>0.9	1.000
Non-normed fit index (Tucker Lewis Index (TLI))	>0.9	1.029
Comparative fit index (CFI)	>0.9	1.000
Root mean square error of approximation (RMSEA)	<0.05-0.08	0.000

SEM was used to test if the empirical data conformed to the presumed model. The model included 19 items describing five latent constructs: Attitude, subjective norm, perceived behavioural control, intention and actual behaviour. The measurement model test presented a good fit between the data and the proposed measurement model. For instance, the χ^2/df (0.061/1) was used because of an inherent difficulty with the sample size. The χ^2 /df value was 0.061. The model presents a good fit for the data, based on this suggestion. The value of GFI is 1.000. RMSEA was less than the recommended range of acceptability (<0.05-0.08) suggested by MacCallum *et al*. (1996). Thus, the measurement model provides a good fit with the data based on assessment criteria such as RMR, GFI, NFI, NNFI, CFI and RMSEA.

Figure 5.6 presents the significant structural relationships among the research variables and the standardised path coefficients. Most of the hypotheses were strongly supported except for hypothesis H4. Regarding hypothesis H4, the results indicate that attitude towards green computing on actual behaviour is not significant. However, it does have a significant indirect effect on actual behaviour through intention for hypotheses H1 and H5 (H1: β=0.184, P<0.01 and H5: β=0.237, P<0.01) and also has a significant positive direct effect on intention to green computing (H1: β=0.184, P<0.01). This means that the attitude of IT users towards green computing is an important determinant of performing actual behaviour. The results also show that subjective norm directly influences intention (H2: β=0.302, P<0.01) and that actual behaviour to practise green computing (H6: β=0.245, P<0.01) indirectly influences actual behaviour. The results confirm that perceived behavioural control positively and directly influences both intention (H3: β=0.253, p<0.01) and actual behaviour (H7: β=0.144, p<0.01). The data also shows that intention directly influences actual behaviour (H5: β=0.237, p<0.01) to practise green computing.

5.10.3 Discussion

The theory of planned behaviour and the theory of reasoned action were used to frame the significance of each hypothesis. The research uncovered the most important factors of green IT through the use of SEM and hierarchical regression analysis. This enabled the researcher to find the most critical constructs of intention and actual behaviour. Thus the beliefs and behaviours of IT users around green IT could be understood better.

Intention to practise green IT

Subjective norms towards green IT have the highest path coefficient and explain 39% of the variance in the intention to practise green IT. The decision variable of attitude contributes 44% and PBC 17%. These results differed from those found in the Hong Kong study. Our results showed that IT user's intention to practise green IT is highly dependent on what most people think, what most "people in my life whose opinion's I value" think and how most "people like me" engage in green IT activities. In the urban areas of South Africa and in universities several measures and campaigns have been put in place to promote green IT; these include recycling plastic boxes on campuses that allow students to deposit old laptops, PCs, memory sticks, printers and cell phones.

Actual green IT behaviour

According to Chow (2009:140) and De Vries *et al*. (1988), the intention of an act plays a higher influencing role than the factor of self-efficacy or perceived behavioural control in predicting the actual behaviour. However, the researcher of this study found different results. The decision variable of subjective norm in the research study was found to have a higher path coefficient and explained 51% of the variance in the actual behaviour. This finding implies that IT users will actually carry out green IT activities by modelling the expectation of their peers and people they respect. The decision variable of perceived behavioural control has a slightly higher direct effect on intention than actual behaviour. This implies that IT users will actually carry out green IT if they have total control over the means of doing so. Some of the activities may include events such as hibernating the PC when not in use, using a smart phone to read notes, using electronic means for assignments and communication with students, and using a memory stick, PowerPoint for presentations and CDs or DVDs. However, the decision variable SN remains the main factor dictating commitment of IT users to green IT followed by intention towards actual behaviour.

5.11 Summary

This chapter examined the frequency distribution of the demographic variables, as well as reliability and convergent validity of the measuring instruments used before the correlation, independent sample test, analysis of variance, regression analysis and structural equation modelling were done.

The results show that the measurement instruments were reliable and valid. The comparison of factor loading of green IT between the Hong Kong and South Africa studies showed that there is a significant difference. Moreover, all measurement items converged on the decision variables, with each factor loading having a value above 0.6. There was a significant difference between the mean and standard deviation of each decision variable in SA compared to HK. Correlation between the decision variables was deemed to be suitable for use in regression and structural equation modelling in SA. The correlation shows an association for all the decision variables for the model of green IT. Analysis of variance showed that there was no significant difference between “gender and decision variables” and “employment status and decision variables” but there was a significant difference between “level of education and perceived behavioural control”. Perception of behaviour control increased from first-year to second-year students. It mighty be because students adapt to new environments and knowledge. Perception of behaviour control decreased from second-year to third-year students due to the pressure of exams, the participants appeared to give more priority to class work. Then perception of behaviour control increased slightly from third-year students to fourth-year students, but the difference was insignificant. Marital status showed an imbalance and as a result was not considered for analysis in SA.

Multiple hierarchical regression analysis and structural equation modelling show that subjective norm was the main contributing factor in actual green IT behaviour and intention in SA even though perceived behavioural control was the greatest factor contributing to the actual behaviour of practising green IT in HK in 2009. Attitude towards the actual behaviour of practising green IT was not significant but was important in determining intention and actual behaviour indirectly in SA. Attitude was the greatest factor contributing to the intention of practising green IT in HK. University students made up the sample of the population in HK. IT students and staff made up the sample of the population at TUT; this enabled the researcher to understand more about the resources being used by the participants. The different methods used for analysis did not have a major impact on the results because the PLS method is

designed to maximise prediction rather than to fit, and SEM is used to determine the most likely models but both are used for testing latent variables. Analyses were conducted to determine multicollinearity and VIF scores.

Chapter 6 provides a conclusion to this study, limitations and some recommendations for future studies.

Chapter 6: Conclusion and Future Research

6.1 Introduction

Most research in green IT tend to focus on the practices of large IT vendors and companies (Williams and Curtis, 2008:12; Wilbanks, 2008:64; Kurp, 2008:11). There is thus a need to examine the beliefs of individual IT users about green IT and their actual behaviour in this regard, as such beliefs and behaviour impact significantly on energy consumption and computer design. The main research question that this study aimed to answer was, “Are IT users concerned with regard to green IT issues?” The main purpose of this study was thus to evaluate the beliefs and actual behaviour of IT users regarding green IT in South Africa. This was done by means of a survey involving university students and lecturers.

The paucity of local research on this subject justified the importance of conducting this study. A hypothesis research model based on the theory of planned behaviour (TPB) was used to empirically evaluate the main factors contributing to green IT awareness. A mixed research method formed the paradigm whereby aspects from both the interpretive and positivist research approaches could be combined. Data was collected from university students and lecturers by means of a questionnaire. The data was then captured and analysed for convergent validity. The reliability of the measurement items was tested using Cronbach’s alpha.

The rest of this chapter is organised as follows: Section 6.2 provides an overview of the research, followed by Section 6.3 which summarises the findings of the study. In Section 6.4 a summary of the whole research study is given. The limitations of the study are discussed in Section 6.5, followed by some of the most important contributions of the study in Section 6.6. The recommendations and suggestions for future work are presented in Sections 6.7 and 6.8 respectively.

6.2 Overview of the Research

Below is an overview of the study where each chapter is briefly summarised.

Chapter 1 introduced the study by giving a background of the increasing need to examine IT users’ beliefs and behaviour regarding green IT issues. This chapter presented the research questions that needed to be answered in order to address the problems identified. The major objective of this study was to evaluate the theoretical framework which was used to assess how

users practised green IT. Hence, in chapter 1 the specific objectives were set and that needed to be met before the goal could be achieved.

Chapter 2 examined the literature related to green computing. Issues that were looked at in this chapter included possible solutions for the high consumption of energy, the use of renewable resources in data centres, recycling of IT resources and improvements in productivity, as well as computer design and green energy sustainability. This, then, set the scene for the objectives of this study.

In chapter 3 the development of the theoretical framework of the models of green IT was discussed. Based on the literature, and by using the theory of reasoned action and the theory of planned behaviour, the factors were established that were deemed essential in the development of the conceptual framework of the study. Based on this conceptual framework, relationships between the identified constructs were hypothesised.

Essentially chapter 4 presented the relevant research design and methodology that were followed in this study. The methods that were used to collect the data were discussed, as well as how the participants were selected and how the collected data was analysed. The chapter also included a discussion on the construction of the questionnaire and described the assumptions, delineations and limitations of the research.

Chapter 5 presented the results of the study. There were two parts to the results: First, the chapter presented the demographic characteristics of the participants followed by descriptive statistics that showed how each item in the questionnaire was answered. In the second part the results obtained from the confirmatory factor analysis (CFA), Cronbach's alpha, correlation, analysis of variance (ANOVA), multiple hierarchical regression and structural equation modelling (SEM) were presented. A comparison between the South African study presented in this dissertation and the Hong Kong study conducted in 2009 was presented. Lastly, the hypotheses that had been mentioned in chapter 3 were tested and the results tabulated.

In this concluding chapter the researcher presents and discusses the interpretation of the research findings and the implications of practising green IT. This chapter also details how the findings may be applied in the context of a university green IT policy.

6.3 Summary of the Findings

The data analysis section of this study provided partial answers to the hypotheses, the objectives, and the main and sub-research questions. A summary of the findings is given below. Conclusions are then drawn from the findings and recommendations are made.

6.3.1 Objectives

General objective

Table 6.1: Objectives

To determine the most significant factors that are associated with the (supporting or non-supporting) beliefs and actual behaviour (supporting or non-supporting) of IT users. Subjective norm was the most significant factor that was associated with beliefs and actual behaviour of IT users (see Section 5.7 and Section 5.8).

Table 6.2: Specific objectives

To promote the commitment of individuals to behave in a sustainable way to promote green IT. The students and staff who participated in the survey managed to use the available resources efficiently and effectively and were aware of the impact on the environment and people. Individuals thus behaved in a sustainable way by relying on alternative media. A follow-up study was conducted (see Appendix B).
To determine the main demographic factors that influence decision variables pertaining to green IT. One of the main demographic factors, i.e. "level of education" was found to have an influence on perceived behavioural control (see Section 5.6.2).
To identify the gap between literature trends and existing exercises in green IT. The literature review showed that limited research has been done on the practice of green IT behaviour and the beliefs of individual IT users. Most of the research sugest ways to reduce the consumption of energy by reviewing other related work done in different parts of the world (see chapter 2). The researcher managed to find research conducted in Hong Kong by Chow and Chen in 2009 on which the current study was based.
Hypotheses (see figure 1.2)
H1: The results show that the attitude of IT users has an association with the intention to exercise green IT.
H2: The results show that subjective norm has an association with the intention to exercise green IT.
H3: The results reveal that the perceived behavioural control of IT users has an association with the intention to exercise green IT.
H4: The results show that the attitude of IT users has an association with actual green IT behaviour to exercise green IT.
H5: The results reveal that the intention of IT users has an association with actual green IT behaviour to exercise green IT.
H6: The results show that subjective norm of IT users has an association with actual green IT behaviour to exercise green IT.
H7: The results reveal that perceived behavioural control of IT users has an association with actual green IT behaviour to exercise green IT.

6.3.2 Research questions

The research revealed that IT users were concerned with regard to green IT issues and that the university where the study was carried out is providing incentives for practising green computing. The majority of staff members and students had limited knowledge regarding the real meaning of green IT before the commencement of the study. The participants were aware of some of the effects of green IT after these were explained and were then more concerned about and interested in practising green IT themselves.

Sub questions

What is the main factor associated with the beliefs or intent of IT users to practise green IT?

As mentioned in chapter 5, the researcher did a follow-up study. Subjective norm was the main factor associated with intention. Other factors such as attitude and perceived behavioural control affect intention but have less influence compared to subjective norm (see Section 5.7 and Section 5.8).

From the open-ended questions some of the results indicate the following: The advantage of practicing green IT is to reduce the cost. The disadvantage is that most students, when under pressure of writing examinations and test, do not practice green IT to the same degree. When it comes to green IT most students use resources effectively and efficiently since majority of the students attended Green IT worshops at least once during the past 5 years. Most students think their lecturers and IT experts would encourage them to practise green computing. They are of the opinion that the whole of South Africa should practise green computing to prevent environmental pollution. Friends could hinder them in their IT students to practice green IT. The majority of students look at their friends or lecturers when they are not sure what to do (practicing green IT). Resources such as emails, CDs, DVDs, external hard drives and smart phones enable IT users to practise green computing. They were aware of the policies of the university that work against Green IT, such as not to switch off the computers during the day and using CRT monitors that consume high volume of energy consumption (See Appendix A).

What is the main factor associated with IT users' actual behaviour to behave in ways consistent with green IT?

Subjective norm was the main factor associated with actual behaviour. Other factors such as perceived behavioural control and intention also affect actual behaviour. Attitude did not affect actual behaviour. Attitude has an indirect effect on actual behaviour so was regarded as a significant factor of the decision variables (see Section 5.7 and Section 5.8).

What are the main factors associated with IT users' beliefs or intent and actual behaviour which is in agreement (same) when practising green IT?

Subjective norm was the main factor associated with actual behaviour and intent (see Section 5.7 and Section 5.8).

The Tshwane University of Technology have launched several campaigns to promote green computing such as placing recycling boxes on campuses that allow students to deposit unwanted computing resources such as PCs and laptops (approximately 99%) and printed output. Over the a three months period IT users had used fewer IT resources such as printing paper (approximately 90%), and also reduce the use of other devices such as 96% of students powering off the PC when not in use (also refer to Appendix B). Electronic substitution of paper forms was used such as students registering through ITS, putting announcements on the TUT e-Tutor facility, and electronic campus (EC), and lecturers demonstrating tutorials using "Nettop software".

6.4 Conclusion

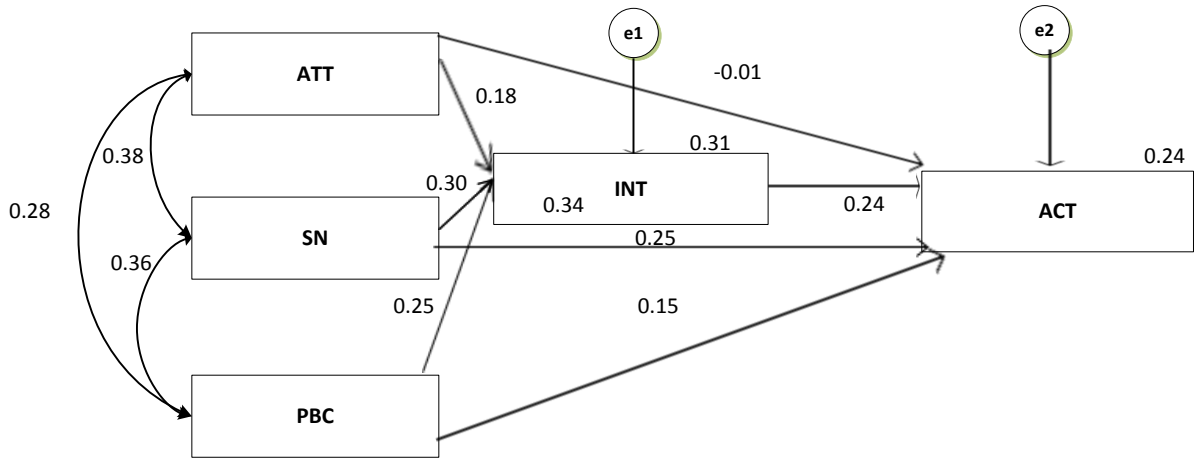
The research questions were shown to be reliable and of value for future research as discussed in chapter 5 (see Sections 5.3 and 5.4). Gender, age and level of study were almost equally balanced except for employment status. There was a significant difference between the level of education and perceived behavioural control. This means that the level of education as an external factor is a major contributing factor with regard to the level of perceived behavioural control. The more knowledge individual IT users have, the more perceived behavioural control they will be able to exert. There was no significant difference between "gender and decision variables" and "employment status and decision variables". This means that gender and employment status as external factors do not affect the decision variables in terms of practising green IT. There was a significant difference between South Africa and Hong Kong with regard to the mean and standard deviation of the decision variables. The difference in factor loadings between South Africa and Hong Kong was significant with South Africa having a lower factor loading than Hong Kong. This means that the decision variables in the South African study are different from those of the Hong Kong study.

Table 6.3: Summary of differences between Hong Kong and South Africa

Hong Kong		South Africa	
Contributing factors	**Implications**	**Contributing factors**	**Implications**
1. An independent sample test	Not carried out	An independent sample test	No significant difference between independent sample test
2. ANOVA (level of study and perceived behavioural control)		ANOVA (level of study and perceived behavioural control)	Significant difference between level of study and perceived behavioural control
3. Marital status		Marital status	Not considered for analysis
4. ANOVA (employment status and decision variables)		ANOVA (employment status and decision variables)	No significant difference between employment status and decision variables
5. Partial Least Square	The Partial Least Square method is designed to maximise production	Structural equation modelling	A structural equation modelling method is designed to fit the model
6. Perceived behavioural control	A main contributing factor is perceived behavioural control towards actual behaviour	Subjective norm	Subjective norm is the main contributing factor towards actual behaviour
7. Attitude	The main contributing factor is attitude towards intention	Subjective norm	Subjective norm is the main contributing factor towards intention
8. Only university students	Limited information on resource utilisation	Both university students and staff	Enough information on resource utilisation

The research study examined the perception of IT students regarding intended beliefs and actual behaviour through the use of the theory of planned behaviour. It was found that attitude, subjective norm and perceived behavioural control have an association with the intention and actual behaviour of practising green IT. Furthermore, attitude, subjective norm and perceived behavioural control have a direct effect on the intention of practising green IT. These findings will help green IT researchers and experts to concentrate on the most significant activities so that the behaviour of IT users and their beliefs about green IT can be better understood. With regard to the hierarchical regression analysis and structural equation modelling, subjective norm was found to be the dominant factor in the accomplishment of intention. The results of South Africa are different from the Chow and Chen results in Hong Kong as shown in Table 6.3 (Chow and Chen 2009:140). In terms of actual green IT behaviour, subjective norm is the most critical factor affecting actual behaviour of green IT in South Africa.

Figure 6.1: Structural equation modelling: Research model for green computing



These results show that the dominant factors that determine whether individuals practise green IT are different from the Chow and Chen findings (Chow and Chen 2009:140). IT students and lecturers tend to have a higher level of green IT intention than is reflected in their actual behaviour (see Figure 6.1). To encourage IT students and lecturers to translate their intention into actual behaviour, IT policies need to be designed and implemented. Also IT experts need to design a green environment that enables IT students and lecturers to embrace such a green approach. Attitude regarding green IT was found to be statistically significant but the subjective norm is the single-most important factor which needs to be taken into consideration when promoting green IT in SA. The co-variance shown on the left-hand side in Figure 6.1. The diagram shows that the main contributing constructs based on co-variance between attitude and subjective nom (r=0.38).

In conclusion, the hypotheses, objectives and research questions were answered. The findings of this study may help to promote energy conservation and other green IT initiatives by encouraging efficient and effective use of information systems and technology.

6.5 Limitations

- The theory of planned behaviour (TPB) does not factor in personality and emotions of IT students and lecturers.
- The theory of planned behaviour is based on the assumption that humans are rational beings that make systematic judgments.
- The theory does not account for unconscious motives.

- The theory of planned behaviour is designed to measure a very specific action. The theory thus only allows for the achievement of those specific actions and does not consider related behaviours. In this case, the theory was used to study the intention and actual behaviour of practising green IT.
- The research does not focus on social capital factors such as the influence of parents (e.g. financial background).
- Another limitation of the study is the actual measures of attitude, subjective norm, perceived behavioural control and intention towards the act. These measures are indirect because actual observations of these variables are not possible, but they could still include TPB predictions as part of a broader model.
- The research is specific to the context of the Tshwane University of Technology (TUT) and cannot be generalised to other universities.
- The data used in this study was collected at one point in time. This was followed by a follow-up to measure any subsequent change in beliefs and behaviour.
- Due to the lack of knowledge of users with regards to green IT concepts, as well as the explosive development in technological innovations and adoption, the results of this study may be limited in terms of forecasting general future trends.
- Due to the lack of resources the location of the research was limited to Tshwane University of Technology.

Nevertheless, these limitations may spark a number of new research studies.

6.6 Research Contribution

The research shows that there appears to be a reduction in the use of hardware where equivalent software devices are available to replace the hardware (see Appendix B). The empirical results of the study provide new insights into the behaviour and beliefs of IT users practising green IT, which is still in its infancy due to limited research. The study used university students and lecturers as a sample population. The research showed that energy can be conserved through the use of different methods such as recycling waste material, switching the machine when not in use, and following the trend where software is replacing hardware.

In terms of the study, it appears that the subjective norm is critical since it is the major contributing factor towards enhancing actual behaviour and the intention of practising green IT.

The university can help to preserve the environment through implementing green IT practices (see chapter 2) which will also lead to a reduction in costs. A well-documented policy framework and an implementation guide should be drawn up by the university to encourage reduced energy consumption.

Finally, this study presents a comprehensive analysis of the effect of the subjective norm, perceived behavioural control and attitude on the intention and actual behaviour of individual IT users practising green IT.

6.7 Recommendations

In terms of the findings from this research study, the following is recommended:

- Manufacturers and IT experts need to design PCs and laptops with high usability based on user requirements. They should focus on the most important subjective norms in order to understand the behaviour of IT users and their beliefs, and tailor IT devices accordingly and in line with green IT practices.
- This study provides researchers with important knowledge regarding the practice of green IT which they can use for further research and for encouraging IT users to employ IT resources more efficiently and effectively in a sustainable way.
- It is recommended that the Tshwane University of Technology implement a green IT policy that is available to all.
- Corporate sponsors should reward residential universities which implement sustainable green IT policies with incentives to further improve their efficiency and effectiveness regarding the practice of green IT.
- An IT user's intention and actual behaviour to practise green IT are highly dependent on "what most people think", "what most people in my life whose opinion's I value think" and "how most people like me behave" (i.e. the user's peers) when engaging in green IT activities. The university should therefore educate new students and staff on green IT practices from the first day so that all students and staff members will engage in green IT right from the beginning. One way of doing this would be for the university to introduce subjects on green IT into the university curriculum in collaboration with producers of information technology and IT experts.

6.8 Future Research

In view of the findings of this research, the following recommendations are made for future research:

- Further research could focus on the following constructs: Outcome evaluation, the strength of behavioural beliefs and control beliefs, normative beliefs, the injunction of a normative referent and the power of control factors. The data analysis for reliability and convergent validity can be found in Appendix F.
- A comparative study across different universities would be interesting as South Africa is a diverse country and each province might prove to have different beliefs and behaviour patterns influenced by different political and socio-economic circumstances.
- Future studies could assess the practice of green IT by applying longitudinal surveys rather than a slice-time method as used in this research. Using data collected over a longer time period will help researchers to forecast possible trends in green computing in the institutions.
- Future investigations could be conducted to examine whether the subjective norm continues to be the most significant predictor of intention and actual behaviour with regard to the practice of green IT. It is not clear whether the findings of the current study are unique or can be generalised to other contexts.
- Future research might consider using a post-intentional approach, such as implementation intention in addition to the TPB. In this approach, participants are not just asked what they intend to do, but are also asked to formulate a very specific plan about how they would go about achieving their goal. In this way, an individual is forced to think about the realities of their behavioural plan, which may otherwise be too vague. Implementation intention may better predict practice behaviour than merely the intention.
- Future investigations should examine the mediating effect of past behaviour in the relationship between intention and actual behaviour with regard to the practice of green IT.
- This study has found that the level of education is important when it comes to perceived behaviour control. Therefore more research should be done around the question of the way in which education affects perceived behaviour control.

Reference

Adams, N. E., Bandura, A. & Beyer, J. (1977). Cognitive processes mediating behavioral change. *Journal of Personality and Social Psychology, 35*(3), 125-139.

Adams, N. E., Bandura, A., Hardy, A. B. & Howells, G. N. (1980). Tests of the generality of self-efficacy theory. *Cognitive Therapy and Research, 4*(1), 39-66.

Agarwal, S. & Nath, A. (2011). Green computing - a new horizon of energy efficiency and electronic waste minimization: A global perspective. *Communication Systems and Network Technologies (CSNT)*, 688-693.

Ajzen, I. (1985). From intentions to actions: a theory of planned behavior. In J. Kuhl. & J. Beckmann(Eds.), Efficacy toward a unifying theory of behavioural change. *Psychological Review, 84*(2), 191-215.

Ajzen, I. (1991). The Theory of planned behavior. *Organizational Behavior and Human Decision Process, 50*, 179-211.

Ajzen, I. (2002). Constructing a Tpb questionnaire: Conceptual and methodological considerations: results of the structural model winter. *Journal of Computer Information Systems, 141*.

Ajzen, I. & Fishbein, M. (1975). *Belief, attitude, intention and behavior: An introduction to theory and research.* Reading, MA: Addison - Wesley.

Ajzen, I. & Fishbein, M. (1977). Attitude-behavior relations: A theoretical analysis and review of empirical research. *Psychological Bulletin, 84*(5), 888-918.

Ajzen, I. & Fishbein, M. (1980). *Understanding attitudes and predicting social behavior.* Englewood Cliffs, NJ: Prentice Hall.

Ajzen, I. & Fishbein, M. (2003). Questions raised by a reasoned action approach: Comment on Ogden. *Health Psychology, 23*(4), 431-434.

Ajzen, I. & Madden, T. J. (1986). Prediction of goal-directed behavior: Attitudes, intentions and perceived behavioral control. *Journal of Experimental Social Psychology, 22*(5), 453-474.

Armitage, C. J. & Conner, M. (2001). Efficacy of the theory of planned behaviour: A meta-analytic review. *British Journal of Social Psychology, 40*(4), 471-499.

Babbie, E. (2001). *The practice of social research.* Belmont, CA: Wadsworth.

Babbie, E. (2005). *The basic of social research.* Thomson: Wadsworth.

Babbie, E. (2009). *The practice of social research .* Belmont, CA: Wadsworth.

Bandura, A. (1978). Reflections on self-efficacy. In S. Rachman (Ed.), *Advances in Behavioral Research and Therapy.* Oxford, England: Pergamon Press.

Bandura, A. (1982). Self-efficacy mechanism in human agency. *American Psychologist, 37*(2), 122-147.

Bandura, A. (1986). Social foundations of thought and action: A social cognitive theory. Beckmann (eds.), *Action control: From cognition to behavior, 11-39.* (pp. 11-39). Englewood Cliffs, NJ US: Prentice-Hall.

Bandura, A. (1997). *Self- efficacy: The exercise of self-control.* New York: W.H. Freeman and Company.

Berthon, P., Crittenden, V., Desautels, P. & Pitt, L. (2010). *Get the most out of green it*. Retrieved June 12, 2012, from http://www.iienet2.org/details.aspx?id=21932

Bhattacherjee, A. (2012). *Social science research: Principles, methods and practices.* USF Open Access Textbooks Collection.

Bollen, K. A. (1989). Structural equations with latent variables. In S. Wiley, *Probability and mathematical statistics* (p. 514). New York: Wiley.

Bradley, N. (2007). *Marketing research, tools and techniques.* New York: Oxford.

Bradsher, K. & Barboza, D. (2006, June 11). Pollution from Chinese coal casts a global shadow. *The New York Times*, 1-6.

Budde, P. (2010). *ICT solutions for global warming and energy saving*. Retrieved May 14, 2012, from http://www.reportbuyer.com/blog/ict-solutions-for-global-warming-andenergysaving/

Burns, N. & Grove, S. K. (2003). *Understanding nursing research.* Philadelphia, PA: Saunders, W B.

Burrell, G. & Morgan, G. (1979). *Sociological paradigms and organizational analysis.* London: Heinemann.

Cearly, D. W. (2008). *Gartner's top 10 strategic techniques for 2009*. Retrieved July 1, 2012, from http://blogs.gartner.com/david_cearley/2008/10/14/gartner%E2%80%99stop-10-strategic-technologies-for-2009/

Charles, C. M. (1995). *Introduction to educational research.* San Diego: Longman.

Cheung, W., Chang, M. K. & Lai, V. S. (2000). Prediction of internet and world wide web usage at work: A test of an extended triandis model. *Decision Support Systems, 30*, 83-100.

Chin, W. W., Marcolin, B. L. & Newsted, P. R. (2003). A partial least squares latent variable modeling approach for measuring interaction effects: Results from a Monte Carlo simulation study and an electronic-mail emotion/adoption study. *Information Systems Research, 14*(2), 189-217.

Chow, W. S. (2001). Ethical belief and behavior of managers using information technology for decision making in Hong Kong. *Journal of Managerial Psychology, 16*(4), 258-267.

Chow, W. & Chen, Y. (2009). Intended belief and actual behavior in green computing in Hong Kong. *Journal of Computer Information Systems, 50*(2), 136-141.

Churchill, G. A. (1979). A paradigm for developing better measures of marketing constructs. *Journal of Marketing Research, 16*(1), 64.

CNET Networks. (2007). *IT departments slow to adopt green tech*. Retrieved March 27, 2013, from http://www.zdnet.co.uk/news/systems-management/2007/05/14/it-departments-slow-to-adopt-green-tech-39287053/

Cocktail. (2010). *A perfect mixture for Mac OS X*. Retrieved May 12, 2012, from http://fypower.org/news/?p=601

Cooper, D. R. & Schindler, P. S. (2003). *Business research methods.* Boston: McGraw-Hill Inc.

Cooper, D. R. & Schindler, P. S. (2008). *Business research methods.* Boston: McGraw-Hill Inc.

Cooper, D. R. & Emory, C. W. (1995). *Business research methods.* Chicago: Irwin.

Corporation, M. (2006). *Help save energy and the environment by putting your monitor to sleep*. Retrieved May 14, 2012, from http://www.microsoft.com/windowsxp/using/setup/tips/sleep.mspx

Costanzo, A. (2006). The eastern lowland gorilla: Saving the victims of coltan. *Bepress Legal Series*, 1586-1596.

Creswell, J.W. (2007*).* Qualitative inquiry and research design: Choosing among five approaches (2nd ed.). Thousand Oaks,. CA: Sage.

Creswell, J. W. (2009). *Research design: Qualitative, quantitative and mixed methods approach.* Thousand Oaks: Sage Publications Inc.

Crotty, M. (1988). *The Foundations of social research: Meaning and perspective in the research process.* London: Sage Publications.

Da Silva, R. (2009). Green computing – power efficient management in data centers using resource utilisation as a proxy for power. *Manuscript submitted for publication, Computer Science and Engineering*.

Dane, F. C. (1990.). *Research methods.* Califonia: Brooks / Cole.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use and user acceptance of Information Technology. *MIS Quarterly, 13*(3), 319-340.

Davis, F. D. & Venkatesh, V. (1996). A Model of the antecedents of perceived ease of use: Development and test. *Decision Sciences, 27*(3), 451-481.

De Vaus, D. A. (2001). *Research design in social research.* London: Sage Publications Ltd.

De Villiers, M. R. (2007). Interpretive research models for Informatics: Action research, grounded theory, and the family of design and development research. *Alternation* (12), 10-52.

De Villiers, M. R. (2012). Models for Interpretive information systems research, part 2: Design research, development research, design - science research and design - based research – a meta-study and examples. In M. Mora, O. Gelman, A. Steenkamp & M. S.

Raisinghani, .(eds).*Research Methodologies, Innovations and Philosophies in Software Systems Engineering and Information Systems.* Autonomous University of Aguascalientes, Mexico.

De Vries, H., Kijkstra, M. & Kuhlman, P. (1988). Self-efficacy: The third factor besides attitude and subjective norm as a predictor of behavioral intentions. *Health Education Research, 3*(3), 273-282.

Dillman, D. (2000). *Constructing the questionnaire: Mail and internet surveys.* New York: John Wiley & Sons.

Dillion, A. & Morris, M. (1996). User acceptance of information technology: Theories and model. In *Annual Review of Information Science and Technology* (pp. 3-32). Medford NJ: Information Today, Inc.

Dion, P. A. (2008). Interpreting structural equation modelling results: A reply to Martin and Cullen. *Journal of Business Ethics,* 83(3): 365-368.

Dista, G. (2003). Executive Information Systems use in organisational contexts: An exploratory user behaviour testing. *Information Management: Support systems & Multimedia Technology*.

Dumas, J. S. & Redish, J. C. (1993). *A practical guide to usability testing.* Norwood, NJ: Ablex Publishing Company.

Durrheim, K. (1999). Research design. In M. Terre Blanche, & K. Durrheim, *Research in practice: Applied methods for the social sciences.* Cape Town: UCT Press.

Dutta, S. K., Upadhyay, V. & Sridharan, U. (2006). Environmental management of industrial hazardous wastes in India. *Journal of Environmental Science & Engineering, 48*(2), 143-150.

Emissions, R. G. (2010). *Discussion paper for public comment*. Retrieved March 12, 2012, from http://uscdn.creamermedia.co.za/assets/articles/attachments/31159_31158_discussion_paper_carbon_taxes_81210[1].pdf

energystar.org. (n.d.). *Verizon's monitor and PC power management initiative could save $7million annually*. Retrieved June 08, 2012, from ehttp://www.energystar.gov/ia/products/power_mgt/VerizonCaseStudy.pdf

Environmental Protection Agency. (2012). *Lead in paint, dust and soil*. Retrieved October 26, 2012, from http://www.epa.gov/lead

Erickson, F. (1982). Audiovisual records as a primary data source. *Sociological Methods and Research, 11*(2), 213-232.

Erickson, F. (1992). Ethnographic microanalysis of interaction. In M. D. Lecompte, W. L. Milroy, & J. Preissle, *The handbook of qualitative research in education.* New York: Academic Press.

Eskom. (2013). *Eskom calls for cost-related tariff*. Retrieved November 1, 2013, from http://www.fin24.com/Companies/Industrial/Eskomcalls-for-cost-related-tariff-20120523

Espiner, T. (2007, 4 May). IT departments slow to adopt green tech. *Daily Newsletter*.

Foster, A. & Ford, N. (2003). Serendipity and information seeking: An empirical study. *Journal of Documentation, 59*(3), 321-340.

Francis, C. D. (1990). *Research methods.* Pacific Grove, Calif: Brooks / Cole Pub. Co.

Galliers, R. D. (1991). *Choosing appropriate systems approaches: A revised taxonomy, information systems research.* Amsterdam, North Holland.

Gartner, P. C. (2012). *Gartner Says 60 percent of virtualised servers will be less secure than the physical servers they replace through 2012*. Retrieved May 21, 2013, from http://www.gartner.com/it/page.jsp?id=1322414

Gerber, S. B. & Finn, K. V. (1999). *Using SPSS for Windows: Data analysis and graphics.* New York: Springer.

Goddard, W. & Melville, S. (2001). *Goddard, W. & Melville, S. 2001. Research methodology: An introduction.* (2nd e.d). South Africa: Juta and Co.

Godin, G. & Kok, G. (1996). The Theory of planned behavior: A review of its applications to health-related behaviors. *American Journal of Health Promotion, 11*, 87-98.

Golafshani, N. (2003). Understanding reliability and validity in qualitative research. *The qualitative report, 8*(4), 597-607.

Greene, K. L., Hale. J.L. & Householder, B. J. (2002). The theory of reasoned action. In J. P. Dillard, & M. Pfau, *The persuation handbook: developments in theory and practice* (pp. 259 - 286). Thousand Oaks, CA: Sage.

Greene, K., Hale, J. L. & Rubin, D. L. (1997). A test of the theory of reasoned action in the context of condom use and AIDS. *Communication Reports, 10*(1), 21-33.

Grimshaw, A. (1982). Sound-image data records for research on social interaction: Some questions and answers. *Sociological Methods and Research, 11*(2), 121-144.

Grix, J. (2004). *The foundations of research.* New York, NY: Palgrave Macmillan.

Gupta, P. &.Singh. G. (2012). Minimizing power consumption by personal computers: Technical survey. *International Journal of Information Technology and Computer Science, 4*(10), 57-66.

Hair, J.F., Black, W.C., Babin, J.B., Anderson, R.E., Tatham, R.L. & Black, W. C. (2006). *Multivariate data analysis.* Upper Saddle River, NJ. : Pearson Prince Hall.

Hair, J. F., Anderson, R. E., Tatham, R. L. & Black, W. C. (1995). *Multivariate data analysis.* New York: Macmillan Publishing Company.

Hair, J., Bush, R. P. & Ortinau, D. J. (2000). *Marketing research: A practical approach for the new millennium.* Burr Ridge: Irwin, R D.

Hanna, L., Risden, K. & Alexander, K. J. (1997). Guidelines for usability testing with children. *Interactions*, 9-14.

Hannum, A., Jonker, J. & Pennink, B. (2010). *The Essence of research methodology: A concise guide for master and PhD students in management science.* The Essence of research methodolodology. New York: Springer.

Harmon, R. R. & Auseklis, N. (2009). Sustainable IT services: Assessing the impact of green computing practices. *Proceedings of the Portland International Conference Management of Engineering & Technology*, (pp. 1707-1717). Portland, Oregon.

Hausenblas, H. A., Carron, A. V. & Mack, D. E. (1997). Application of the theories of reasoned action and planned behavior to exercise behavior: A meta-analysis. *Journal of Sport & Exercise Psychology, 1*, 36-51.

Hayes, N. (2000). *Doing psychological research.* Taylor & Francis Group.

Heilliger, J. (2011). *Building efficient data centres with the open compute project*. Retrieved June 04, 2012, from http://www.facebook.com/note.php?note_id=10150144039563920

Hofstee, E. (2006). *Constructing a good dissertation: A practical guide to finishing a master's MBA or PHD on schedule.* Johannesburg: EPE.

Hogan, R. (2011). *Sedgwick claims management services.* Eugene: University of Oregon.

Holleran, P. A. (1991). A methodological note on pitfalls in usability testing. *Behaviour and Information Technology, 10*(5), 345-357.

Howe, K. R. (1988). Against the quantitative and qualitative incompatibility thesis or dogmas die hard. *Educational Researcher, 17*(8), 10-16.

Hu, L. & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Coventional criteria versus new alternatives. *Structural Equation Modeling, 6*(1), 1-55.

Hu, P. J., Chau, P. Y., Sheng, O. R. & Tam, K. Y. (1999). Examining the technology acceptance model using physician acceptance of telemedicine technology. *Journal of Management Information Systems, 16*(12), 91-112.

Joppe, M. (2011). *The Research process*. Retrieved June 08, 2012, from http://www.ryerson.ca/~joppe/rp.htm>

Joumaa, C. & Kadry, S. (2012). Green IT: Case studies. *Energy Procedia, 16*(2012), 1052-1058.

Justin, G. (2008). *Screensavers: They aren't saving your screen but they are sapping your savings*. Retrieved May 21, 2011, from http://fypower.org/news/?p=601

Kabiraj, S., Topkar, V. & Walke, R. (2010). Going green: A holistic approach to transform business. *International Journal of Managing Information Technology (IJMIT), 2*(3), 22-31.

Kaestner, R. (2009). Computers and the environment: Minimizing the carbon footprint. *School Business Affairs*, 18-19.

Kalogirou, S. A. (n.d.). *Solar energy conversion and photoenergy systems: Solar energy, power generation and desalination systems.* Limassol, Cyprus : Cyprus University of Technology.

Karabuto, A. (2005). *HDD diet: power consumption and heat dissipation*. Retrieved June 09, 2012, from http://www.digit-life.com/articles2/storage/hddpower.html

Kerlinger, F. N. (1986.). *Foundations of behavioural research,* 3rd ed. London: Holt Rinehart & Wiston Publication.

Khalifa, M. & Shen, K. N. (2008). Drivers for transactional B2C m-commerce adoption: Extended theory of planned behavior. *Journal of Computer Information Systems, 48*(3), 111-117.

Khan, S., Kumar, V. K. & Razak, H. A. (2011). Prioritization of green IT parameters for Indian IT industry using analytical hierarchy process. *World Journal of Social Sciences, 1*(4), 179-194.

Klein, H. K. & Myers, M. D. (1999). A set of principles for conducting and evaluating interpretive field studies in information systems. *MIS quarterly, 23*(1), 67-93.

Knox, K. (2004). A Researcher's dilemma - philosophical and methodological pluralism. *Electronic Journal of Business Research Methods, 2*(2), 119-128.

Kolb, B. (2008). *Marketing research: A practical approach.* London: Sage Publications Ltd.

Kurp, P. (2008). Green computing. *Communications of the ACM, 51*(10), 11-13.

Lamb, J. P. (2009). *How companies can make a difference for the environment.* United States: IBM Press/Pearson.

Lane, M. S., Howard, A. & Howard, S. (2009). The energy inefficiency of office computing and potential emerging technology solutions. *Issues in Informing Science and Information Technology, 6*, 795-808.

Lane, S. M. & Meissner, C. A. (2008). A 'Middle Road' approach to bridging the basic applied divide in eyewitness identification research. *Applied Cognitive Psychology, 22*, 779-789.

Leedy, P. D. & Ormrod, J. E. (2001). *Practical research: Planning and design.* Upper Saddle River, NJ: Prentice Hall.

Leedy, P. D. & Ormrod, J. E. (2005). *Practical research: Planning and design.* Upper Saddle River, NJ: Prentice Hall.

Leedy, P. D. & Ormrod, J. E. (2010). *Practical research: Planning and design.* New Jersey: Pearson Education.

Leong, F. T. & Austin, J. T. (2006). *The Psychology Research Handbook: A Guide for graduate students and research assistants.* Sage Publications.

Loeser, F., Erek, K., Schmidt, N. H., Zarnekow, R. & Kolbe, L. M. (2011). Aligning green IT with environmental strategies: Development of a conceptual framework that leverages sustainability and firm competitiveness. *Proceedings of the 17th Americas Conference on Information Systems*, (pp. 1-9). Detroit, Michigan.

MacCallum, R. C., Browne, M. W. & Sugawara, H. W. (1996). Power analysis and determination of sample size for covariance structure modeling. *Psychological Methods, 1*, 130-149.

Madden, T. J., Ellen, P. S. & Ajzen, I. (1992). A comparison of the theory of planned behavior and the theory of reasoned action. *Personality and Social Psychology Bulletin, 18*, 3-9.

Mark, I. & Hay, I. (2006). *Research ethics for social scientists: Between ethical conduct and regulatory compliance.* London: Sage Publications.

Martin, P. (1991). Telecommuting: The ride of the future. *Legislative Reference Bureau*, 5-8.

Mathieson, K. (1991). Predicting User Intentions: Comparing the technology acceptance model with the theory of planned behavior. *Information Systems Research, 2*(3), 173-192.

Mathieson, K., Peacock, E. & Chin, W. W. (2001). Extending the technology acceptance model: The influence of perceived user resources. *ACM SIGMIS Database, 32*(3), 86-112.

McMillan, J. H. & Schumacher, S. (2010). *Research in Education: Evidence-based inquiry.* Boston, M A: Pearson.

Microsoft, Corporation. (2006). *Help save energy and the environment by putting your monitor to sleep*. Retrieved November 11, 2011, from http://www.microsoft.com/windowsxp/using/setup/tips/sleep.mspx

Miles, M. B. & Huberman, A. M. (1994). *Qualitative data analysis.* Thousand Oaks, CA: Sage Publications.

Mouton, J. (2001). *How to succeed in your master's and doctoral studies: A South Africa guide and resource book.* Pretoria: Van Schaik.

Mukaka, M. M. (2012). Statistics Corner: A guide to appropriate use of correlation coefficient in medical research. *Malawi Medical Journal, 3*, 69-71.

Murugesan, S. (2008). Harnessing green IT: Principles and practices. *IT professional, 10*(1), 24-33.

Murugesan, S. (2010). Making IT green. *IT Professional, 12*(2), 4-5.

Murugesan, S. (2011). Strategies for greening enterprise IT: Creating business value and contributing to environmental sustainability. In B. Unhelkar (Ed), *Handbook of research on green ICT: Technology* (pp. 51-64).

Muyot, M. (2010). *Apple underperforms Dell, HP and IBM on sustainability performance*. Retrieved June 25, 2012, from http://www.justmeans.com/Apple-underperforms-Dell-HP-IBM-on sustainability-Performance/26280.html

Mwakasonda, S. A. (2007). *South Africa Low Carbon Scenario Report.* University of Cape Town: Energy Research Centre.

Nachmias, C. F. & Nachmias, D. (2008). *Research methods in the social sciences.* New York: Worth.

Nielsen, J. (1994). *Usability engineering.* Academic Press.

Nieuwenhuis, J. (2007). Introduction qualitative research. In K. Maree, *IntroSteps in Research* (pp. 47-66). Preoria: Van schaik Publishers.

Nieuwenhuis, J. (2010). Qualitative research designs and data gathering techniques. In K. Maree (Ed), *Steps in research* (pp. 69-97). Pretoria: Van Schaik Publishers.

Norusis, M. J. (2002). *SPSS 11.0 guide to data analysis.* Upper Saddle River, NJ: Prentice Hall.

Nunnally, J. C. (1978). *Nunnally, J. C. 1978. Psychometric theory.* New York, NY: McGraw-Hill.

Oates, B. J. (2006). *Researching information systems and computing.* London: Sage Publications Ltd.

Odhiambo, N. M. (2011). Economic growth and carbon emissions in South Africa: An empirical investigation. *International Business & Economics Research Journal (IBER), 10*(7), 75-84.

Ogden, J. (2003). Some problems with social cognition models: A pragmatic and conceptual analysis. *Health Psychology, 22*(4), 424-428.

Olivier, M. S. (2004). *Information Technology research: A practical guide for computer science and informatics.* Pretoria: Van Schaik.

Omer, A. M. (2012). Renewable for power generation: Clean energies utilization and development. *International Research Journal of Engineering Science, Technology and Innovation, 1*(3), 71-93.

OpenNebula.org. (n.d.). *Virtualization data center management solution*. Retrieved May 12, 2012, from http://www.opennebula.org

Pallant, J. (2001). *The SPSS survival manual: A step-by-step guide to data analysis using SPSS for windows (version 10).* St Leonards, NSW: Allen & Unwin.

Patton, M. Q. (2001). *Qualitative research and evaluation methods.* Thousand oaks, CA: Sage Publications.

Pearl, J. (2000). *Causality: models, reasoning and inference.* London: Cambridge University Press.

Pedhazur, E. J. (1982). *Multiple regression in behavioral research: Explanation and prediction.* New York: Holt, Rinehart & Winston .

Pepper, L. (2008). *Green and lean: Four steps to improving data center efficiency without capital expenditures*. Retrieved October 12, 2011, from

http://www.greenbiz.com/blog/2008/06/24/green-and-lean-four-steps-improving-datacenter-efficiency-without-capital-expenditu

Petzer, C., McGibbon, C. & Brown, I. (2011). Adoption of green IS in South Africa: An exploratory study. *Proceedings of the South African Institute of Computer Scientists and Information Technologists Conference on Knowledge, Innovation and Leadership in a Diverse, Multidisciplinary Environment ACM*, (pp. 330-333).

Polit, D. F. & Beck, C. T. (2004). *Nursing research: Principles and methods .* Philadelphia: Lippincott.

Polit, D. F. & Hungler, B. P. (1999). *Nursing research principles and methods.* Philadelphia, Lippincott.

Popescu, D. E., Prada, M. F., Mancia, A., Robu, N., Cornellu, B., Gheorghe, L. & Dimitrios, P. (2009). Some aspects about the new green data centre challenge. *Proceedings of the 11th WSEAS International Conference on Sustainability in Science Engineering*, (pp. 230-235).

Pouraghajan, A. & Boroujerdi, F. S. (2013).The Effect of voluntary disclosure on the value relevance of accounting information companies listed in the Tehran stock exchange. *Applied mathematics in Engineering, Management and Technology,* 1 (4):434-444

Puttergill, C. (2000). Strategies of discovery. In K. J. Collins, G. M. Plooy, M. M. Grobbelaar, C. H. Puttergill, M. Terre Blanche, R. V. Eeden, G. H.V. Rensburg. & D.J. Wigston, (E.ds) .*Research in the Social Sciences: Only study guide for RSC201*. Research in the Social Sciences: Only Study Guide for RSC201. Pretoria: Unisa Press.

Rana, P. (2010). Green computing saves green. *International Journal of Advanced Computer and Mathematical Sciences, 1*(1), 45-51.

Randall, D. M. & Gibson, A. M. (1990). Methodology in business ethics research: A review and critical assessment. *Journal of Business Ethics, 9*(6), 457-471.

Republic of South Africa Department of Environmental Affairs and Tourism. (1999). *National waste management Strategy.* Pretoria: Government Printer.

Republic of South Africa Department of Environmental Affairs and Tourism. (2000). *White paper on integrated pollution and waste management for South Africa: A policy on pollution prevention, waste minimisation, impact management and remediation.* Pretoria: Government Printer.

Republic of South Africa Department of Environmental Affairs and Tourism. (2002). *Study of product stewardship.* Pretoria: Government Printer.

Republic of South Africa Department of Environmental Affairs and Tourism. (2005). *Environmental reporting, integrated environmental management information.* Pretoria: Government Printer.

Republic of South Africa. Department of National Treasury. (2010). *Reducing greenhouse gas emission: The carbon tax option.* Pretoria: Government Printer.

Rubin, A. & Babbie, E. (2001). *Research methods for social work.* Belmont, CA: Wadsworth/Thomson Learning.

Sarrel, M. (2006). *Recycling e-waste*. Retrieved March 12, 2013, from http://www.pcmag.com/article2/0,2817,2064148,00.asp

Schmuck, R. (1997). *Practical action research for change.* Arlington Heights: IRI / Skylight Training and Publishing.

Shaik, A. (2012). Green PC saves human life. *International Journal of Electronics and Computer Science Engineering, 1*(2), 651-656.

Sharma, M. (2007). *Theory of reasoned action & theory of planned behavior in alcohol and drug education.* Retrieved from: http://www.thefreelibrary.com/Theory of reasoned action & theory of planned behavior in alcohol and...-a0163097578.

Sheppard, B. H., Hartwick, J. & Warshaw, P. R. (1998). The theory of reasoned action: A meta-analysis of past research with recommendations for modifications and future research. *Journal of Consumer Research, 15*(3), 325-343.

Sobotta, A. T., Sobotta, I. N. & Gotze, J. (2010). *Greening IT: How greener it can form a solid foundation for a low-carbon society.* (1st, Ed.) London: Creative Commons.

Soomro, T. R. & Sarwar, M. (2012). Computing: Green from current to future. *Trends World Academy of Science, Engineering and Technology, 63*.

Sparks, P., Shepherd, R. & Frewer, L. J. (1995). Assessing and structuring attitudes toward the use of gene technology in food production: The role of perceived ethical obligation. *Basic and Applied Social Psychology, 16*(3), 267-285.

Stevens, H. (2008). *Gartner says agility will become the primary measure of data centre excellence by 2012*. Retrieved October 23, 2012, from http://www.gartner.com/it/page.jsp?id=535714

Struwig, F. W. & Stead, G. B. (2001). *Planning, designing and reporting research.* Cape Town: Pearson.

Sullivan, R. (2009). *Greening IT*. Retrieved November 15, 2011, from http://www.ecosmagazine.com/?paper=EC150p24

Terre Blanche, M. & Kelly, K. (1999). *Interpretive Methods*. In M. Terre Blanche. & Durrheim, K (Eds), *Research in practice*: *Applied methods for the social sciences*. Cape Town, UCT Press.

The University of Colorado Boulder. (2004). *Green computing guide.* United States: Encyclopedia of Life Support Systems.

Thibodeau, P. (2008). *Environmental impact: It sees the light on green computing*. Retrieved October 12, 2013, from http://www.computerworld.com/s/article/321181/Environmental_Impact_IT_Sees_the_Light_on_Green_Computing

Thompson, R. L., Higgins, C. A. & Howell, J. M. (1991). Personal computing: toward a conceptual model of utilization. *MIS Quarterly, 15*(1), 125-143.

Thorne, S. (2000). Data analysis in qualitative research. *Evidence Based Nursing*(3), 68-70.

Tongco, M. D. (2007). Purposive sampling as a tool for informant selection. *Ethnobotany Research & Applications, 5*, 147-158.

Triandis, H. C. (1988). *Values, Attitudes and Interpersonal Behavior*. In M.M, Nebraska (Ed), Symposium on Motivation, Beliefs, Attitudes and Values (pp. 195-259). Lincoln: University Nebraska Press.

Trochim, W. M. (2006). *Research methods knowledge*. Retrieved May 12, 2012, from http://www.socialresearchmethod.net/kb/sampling.php

Underwood, R. (2008). Save the planet—and save the company a lot of power and paper tools for greening up around the office. *Academic Search Premier, 30*(6), 32-35.

Vajda, A. (2011). Multi-core and many-core processor architectures. *Business Media*, 9-43.

Venkatesh, V., Morris, M. G., Davis, G. B. & Davis, F. D. (2003). User acceptance of Information Technology: Toward a unified view. *MIS Quarterly, 27*(3), 425-478.

VMware. (2007). *Understanding full virtualization, par virtualization and hardware assist*. Retrieved 19 March, 2013, from http://www.vmware.com/files/pdf/VMware_paravirtualization.pdf

VMware. (2009). *Reduce energy costs and go green: With VMware green IT solutions*. Retrieved July 27, 2012, from http://www.vmware.com/files/pdf/VMware-GREEN-IT-OVERVIEW-SB-EN.pdf

Walsham, G. (1995). The emergence of interpretivism in IS research. *Information Systems Research, 6*(4), 376-394.

Welman, J. C. & Kruger, S. J. (2001). *Research methodology for the business and administrative sciences.* Cape Town: Oxford University Press.

Wilbanks, L. (2008). Green: My favorite color. *IT professional, 10*(6), 64-63.

William, H. G. (1993). Frontier production functions. In N. Leonard (Ed), *Working papers* (pp. 93-120). New York University: Stern School of Business, Department of Economics.

Williams, J. & Curtis, L. (2008). Green: The new computing coat of arms? . *IT Professional, 10*(1), 12-16.

Wingerchuk, D. M., Lennon, V. A., Pittock, S. J., Lucchinetti, C. F. & Weinshenker, B. G. (2006). Revised diagnostic criteria for neuromyelitis optica. *Neurology, 10*, 485-1489.

Winkler, H., Hughes, A., Marquard, A., Haw, M. & Berven, B. (2011). South Africa's greenhouse gas emissions under business-as-usual: The technical basis of growth without constraints in the long-term mitigation scenarios. *Energy Policy, 39*(2011), 5818-5828.

www.paperrecycles.org. (n.d.). *Recycling: It starts with you.* Washington U.S: American Forest & Paper Association.

Yeaman, A. R. (1988). *Attitudes, learning and human-computer interaction: An application of the Fishbein and Ajzen model of attitude-behavior consistency.* Retrieved July 27, 2012, from http://www.attitude.com/files/pdf/*human-computerinteraction*.pdf

Zikmund, W. G. (2003). *Business research methods.* New York: Thompson South-Western.

Appendix A: Questionnaire

Green Computing Survey

Course Number: _____ Date:_____

As you may know earth may no longer be a sustainable environment for living organisms if we do not reduce the amount of toxic waste. The purpose of this study is to evaluate the beliefs and behaviour of IT users regarding Green IT in South Africa through a questionnaire. It will be completed by university students and staff at the Tshwane University of Technology (TUT).

The questionnaire forms part of an investigation that tries to discover some of the reasons why users contribute to a continuous increase in the consumption of energy, especially through the use of IT resources. Specifically, we are interested in your own behaviour and beliefs regarding green computing. Green computing is the continuous study and practice of using computing resources efficiently and effectively with the aim to minimise the pollution of the environment by all IT users, i.e. production, disposal, electricity / energy use etc.

Please read each question carefully and answer it to the best of your ability. There are no correct or incorrect responses; we are merely interested in your personal point of view.

Please enter the date, and the course number in the designated spaces above. All responses to this survey are completely confidential. The instructor of this course will not disclose your responses to the university staff or society. Please be assured that the information you provide in this study will have no effect on your studies/work.

Instructions

Many questions in this survey make use of 5 point likert scale; you should make an *x* besides the number that best describes your opinion.

For example, if you were asked to rate "The Weather in South Africa" on such a scale, the 5 places should be interpreted as follows:

1	quite good	
2	slightly good	
3	neither good nor bad	
4	slightly bad	
5	quite bad	

1.If you think the weather in South Africa is quite good, then you should make an *x* besides the *number 1*, as follows:
The Weather in South Africa is:

1	quite good	X
2	slightly good	
3	neither good nor bad	
4	slightly bad	
5	quite bad	

2. If you think the weather in South Africa is slightly bad, then you should make an *x* besides the *number 4*.
The Weather in South Africa is

1	quite good	
2	slightly good	
3	neither good nor bad	
4	slightly bad	X
5	quite bad	

3. If you think the weather in South Africa is slightly good, then you should make an *x* besides the *number 2*.
The Weather in South Africa is:

1	quite good	
2	slightly good	X
3	neither good nor bad	
4	slightly bad	
5	quite bad	

In making your ratings, please remember the following points:

- Please read each question carefully.
- Answer all questions – do not omit any.
- Please answer each of the questions by writing a symbol *x* next to the number that best describes your opinion.
- Some of the questions may appear to be similar, but they do address different issues.
- Never write the symbol *x* next to more than one number on a single scale.

Please note that the following questions are for students not for lecturers to answer:

Questions 8.2, 8.4, 8.5, 9.2, 9.3, 10.4, and 11.4

Section A:
Demographical information:

1.1 Gender:

1	Male	
2	Female	

1.2 Age:

1	16-20	
2	21-25	
3	26-30	
4	31-35	
5	36-40	
6	Above 40	

1.3 Current level of study:

1	First Year	
2	Second Year	
3	Third Year	
4	Fourth Year/ B Tech or Hons	
5	Masters	
6	PhD/ Post Doc	

1.4 Student and staff employment status:

1	Unemployed	
2	Part-time employed	
3	Full-time employed	
4	Self-employed	

1.5 Marital status:

1	Single	
2	Married	
3	Separated/Divorced /Widowed	

Section B: Attitude:

2.1 For me the idea of practising green computing on a regular basis is beneficial.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly disagree	
5	Disagree	

2.2 For me the idea of practising green computing on a regular basis is good.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly disagree	
5	Disagree	

2.3 For me the idea of practising green computing on a regular basis is valuable.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly disagree	
5	Disagree	

2.4 For me the idea of practising green computing on a regular basis is pleasant.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly disagree	
5	Disagree	

2.5 For me the idea of practising green computing on a regular basis is enjoyable.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly disagree	
5	Disagree	

2.6 For me the idea of practising green computing on a regular basis is possible.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly disagree	
5	Disagree	

2.7 For me the idea of practising green computing on a regular basis is interesting.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly disagree	
5	Disagree	

Section C: Subjective norms:

3.1 Most people who are important to me think that I should practise green computing on a regular basis.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly disagree	
5	Disagree	

3.2 Most people who are important to me practise green computing on a regular basis.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly disagree	
5	Disagree	

3.3 It is expected of me to practise green computing on a regular basis.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly disagree	
5	Disagree	

3.4 Most people in my life whose opinions I value would approve of me practising green computing on a regular basis.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly disagree	
5	Disagree	

3.5 Most people in my life whose opinions I value practise green computing on a regular basis.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly disagree	
5	Disagree	

3.6 Most people like me because I practise green computing on a regular basis.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly disagree	
5	Disagree	

4.1 Section D: Perceived behavioural control:

I am confident that if I wanted to I could practice green computing on a regular basis.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly disagree	
5	Disagree	

4.2 Whether or not I practice green computing on a regular basis is completely up to me.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly disagree	
5	Disagree	

4.3 I have total control to improve the practice of green computing.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly disagree	
5	Disagree	

4.4 I can improve the practice of green computing in the forthcoming months.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly disagree	
5	Disagree	

4.5 I could definitely improve the practice of green computing in the forthcoming months.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly disagree	
5	Disagree	

Section E: Intention:

5.1 I plan to practise green computing on a regular basis.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly disagree	
5	Disagree	

5.2 I will make an effort to practise green computing on a regular basis.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly disagree	
5	Disagree	

5.3 I intend to practise green computing on a regular basis.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly disagree	
5	Disagree	

Section F: Outcome Evaluation:

6.1 For me to conserve energy and decrease greenhouse gas emission is good.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly disagree	
5	Disagree	

6.2 For me to have the opportunity to interact with instructors or other experts in green computing is good.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly disagree	
5	Disagree	

6.3 For me to pay lower electricity bills is good.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly disagree	
5	Disagree	

6.4 For me to conserve life for generations to come is good.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly disagree	
5	Disagree	

6.5 For me to develop good habits of practising green computing, self-discipline, and a feeling of self-esteem is good.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly disagree	
5	Disagree	

6.6 My habit of not practising green computing is good.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly disagree	
5	Disagree	

6.7 For me, getting information and explanation regarding good practise of green computing methods is good.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly disagree	
5	Disagree	

6.8 For me being subjected to tediousness and boredom is pleasant.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly disagree	
5	Disagree	

6.9 Contributing to human life being conserved is good

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly disagree	
5	Disagree	

Section G: Behavioural belief strength:

7.1 Practising green computing on a regular basis enables me to reduce the consumption of energy.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly disagree	
5	Disagree	

7.2 Practising green computing on a regular basis will help me to decrease greenhouse gas emission.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly disagree	
5	Disagree	

7.3 Practising green computing on a regular basis will give me the opportunity to communicate with the instructor, IT experts and other students.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly disagree	
5	Disagree	

7.4 Practising green computing on a regular basis have a negative effect on my studies.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly disagree	
5	Disagree	

7.5 Practising green computing on a regular basis will help me conserve life for generations to come.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly disagree	
5	Disagree	

7.6 Practising green computing on a regular basis develop good habits, self-discipline, and a feeling of self-esteem.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly disagree	
5	Disagree	

7.7 Practising green computing on a regular basis will contribute to human life being saved.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly disagree	
5	Disagree	

7.8 Practising green computing on a regular basis will help me gathering information and explanation regarding good practise of green computing methods.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly disagree	
5	Disagree	

7.9 Practising green computing on a regular basis will subject me to tediousness and boredom.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly disagree	
5	Disagree	

7.10 Practising green computing on a regular basis will cause me not to pass the examinations.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly disagree	
5	Disagree	

Section H: Injunctive normative referent:

8.1 The instructor and IT experts of this survey think that I should practise green computing on a regular basis.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly disagree	
5	Disagree	

8.2 My lecturer thinks that I should practise green computing on a regular basis.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly disagree	
5	Disagree	

8.3 Many of my friends and my classmates practise green computing on a regular basis.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly disagree	
5	Disagree	

8.4 My friends and classmates think that I should practise green computing on a regular basis.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly disagree	
5	Disagree	

8.5 IT experts and my colleagues practise green computing on a regular basis.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly disagree	
5	Disagree	

8.6 IT experts and researchers practise green computing on a regular basis.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly disagree	
5	Disagree	

Section I: Normative beliefs

9.1 I care what the instructor of this survey thinks I should do.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly disagree	
5	Disagree	

9.2 I care what close friends, classmates and the whole university think I should do.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly disagree	
5	Disagree	

9.3 IT experts care that I should practise green computing.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly disagree	
5	Disagree	

9.4I care what my lecturer think I should do.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly disagree	
5	Disagree	

Section J: Power of control factors:

10.1 If the work place or the university makes unanticipated demands not to shut down the computers, it would make it more difficult to practise green computing on a regular basis.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly disagree	
5	Disagree	

10.2 If l do not know how to hibernate my computer and change other settings to lower energy consumption, it would make it more difficult to practise green computing on a regular basis.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly disagree	
5	Disagree	

Section K: Control belief strength:

11.1 l encounter unanticipated events that place demands on my time.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly disagree	
5	Disagree	

10.3 If our class gives an order to print on only one side of the paper, it would make it more difficult to practise green computing on a regular basis.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly disagree	
5	Disagree	

11.2 My other classes place heavy demands to print only on one side of the paper.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly disagree	
5	Disagree	

10.5 Encountering unanticipated events that place demands on my time would make it difficult for me to practise green computing on a regular basis.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly disagree	
5	Disagree	

11.3 l fail to hibernate the computers or to operate the settings of the computer to lower energy consumption.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly agree	
5	Disagree	

10.3 If l had family obligations that place unanticipated demands on the way l need to conserve energy, it would make it more difficult for me to practise green computing.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly agree	
5	Disagree	

11.4 The university places unanticipated demands on me not to shut down the computers.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly agree	
5	Disagree	

11.5 I am aware of new green IT regulations being implemented.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly agree	
5	Disagree	

11.6 My family obligations place unanticipated demands on the way I conserve energy.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly agree	
5	Disagree	

Section L: Actual behaviour

12.1 I currently practise green computing on a regular basis.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly agree	
5	Disagree	

12.2 In the past I practised green computing on a regular basis.

1	Agree	
2	Slightly agree	
3	Neither agree nor disagree	
4	Slightly agree	
5	Disagree	

Past behaviour:M

12.1 During the past 5 years, how many workshops on practising green computing have you attended?

During the past 5 years, I have attended about _____ workshops on practising green computing.

Instructions: Please take a few minutes to tell us what you think about practising green computing. There are no right or wrong responses; we are merely interested in your personal opinion. In response to the questions below, please list the thoughts that come immediately to mind. Write each thought on a separate line. (Five lines are provided for each question.)

Groups of people are going to be coded into categories which are:

Friends, relatives and experts

Section N:

(1) What do you regard as the advantages of practising green computing?

---

(2) What do you regard as the disadvantages of practising green computing?

---

(3) What else comes to mind when you think about practising green computing?

Section O:

When it comes to practising green computing there might be individuals or groups who would think you should or should not practise green computing.

(1) Please list the individuals or groups who would approve or think you should practise green computing.

---

(2) Please list the individuals or groups who would disapprove or think you should **NOT** practise green computing.

---

(3) Sometimes, when we are not sure what to do, we look to see what others are doing in practising green computing. Please list the individuals or group whom you can see are practising green computing.

---

(4) Please list the individuals or groups whom, after environmental pollution, are likely to practise green computing.

Section P:

(1) Please list any factors or circumstances that would make it easy or enable you to practise green computing.

---

(2) Please list any factors or circumstances that would make it difficult or prevent you from practising green computing.

Appendix B: Observation Guidelines

Table 7.1: Observations guidelines used by the researcher for observation

Questions	Total	Male	Female	Usage Total	Percentage
1. Students using memory stick or flash drives	345	180	160	340	99%
2. Students using mobile phone to read notes and assignments	345	110	90	200	58%
3. Students using CDs for keeping their software	345	198	144	342	99%
4. Students using DVDs for keeping their software	345	196	144	340	99%
5. Students using external hard drive for keeping their software.	345	186	134	320	93%
6. Students printing on both sides of paper when printing	345	176	134	310	90%
7. Students powering off the PC when they have finished their lectures.	345	186	144	330	96%
8. Students dimming their PC and laptop when not in use	345	178	136	314	91%
9. Students dumping PC and laptop for recycling in their dumping site	345	196	144	340	99%
10. Students using E-Tutor and EC software for writing their assignment and examination	345	200	145	345	100%
11. Students registering through ITS	345	200	145	345	100%
12. Lecturer putting announcements on e-Tutor and EC software	5	2	3	5	100%
13. Lecturer broadcasting software for demonstration in the lecture i.e. Nettop software	5	2	3	5	100%

Appendix C: Ethical Clearance Form

UNIVERSITY OF SOUTH AFRICA

School of Computing, College of Science, Engineering and Technology

ETHICAL CLEARANCE APPLICATION FORM Date: 15 November 2012

PLEASE NOTE THAT THE FORM MUST BE COMPLETED IN TYPED SCRIPT. HANDWRITTEN APPLICATIONS WILL NOT BE CONSIDERED.

SECTION 1: PERSONAL DETAILS

1	**Full Name and Surname of Applicant:**	Tawanda Blessing Chiyangwa
1.2	Title (Ms/ Mr/ Mrs/ Dr/ Professor/etc.):	Mr
1.3	Student Number (where applicable):	4991 849 4
	Staff Number (where applicable):	N/A
1.4	School:	School of Computing
1.5	College:	College of Science, Engineering and Technology
1.6	Campus:	Florida Campus
1.7	Existing Qualifications:	B Technology Hons in Computer Science
1.8	Proposed Qualification for Project: (In the case of research of degree purposes)	MSc Computer Science
2.	**Contact Details**	
	Telephone Number	N/A
	Cell. Number :	074 366 3721 or 0837127800
	e-Mail :	chiyangwa.tawanda@gmail.com
Postal address (in the case of students and external applicants)		38 Amble View Gardens Amandasig Pretoria north

3. SUPERVISOR/ PROJECT LEADER DETAILS

NAME	TELEPHONE NO.	EMAIL	SCHOOL / INSTITUTION	QUALIFICATIONS
3.1 Ms T Hörne	012 429 6450	hornet@unisa.ac.za	Unisa	MSc
3.2 Mr TJ van Dyk	012 429 6676	vdyktj@unisa.ac.za	Unisa	MSc

SECTION 2: PROJECT DESCRIPTION

Please do not provide your full research proposal here: what is required is a short project description of not more than two pages that gives, under the following headings, a brief overview spelling out the background to the study, the key questions to be addressed, the participants (or subjects) and research site, including a full description of the sample, and the research approach/ methods

2.1 Project title	Belief and Actual Behaviour in green Information Technology within South Africa tertiary
2.2 Location of the study (where will the study be conducted)	Tshwane University of Technology
2.3 Objectives of and need for the study	
(Set out the major objectives and the theoretical approach of the research, indicating briefly, why you believe the study is needed.)	To determine the most significant factors associated with the (supporting or non-supporting) beliefs and (supporting or non-supporting) actual behaviour of IT users.
2.4 Questions to be answered in the research (Set out all the critical questions which you intend to answer by undertaking this research.)	Are IT users genuinely concerned with regards to green IT issues?
2.5 Conflict of Interest:	N/A

2.5 Research approach/ methods

(This section should explain how you will go about answering the critical questions which you have identified under 2.4 above. Set out the approach within which you will work, and indicate in step-by-step point form the methods you will use in this research in order to answer the critical questions).

For a study that involves surveys, please append a provisional copy of the questionnaire or interview questions and the consent form to be used. The questionnaire/interview protocol should show how informed consent is to be achieved as well as indicate to respondents that they may withdraw their participation at any time, should they so wish.

2.6 Proposed work plan

Set out your intended plan of work for the research, indicating important target dates necessary to meet your proposed deadline.

STEPS	DATES
Final proposal	End June 2012
Literature review	June 2012 – Mid October 2012
Research design and methodology	Mid October 2012 – December 2012
Pilot questionnaire	January 2013 – Mid January 2013
Main field survey	Mid January 2013 – End January 2013
Data analysis	February 2012 – May 2013
Staged write-up of dissertation	June 2013 – November 2013
Submission of first draft	January 2014
Submission of final dissertation	February 2014

SECTION 3: ETHICAL ISSUES

The UNISA Ethics Policy[3] applies to all members of staff, graduate and undergraduate students who are involved in research on or off the campuses of UNISA. In addition, any person not affiliated with UNISA who wishes to conduct research with UNISA students and/or staff is bound by the same ethics framework. Each member of the University community is responsible for implementing this Policy in relation to scholarly work with which she or he is associated and to avoid any activity which might be considered to be in violation of this Policy.

All students and members of staff must familiarize themselves with AND sign an undertaking to comply with the University's "Code of Conduct for Research" (the policy can be accessed at the following

URL:http://cm.unisa.ac.za/contents/departments/res_policies/docs/ResearchEthicsPolicy_apprvCounc_21Sept07.pdf).

QUESTION 3.1

Does your study cover research involving:	YES	NO
Children		√
Persons who are intellectually or mentally impaired		√
Persons who have experienced traumatic or stressful life circumstances		√
Persons who are HIV positive		?
Persons highly dependent on medical care		√
Persons in dependent or unequal relationships		√
Persons in captivity		√
Persons living in particularly vulnerable life circumstances		√

[3] The URL for this is:

http://cm.unisa.ac.za/contents/departments/res_policies/docs/ResearchEthicsPolicy_apprvCounc_21Sept07.pdf

If “Yes”, indicate what measures you will take to protect the autonomy of respondents and (where indicated) to prevent social stigmatisation and/or secondary victimisation of respondents. If you are unsure about any of these concepts, please consult your supervisor/ project leader.

_____

_____

_____

QUESTION 3.2

Will data collection involve any of the following:	**YES**	**NO**
Access to confidential information without prior consent of participants		√
Participants being required to commit an act which might diminish self-respect or cause them to experience shame, embarrassment, or regret		√
Participants being exposed to questions which may be experienced as stressful or upsetting, or to procedures which may have unpleasant or harmful side effects		√
The use of stimuli, tasks or procedures which may be experienced as stressful, noxious, or unpleasant		√
Any form of deception		√
Any use of materials harmful to human beings		√

If “Yes”, to any of the previously mentioned explain and justify. Explain, too, what steps you will take to minimise the potential stress/harm.

_____

_____

_____

QUESTION 3.3

Will any of the following instruments be used for purposes of data collection:	**YES**	**NO**
Questionnaire	√	
Survey schedule		√
Interview schedule		√
Psychometric test		√
Other/ equivalent assessment instrument		√

If “Yes”, attach copy of research instrument. If data collection involves the use of a psychometric test or equivalent assessment instrument, you are required to provide evidence that the measure is likely to provide a valid, reliable, and unbiased estimate of the construct being measured as an attachment. If data collection involves interviews and/or focus groups, please provide a list of the topics to be covered/ kinds of questions to be asked as an attachment. Explain the withdrawal or discontinuation criteria of respondents.

QUESTION 3.4

Will the autonomy of participants be protected through the use of an informed consent form, which specifies (in language that respondents will understand):	**YES**	**NO**
The nature and purpose/s of the research	√	
The identity and institutional association of the researcher and supervisor/project leader and their contact details	√	
The fact that participation is voluntary That responses will be treated in a confidential manner	√ √	
Any limits on confidentiality which may apply		√
That anonymity will be ensured where appropriate (e.g. coded/ disguised names of participants/ respondents/ institutions)	√	
The fact that participants are free to withdraw from the research at any time without any negative or undesirable consequences to themselves	√	
The nature and limits of any benefits participants may receive as a result of their participation in the research		√
Is a copy of the informed consent form attached?	√	

If not, this needs to be explained and justified, also the measures to be adopted to ensure that the respondents fully understand the nature of the research and the consent that they are giving.

Answered questionnaire are not disclosed to anyone except the researcher, supervisor, examiner and statistician. Participants benefit by reducing the consumption of energy at home, work and university.

QUESTION 3.5

Specify what efforts been made or will be made to obtain informed permission for the research from appropriate authorities and gate-keepers (including caretakers or legal guardians in the case of minor children)?
Permission will be obtained from the Tshwane University of Technology to do the pilot and main survey using staff members as well as students.

QUESTION 3.6

STORAGE AND DISPOSAL OF RESEARCH DATA/SAMPLES: Please note that the research data should be kept for a period of at least five years in a secure environmental safe location by arrangement with your supervisor. In the case of samples will the samples be destroyed
How will the research data be disposed of? Please provide specific information, e.g. shredding of documents incineration of videos, cassettes, etc. All documents will be shredded

QUESTION 3.7

In the subsequent dissemination of your research findings – in the form of the finished thesis, oral presentations, publication etc. – how will anonymity/ confidentiality be protected? If required, reference will only be made to individuals using terms such as student A, B, etc.

QUESTION 3.8

Is this research supported by funding that is likely to inform or impact in any way on the design, outcome and dissemination of the research?	**YES**	**NO** √

If yes, this needs to be explained and justified.

QUESTION 3.9

Has any organisation/company participating in the research or funding the project, imposed any conditions to the research? ~~YES~~/NO

If yes, please indicate what the conditions are.

SECTION 4: FORMALISATION OF THE APPLICATION

APPLICANT

I **Tawanda Blessing Chiyangwa** have familiarised myself with the UNISA Ethics policy, the form completed and undertake to comply with it. The information supplied above is correct to the best of my knowledge. I have read the policy for research ethics of UNISA and the contents of my application as presented to the CREC of CSET is a true and accurate reflection of the methodological and ethical implications of my proposed study. I shall carry out the study in strict accordance with the approved proposal and the ethics policy of Unisa. I shall maintain the confidentiality of all data collected from or about research participants, and maintain security procedures for the protection of privacy. I shall record the way in which the ethical guidelines as suggested in the proposal has been implemented in my research. I shall notify URERC in writing immediately if any change to the study is proposed or if any adverse event occurs or when injury or harm is experienced by the participants attributable to their participation in the study.

NB: PLEASE ENSURE THAT THE ATTACHED CHECK SHEET IS COMPLETED

.

SIGNATURE OF APPLICANT ……..

DATE ……..

SUPERVISOR/DIRECTOR OF SCHOOL

NB: PLEASE ENSURE THAT THE APPLICANT HAS COMPLETED THE ATTACHED CHECK SHEET AND THAT THE FORM IS FORWARDED TO YOUR COLLEGE RESEARCH COMMITTEE FOR FURTHER ATTENTION

DATE: ……..

SIGNATURE OF SUPERVISOR/ PROJECT LEADER

_____

RECOMMENDATION OF COLLEGE RESEARCH AND ETHICS COMMITTEE

The application is (please tick):

	Approved
	Recommended and noted
	Not Approved, referred back for revision and resubmission

NAME OF CHAIRPERSON:

_____SIGNATURE:_____

DATE ……

RECOMMENDATION OF SENATE RESEARCH AND ETHICS COMMITTEE

NAME OF CHAIRPERSON:_____SIGNATURE_____

DATE…….

UNISA

CSET - CREC

ETHICAL CLEARANCE APPLICATIOM FORM

CHECK SHEET FOR APPLICATION

PLEASE TICK

1. Form has been fully completed and all questions have been answered	
2. Questionnaire/interview protocol attached (where applicable)	
3. Informed consent document attached (where applicable)	
4. List of acronyms and abbreviations should be attached.	
5. Approval from relevant authorities obtained (and attached) where research involves the utilization of space, data and/or facilities at other institutions/organisations	
6. Signature of Supervisor / project leader	
7. Application forwarded to College Research Committee for recommendation	
8. A complete copy of the proposal should be available if so requested.	

Appendix D: Letter of Approval

UNISA | college of science, engineering and technology

Mr T Chyangwa (49918494)
School of Computing
UNISA
Pretoria

25 February 2013

TO WHOM IT MAY CONCERN

Permission to conduct MSc research project **Ref: 042/CT/2012**

The request for ethical approval for your MSc research project entitled: "Intended Belief and Actual Behaviour of IT users regarding Green Information Technology at a tertiary institution in South Africa" refers.

The College of Science, Engineering and Technology's (CSET) Research and Ethics Committee (CREC) has considered the relevant parts of the studies relating to the abovementioned research project and research methodology and is pleased to inform you that ethical clearance is granted for your study as set out in your proposal and application for ethical clearance.

Therefore, involved parties may also consider ethics approval as granted. However, the permission granted must not be misconstrued as constituting an instruction from the CSET Executive or the CSET CREC that sampled interviewees (if applicable) are compelled to take part in the research project. All interviewees retain their individual right to decide whether to participate or not.

We trust that the research will be undertaken in a manner that is respectful of the rights and integrity of those who volunteer to participate, as stipulated in the UNISA Research Ethics policy. The policy can be found at the following URL:
http://cm.unisa.ac.za/contents/departments/res_policies/docs/ResearchEthicsPolicy_apprvCounc_21Sept07.pdf

Yours sincerely

Prof E Mnkandla
Chair: School of Computing Ethics Sub-Committee

University of South Africa
College of Science, Engineering and Technology
Preller Street, Muckleneuk Ridge, City of Tshwane
PO Box 392 UNISA 0003 South Africa
Telephone: + 27 12 429 6122 Facsimile + 27 12 429 6848
www.unisa.ac.za/cset

Appendix E: Informed consent form

My name is Mr. Tawanda Blessing Chiyangwa, a Master of Science student in the School of Computing at the University of South Africa. I am conducting a survey to evaluate the beliefs and behaviour of IT users regarding Green IT in South Africa through a questionnaire, working under the supervision of Mrs Horne and Mr van Dyk. I am kindly seeking your permission to include you (IT students / lecturers) as participants in this research. Please read this consent document carefully. If you grant permission to participate in this study, please sign the agreement at the end of the form and return it to me.

Title of the research project:

Intended Belief and Actual Behaviour in Green Information Technology (GIT) tertiary within South Africa Tertiary Institution.

Please take note of the following:

- Only IT students and lecturers are required to answer the questionnaire.
- Data and information I share will be handled confidentially and anonymously.
- Data, information and references will be protected as required by the Data Protection Act of South Africa.
- Your name will not be associated with any data that are collected during this survey.

Time required:

We expect a session to last about 30 minutes. Participants will answer structured and semi-structured questions. Each participant is required to answer all the questions. The data collected will be used for research purposes only.

University of South Africa
Preller Street, Muckleneuk Ridge, City of Tshwane
PO Box 392 UNISA 0003 South Africa
Telephone + 27 12 429 6933 Facsimile + 27 12 429 6848

Risks:

There are no known risks associated with this study.

Finally, we greatly appreciate your time and effort for participating in this survey. Remember, the research does not affect your study or work. Please do not hesitate to ask if you have any questions regarding the experiment.

The rights participants are as follows:

- You are voluntarily taking part in this study and it is your right not to participate.
- You can withdraw from this study at any time and have information provided in your questionnaire removed in its entirety from this study.

My contact details are as follows:

Email address: chiyangwa.tawanda@gmail.co.za

Cell number: +27743663721

Agreement:

Your signature below indicates that you have read this consent form in its entirety and that you are voluntarily participating.

Venue:

The survey will take place in the lecture room at the Tshwane University of Technology.

Surname: _____ Cell Number: _____

Name: _____ Date: _____

Signature: _____

University of South Africa
Preller Street, Muckleneuk Ridge, City of Tshwane
PO Box 392 UNISA 0003 South Africa

Appendix F: Further Research Data

Table 7.2: KMO and Bartlett's Test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.777
Bartlett's Test of Sphericity	Approx. Chi-Square	3529.879
	df	561
	Sig.	0.000

Table 7.3: Communalities

Communalities			Communalities		
	Initial	Extraction		Initial	Extraction
2.1	1.000	0.719	7.2	1.000	0.710
2.2	1.000	0.677	7.5	1.000	0.563
2.3	1.000	0.665	7.4	1.000	0.682
2.4	1.000	0.601	7.8	1.000	0.619
2.5	1.000	0.743	7.10	1.000	0.627
2.7	1.000	0.670	8.4	1.000	0.702
3.1	1.000	0.636	8.5	1.000	0.642
3.2	1.000	0.641	8.6	1.000	0.595
3.5	1.000	0.631	9.1	1.000	0.619
3.6	1.000	0.626	9.2	1.000	0.734
4.3	1.000	0.525	9.3	1.000	0.580
4.4	1.000	0.721	10.1	1.000	0.621
4.5	1.000	0.697	10.2	1.000	0.744
6.1	1.000	0.667	10.3	1.000	0.688
6.2	1.000	0.662	11.1	1.000	0.622
6.4	1.000	0.694	11.2	1.000	0.659
7.1	1.000	0.726	11.3	1.000	0.672
Extraction Method: Principal Component Analysis.					

Table 7.4: Total variance explained

Total Variance Explained									
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.687	16.727	16.727	5.687	16.727	16.727	2.575	7.573	7.573
2	3.314	9.746	26.473	3.314	9.746	26.473	2.046	6.019	13.593
3	2.250	6.616	33.090	2.250	6.616	33.090	2.034	5.982	19.574
4	1.894	5.570	38.660	1.894	5.570	38.660	2.016	5.931	25.505
5	1.598	4.700	43.361	1.598	4.700	43.361	1.999	5.881	31.385
6	1.524	4.482	47.843	1.524	4.482	47.843	1.992	5.858	37.243
7	1.439	4.231	52.074	1.439	4.231	52.074	1.984	5.836	43.080
8	1.291	3.796	55.869	1.291	3.796	55.869	1.961	5.766	48.846
9	1.170	3.441	59.311	1.170	3.441	59.311	1.954	5.747	54.593
10	1.148	3.377	62.688	1.148	3.377	62.688	1.933	5.685	60.278
11	1.066	3.135	65.823	1.066	3.135	65.823	1.885	5.545	65.823
12	0.866	2.547	68.370						
13	0.748	2.200	70.571						
14	0.736	2.166	72.736						
15	0.717	2.110	74.846						
16	0.655	1.927	76.773						
17	0.634	1.864	78.637						
18	0.610	1.793	80.430						
19	0.559	1.644	82.074						
20	0.549	1.614	83.688						
21	0.523	1.538	85.226						
22	0.503	1.480	86.706						
23	0.477	1.403	88.108						
24	0.458	1.346	89.454						
25	0.453	1.333	90.787						
26	0.421	1.239	92.027						
27	0.418	1.230	93.256						
28	0.398	1.172	94.428						
29	0.358	1.052	95.480						
30	0.344	1.013	96.493						
31	0.336	0.989	97.483						
32	0.320	0.942	98.424						
33	0.276	0.812	99.237						
34	0.260	0.763	100.000						
Extraction Method: Principal Component Analysis.									

Figure 7.1: Scree plot diagram

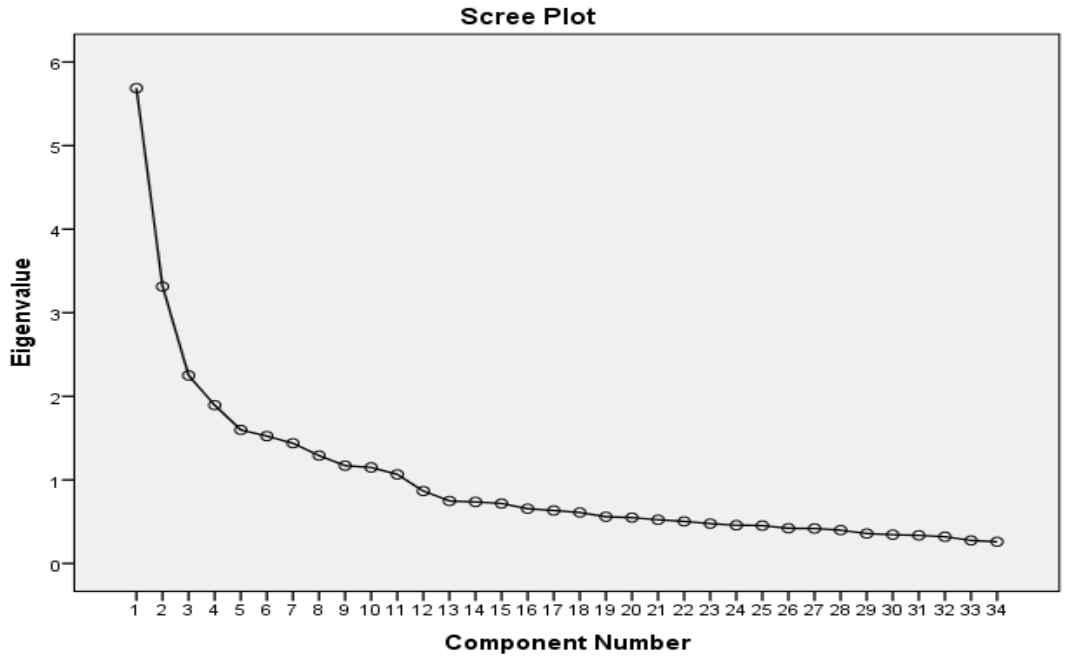


Table 7.5: Rotated component matrix[a]

Table 7.5a: Rotated component matrix[a]

	Component										
	1	2	3	4	5	6	7	8	9	10	11
3.1	0.753										
3.5	0.741										
3.2	0.732										
3.6	0.732										
6.4		0.794									
6.1		0.781									
6.2		0.759									
2.1			0.831								
2.2			0.791								
2.3			0.729								

Table 7.5b: Rotated component matrix[a]											
	1	2	3	4	5	6	7	8	9	10	11
10.2				0.807							
10.3				0.797							
10.1				0.732							
7.1					0.803						
7.2					0.786						
7.5					0.613						
7.4						0.799					
7.10						0.770					
7.8						0.695					
9.2							0.814				
9.1							0.739				
9.3							0.731				
11.3								0.776			
11.2								0.762			
11.1								0.729			
4.4									0.824		
4.5									0.784		
4.3									0.591		
8.4										0.806	
8.5										0.726	
8.6										0.683	
2.5											0.814
2.7											0.747
2.4											0.629
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.											
a. Rotation converged in 7 iterations.											

Table 7.6: Descriptive statistics and internal consistency reliabilities for the theory of planned behaviour (TPB) for individual constructs

Item	N	Mean	SD	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted	Cronbach's Alpha Overall
Outcome Evaluation						0.736
6.1	345	1.41	0.668	0.568	0.648	
6.2	345	1.41	0.623	0.543	0.671	
6.4	345	1.30	0.517	0.591	0.634	
Behavioural belief (1) strength						0.731
7.1	345	1.50	0.678	0.587	0.607	
7.2	345	1.47	0.694	0.584	0.610	
7.5	345	1.48	0.751	0.497	0.718	
Behavioural belief (2) strength						0.708
7.4	345	3.67	1.254	0.550	0.585	
7.8	345	4.00	1.224	0.535	0.605	
7.10	345	3.38	1.238	0.491	0.659	
Injunctive normative referent						0.702
8.4	345	2.78	1.163	0.526	0.604	
8.5	345	2.60	1.038	0.566	0.554	
8.6	345	2.44	1.052	0.470	0.669	
Normative beliefs						0.701
9.1	345	1.67	0.808	0.496	0.635	
9.2	345	1.58	0.755	0.613	0.493	
9.3	345	1.83	0.824	0.451	0.694	
Power of control factors						0.735
10.1	345	1.92	0.896	0.512	0.703	
10.2	345	1.86	0.904	0.602	0.596	
10.3	345	2.03	0.894	0.563	0.644	
Control belief strength						0.707
11.1	345	2.13	0.825	0.514	0.631	
11.2	345	1.97	0.812	0.533	0.606	
11.3	345	2.15	0.819	0.527	0.614	

Table 7.7: Descriptive statistics and internal consistency reliabilities for the total theory of planned behaviour (TPB) for combined related construct

Item	N	Mean	SD	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted	Cronbach's Alpha Overall
Attitude, Outcome Evaluation and Behaviour belief strength						0.751
2.1	345	1.5362	0.60951	0.289	0.743	
2.2	345	1.5072	0.58626	0.349	0.740	
2.3	345	1.5507	0.65451	0.429	0.734	
2.4	345	1.7913	0.79052	0.334	0.739	
2.5	345	1.9130	0.84803	0.258	0.746	
2.7	345	1.7942	0.79677	0.305	0.742	
6.1	345	1.4116	0.66811	0.381	0.737	
6.2	345	1.4116	0.62309	0.400	0.736	
6.4	345	1.2957	0.51671	0.439	0.736	
7.1	345	1.4986	0.67825	0.423	0.733	
7.2	345	1.4667	0.69439	0.396	0.735	
7.5	345	1.4754	0.75105	0.394	0.734	
7.4	345	2.5420	1.45838	0.456	0.730	
7.8	345	2.1420	1.41631	0.431	0.733	
7.10	345	2.8957	1.39167	0.352	0.744	
Subjective Norms, Injunctive normative referent and Power of control factors						0.771
3.1	345	2.37	1.186	0.498	0.744	
3.2	345	2.75	1.365	0.560	0.734	
3.5	345	2.38	1.151	0.501	0.743	
3.6	345	2.77	1.324	0.504	0.743	
8.4	345	2.78	1.163	0.372	0.761	
8.5	345	2.60	1.038	0.491	0.745	
8.6	345	2.44	1.052	0.481	0.747	
9.1	345	1.67	0.808	0.310	0.767	
9.2	345	1.58	0.755	0.352	0.763	
9.3	345	1.83	0.824	0.278	0.770	
Perceived behavioural, Power of control factors and Control belief strength						0.746
4.3	345	1.90	0.928	0.422	0.723	
4.4	345	1.93	0.948	0.353	0.734	
4.5	345	2.03	1.034	0.443	0.720	
10.1	345	2.13	0.825	0.352	0.734	
10.2	345	1.97	0.812	0.417	0.725	
10.3	345	2.15	0.819	0.372	0.731	
11.1	345	2.39	1.191	0.526	0.704	
11.2	345	2.75	1.273	0.455	0.720	
11.3	345	1.89	0.843	0.494	0.714	

Table 7.8: Pearson correlations

Correlations												
	Pearson	ATT	SN	PBC	INT	ACT	CBS_1	PCF_1	NB_1	INR_1	BBS_1	BBS_2
ATT	Correlation	1	0.379**	0.278**	0.369**	0.210**	0.176**	0.158**	0.172**	0.229**	0.178**	0.302**
	Sig. (2-tailed)		0.000	0.000	0.000	0.000	0.001	0.003	0.001	0.000	0.001	0.000
SN	Correlation	0.379**	1	0.355**	0.462**	0.406**	0.213**	0.151**	0.200**	0.390**	0.120*	0.248**
	Sig. (2-tailed)	0.000		0.000	0.000	0.000	0.000	0.005	0.000	0.000	0.026	0.000
PBC	Correlation	0.278**	0.355**	1	0.412**	0.329**	0.191**	0.203**	0.191**	0.285**	0.336**	0.236**
	Sig. (2-tailed)	0.000	0.000		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
INT	Correlation	0.369**	0.462**	0.412**	1	0.410**	0.258**	0.295**	0.297**	0.333**	0.335**	0.363**
	Sig. (2-tailed)	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000	0.000	0.000
ACT	Correlation	0.210**	0.406**	0.329**	0.410**	1	0.326**	0.239**	0.245**	0.449**	0.162**	0.171**
	Sig. (2-tailed)	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.003	0.001
CBS_1	Correlation	0.176**	0.213**	.191**	0.258**	.326**	1	0.276**	0.195**	0.322**	0.198**	0.192**
	Sig. (2-tailed)	0.001	0.000	.000	0.000	.000		0.000	0.000	0.000	0.000	0.000
PCF_1	Correlation	0.158**	0.151**	.203**	0.295**	.239**	0.276**	1	0.212**	0.118*	0.264**	0.194**
	Sig. (2-tailed)	0.003	0.005	.000	0.000	.000	0.000		0.000	0.029	0.000	0.000
NB_1	Correlation	0.172**	0.200**	.191**	0.297**	.245**	0.195**	0.212**	1	0.251**	0.287**	0.247**
	Sig. (2-tailed)	0.001	0.000	.000	0.000	.000	0.000	0.000		.000	0.000	0.000
INR_1	Correlation	0.229**	0.390**	.285**	0.333**	.449**	0.322**	0.118*	0.251**	1	0.147**	0.224**
	Sig. (2-tailed)	0.000	0.000	.000	0.000	.000	0.000	0.029	0.000		0.006	0.000
BBS_1	Correlation	0.178**	0.120*	.336**	0.335**	.162**	0.198**	0.264**	0.287**	0.147**	1	0.369**
	Sig. (2-tailed)	0.001	0.026	.000	0.000	.003	0.000	0.000	0.000	0.006		0.000
BBS_2	Correlation	0.302**	0.248**	.236**	0.363**	.171**	0.192**	0.194**	0.247**	0.224**	.369**	1
	Sig. (2-tailed)	0.000	0.000	.000	0.000	.001	0.000	0.000	0.000	0.000	0.000	
**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).												

Appendix G: Approval from Tshwane University of Technology

Tshwane University of Technology

Research Ethics Committee

The TUT Research Ethics Committee is a registered Institutional Review Board (IRB 00005968) with the US Office for Human Research Protections (IORG# 0004997) (Expires 19 Jan 2014). Also, it has Federal Wide Assurance for the Protection of Human Subjects for International Institutions (FWA 00011501) (Expires 31 Jan 2014). In South Africa it is registered with the National Health Research Ethics Council (REC-160509-21).

March 15, 2013

Ref #: REC2013/03/003
Name: Chiyangwa TB
Student #: 4991-849-4, UNISA

Mr TB Chiyangwa
School of Computing
College of Science, Engineering & Technology
UNISA

Dear Mr Chiyangwa,

Decision: Final Approval

Name: Chiyangwa TB
Proposal: Intended Belief and Actual Behaviour of IT users regarding Green Information Technology at a tertiary institution in South Africa
Qualification: MSc Computer Science, UNISA
Supervisor: Mrs T Horne; Joint supervisor: Mr T van Dyk

Thank you for submitting the revised project documents for TUT ethics clearance to distribute a survey questionnaire amongst IT students and staff members. In reviewing the revised documents, the comments/notes below are tabled for your consideration/attention/notification.

- **Informed Consent:**
  - The TUT Research Ethics Committee (REC) takes note of the UNISA logo that has been added to the first page of the document.
  - The clear indication that completion and voluntary return of an anonymous survey questionnaire will be regarded as *implied consent* to take part in the study is duly noted. However, the last section on page 2 still indicates that the research participant must provide a surname, name, cell number and date. This section needs to be deleted to fully adhere to the implied consent notion.

- **Questionnaire:**
  - The revisions to Item 6.1 and Item 11.2 are duly noted.
  - The additional instruction to research participants regarding the student-specific completion of some items in Sections H, I, J & K is duly noted.

- The clarification regarding the coding strategy of the list of individuals / groups in the open-ended questions (Section B) is duly noted.

- **Formal permission.** The commitment to submit a formal letter of permission from Prof S Ojo (TUT Executive Dean: ICT Faculty) for REC notification is duly noted.

The Chairperson of the Research Ethics Committee of Tshwane University of Technology reviewed the revised documents. The application is **approved.** The decision will be submitted to the next REC meeting on April 22, 2013 for ratification.

The proposed research project may now continue with the proviso that:

1) The researcher/s will conduct the study according to the procedures and methods indicated in the approved proposal, particularly in terms of any undertakings and/or assurances made regarding informed consent and the confidentiality of the collected data.
2) The proposal (inclusive of the applicable information leaflet/s, informed consent document/s, interview guide/s and/or questionnaire/s) will again be submitted to the Committee for prospective ethical clearance if there are any substantial changes from the existing proposal, particularly if those changes affect any of the study-related risks for the research participants.
3) The researcher will act within the parameters of any applicable national legislation, professional codes of conduct, institutional guidelines and scientific standards relevant to the specific field of study.

Note:

The reference number [top right corner of this communiqué] should be clearly indicated on all forms of communication [e.g. Webmail, E-mail messages, letters] with the intended research participants.

Yours sincerely,

WA HOFFMANN (Dr)
Chairperson: Research Ethics Committee
[Ref#: REC2013-03-003-ChiyangwaTB]