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GORDON INSTITUTE
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University of Pretoria

Factors affecting the energy consumption of data centres in South Africa

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Abstract

Companies in the US and the UK are frantically looking for ways to prevent future exorbitant data centre costs. South Africa does not have the space shortages, nor the high energy costs that companies in the US and UK experience. Hence, data centre energy efficiency is currently not a priority for South African businesses. However, things are about to change. Rising electricity costs and high growth rates in electricity consumption will motivate companies to consider implementing energy efficiency initiatives in their data centres.

The purpose of the research begins at an assessment of the level of awareness of the energy consumption of data centres. This report looks at what the perceptions are of the factors that could cause fluctuations in energy usage at the data centre. The report further explores how South African companies are addressing potential fluctuations in usage, and what the motivation is for action taken.

The methodology was a series of telephonic, semi-structured interviews with available and relevant stakeholders in data centre energy management. The interviewees were sourced from ICT companies in South Africa identified by the Market Research Foundation in the publication “Top ICT companies in South Africa 2005/6”, attendees of the ITWEB Green IT Summit 2008, and further referrals from these interviews.

Declaration



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I declare that this research project is my own work. It is submitted in partial fulfilment of the requirements for the degree of Master of Business Administration at the Gordon Institute of Business Science, University of Pretoria. It has not been submitted before for any other degree or examination in any other University. I further declare that I have obtained the necessary authorisation and consent to carry out this research.

Name: Daleela Young

Signature: _____

Date: 13 November 2008

Acknowledgements



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LIST OF ABBREVIATIONS



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AC	alternate current
CPU	central processing unit
DC	direct current
DCiE	data centre infrastructure efficiency ratio
EPA	Environmental Protection Agency
GHG	green house gases
ICT	information communication technology
IDC	International Data Corporation
IT	information technology
PC	personal computer
PSU	power supply unit
PUE	Power Usage Effectiveness
UK	United Kingdom
UPS	uninterruptible power supply
US	United States of America

**Data centre**

Data ^(2nd definition) is defined as “the information operated on by a computer program”

- centre ^(4th definition) is defined as “a place at which some specified activity is concentrated” (Collins English Dictionary, 2004). In practice, a data centre is a facility used to house computer systems and associated components.

Green Data Centre

A data centre that is designed to be energy efficient and minimize its impact on the environment (Bishop, 2007)

Green IT

Optimal use of information and communication technology (ICT) for managing the environmental sustainability of enterprise operations and the supply chain, as well as that of its products, services and resources, throughout their life cycles (Mingay, 2007).

Green productivity

“is a strategy for enhancing productivity and environmental performance simultaneously to achieve overall socio-economic development” (Tuttle and Heap, 2008)

ICT

Information Communications Technology includes all technologies for the manipulation and communication of information.

Server

A computer or program that supplies data or resources to other machines on a network (Collins English Dictionary, 2004)

Virtualisation (Hardware virtualisation)

Partitioning the computer's memory into separate and isolated "virtual machines" simulates multiple machines within one physical computer. It enables multiple copies of the same or different operating systems to run in the computer and also prevents applications from interfering with each other. (TechWeb, 2008)

Chapter 1: problem



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research

*“A stable climate is the most fundamental resource of all.
No one has yet built a civilisation in an unstable climate “
Tom Burke*

There was a time when there was no internet, computers or cellphones. However, now information communication technology has become an integral lifestyle commodity for many people around the world. The benefits of these technologies have outweighed the costs. The time for assessing these costs, financially and environmentally, has now arrived.

Global Trends: Climate change

“Climate change is probably the greatest long term challenge facing the human race” Tony Blair, Prime Minister of the United Kingdom, said in his foreword to the 2006 UK Climate Change Programme. Greenpeace (2008) suggests that the real solution to the climate crisis is the priority of investment in renewable energy and energy efficiency efforts. These have the greatest potential to provide energy security and reduced emissions.

Focus on renewable energy and efficiency efforts by individuals alone will not yield the desired results. Business leaders of the UK state that “Any response to the threat of climate change requires three components for success: politicians must give the issue sustained priority, consumers must be empowered to make informed decisions and business must become green to grow.” (*CBI Climate Change Task Force, 2007*). This report will investigate how information technology (IT) can contribute to business to become environmentally sustainable.

ICT and Sustainability

ICTs have played a central role in bringing people of the globe together. This role should assume the responsibility of ensuring sustainability in delivering its intended purpose. The Brundtland Report (1987) defines sustainable development as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs”. Newport, Chesnes and Lindner (2003) maintain that sustainability is not limited to the environment, but also to economic growth and social equity, the three legs of the sustainability stool.

ICTs have a role to play in affecting all three “legs of the stool”. Economic growth (Erdmann, Hilty, Goodman and Arnfalk, 2005); social equity (Bass, Bigg, Bishop and Tunstall, 2006) and sustainability (Forge, 2007).

ICT's have become an integral lifestyle commodity across the planet, not only on a business level, but also on a personal level. ICT development has been the foundation for huge improvements in medical science breakthroughs. E-commerce, online banking, home shopping and instant access to music, books and videos across up to thousands of kilometers from their source (Loper and Parr, 2007).

One of the side effects of this advancement in technology, is that the hosting of these ICT's have to be powered by about 24 million servers worldwide (Forge, 2007). The operating of these servers requires huge amounts of energy in order to keep lifestyle and business information and product exchanges available 24 hours a day 7 days a week, in the 21st century global village.

Moore's Law states that the complexity of integrated circuits, will double every 18 months (Schaller, 1997). This law has remained consistently successful in predicting future computer processing capacity. The implications of this law are that computing power will improve performance of ICT equipment, whilst simultaneously becoming cheaper over time. This phenomenon has kept the world fascinated with the performance-price trade-off, perhaps to the detriment of the energy-performance trade off, which has become an unwelcome side effect of Moore's Law.

As the processing power of ICT devices increases, so too does their power requirements (Sviokla and McGilloway, 2008). ICT giants such as Yahoo and Google are increasingly mindful of electricity costs and are building new data centres in places with low electricity rates. (Loper and Parr, 2007).

Fortunately, data center energy usage growth can be curbed by up to 55percent (US EPA, 2007) The challenge is to increase awareness among data centre owners and users about the opportunities that exist to reduce energy consumption, and motivate them to make the necessary investments in behavioral changes required to take advantage of these savings.

On a global level

The internet evolved as a vital tool in global commerce and government. Thus, business and government dependency on ICT and the internet has grown exponentially (USA EPA, 2007). E-commerce grows as the internet increasingly becomes a medium for companies to engage and interact with customers



as does government requirements for storage and management of pertinent records. (Abukhader and Jönson, 2003). All this demand for computing power and information storage inevitably drives up the demand for data centre space to house the servers and storage devices and power to feed these machines (US EPA, 2007).

Energy efficiency and optimisation efforts of an organisation's supply chain have become accepted as practical ways of contributing to sustainability of the planet. This report analyses the potential positive contributions the IT Industry can make to these challenges that may have the biggest impact in the short term.

On a business level:

Apart from the conscience of a business, Bob Willard (2002 in Tuttle and Heap, 2008) identify reasons for business to consider adopting a sustainable business strategy. These reasons include the creation of a favourable environment to attract and retain top talent, increased market share through customer retention which would lead to reduced risk and thus, easier financing.

Tuttle and Heap (2008) suggest that businesses which embrace environmental issues together with business issues, in an integrated way, can still be successful, and may be more so as a result of embracing green productivity. In addition, compliance rules are set to increase, so businesses embracing sustainability changes will be better equipped to deal with environmental issues later.

On an Individual level:

Mankind is innately prejudiced against sustainability (Reese, 2002). Man is uniquely adaptive and can exploit most ecosystems and exploit renewable and non-renewable resources. A paradigm shift is necessary on an individual level – where the old paradigm viewed social, economic and environmental performance as conflicting priorities, the new paradigm must see all three as simultaneously achievable. Without this paradigm shift, sustainability cannot be achieved (Reese, 2002).

The need for a fundamental paradigm shift applies to the purchases of ICT devices as well. The number of purchases of PC's, laptops, mobile phones, and storage requirements has grown exponentially over the last 10 years (Forge, 2007). The carbon footprint of these devices has not been seen as critical to be managed, as the benefits seem to outweigh the need for such devices. The growth of combined carbon footprint of ICT devices leaves no doubt that the behaviour of consumption of these devices requires drastic management and measurement (Erdmann et al, 2005).

Research Scope

This report will make the issue of data centre energy consumption relevant in a South African context, and contribute to the environmental impact analysis of data centre energy consumption in South Africa. The following factors will be assessed through this study: the perception of the level of awareness of the power usage particular to data centres; which are the factors that contribute to fluctuations in energy consumption in data centres in South Africa; which actions have been

taken to reduce, op



y usage; and finally, the

potential motivation for these actions.

The subject of energy efficiency of ICT's in general is a broad one. This paper will exclude the following aspects of ICT energy efficiency:

- Energy efficiency of all ICT devices, including mobile telephones, gaming devices, music devices and personal computers;
- Environmental contributors such as greenhouse gas emissions (GHG) attributable to ICT's. (Mingay (2008) attributes 2percent of global GHGs to ICTs);
- Electronic and electric waste and the use of hazardous material in electronic equipment and waste management;
- Printing devices and their paper usage;
- Energy efficiency of the building materials and constituents of the physical structure of the data centre;
- First order effects of ICT's such as product design, input material or manufacturing processes, sustainable purchasing, logistics and transportation or distribution of ICT's
- Second effects of ICTS's such as warehouses and retail space built for e-commerce businesses and travel substitution;
- Third order effects of ICT's such as landfill requirements caused by disposal of ICT's
 - o 2 billion cellphones in use (Forge, 2007)
 - o 130 million personal computers need to be disposed of (Forge, 2007)
 - o 178 million new printers, copiers and multifunction devices were delivered 2007 (Mingay, 2007b).



Research Motivation and relevance to South Africa

Any mechanism that reduces the demand for electricity would inadvertently reduce damage to the environment. ICT energy efficiency measures have the potential to reduce potentially excessive energy usage in the long term if consumption growth rates continue in as those in the United States (US EPA, 2007).

Electricity production in South Africa affects the environment negatively (as per Kilian, Gibson, Henderson, King, Pretorius and Koch, 2006) in the following ways:

- Energy use causes air and water pollution, biodiversity loss and land use change.
- Coal is the predominant fossil fuel for energy use in South Africa, accounting for approximately 75percent of energy used. Dependence on coal for electricity generation is expected to continue in the short to medium term, despite cleaner coal technology development and greater contributions from alternate energy sources.
- The burning of fossil fuels for energy releases approximately 80percent of all human-induced greenhouse gas emissions in the country.
- In 2002, large coal power stations producing electricity for the national grid were the largest producers of sulphur dioxide (70.5percent) and nitrogen oxides (54.9percent) in the country.

Kilian et al (2006) fur




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al energy demand over the

past 25 years has resulted in a corresponding increase in coal consumption (by 23percent since 1992). Industry is the largest consumer of electricity (68percent), followed by residential (17percent) and then commercial (10percent) sectors. The tertiary sector may be a small consumer of electricity in South Africa in 2008, but this sector has grown in South Africa since 1994 (Kilian et al, 2006). Furthermore, the South African Government plans to accelerate the development of this sector, including the infrastructure required by ICT's through its Accelerated and Shared Growth Initiative for South Africa (AsgiSA). One of the binding constraints mentioned in the statement on the release of the annual report for 2006 on AsgiSA, is the poor international competitiveness of manufacturing and services sectors. Tourism, business process outsourcing and small business development are targeted as specific efforts to address this binding constraint (Asgisa, 2006).

These efforts would boost the tertiary sector activities, such as retail and wholesale operations, government services, real estate and finance. The energy usage measurements of the tertiary sector include ICT energy usage. For example, real estate agents make extensive use of the internet for advertising properties; the government makes use of ICT for storing and managing government employee records and civilian records; the banking sector makes extensive use of ICTs for maintaining client records and regulatory purposes. The actual usage of ICTs is therefore, currently hidden in these sector usage figures.

This serves to confirm that South Africa has very little available measurements of its current ICT energy usage. Considering the following factors, it has become imperative that these measurement become part of operational measurements

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- Energy consumption in the US between 2000 and 2006 (US EPA, 2007), indicate similar growth may be a possibility in South Africa as well. These rates are not sustainable in the long term;
 - The magnitude of 3rd order effects of ICT's are considerable when the entire life cycle of ICT's is measured. Measurement of data centre energy consumption will begin to highlight this reality for future control and management;
 - There are huge amounts of electricity that are wasted during transmission and distribution. Gartner estimates that approximately only 1 percent of the electricity that is generated actually powers the equipment in the data centre (Mingay, 2008)

These reasons illustrate how important it has become to raise the level of awareness of ICT energy usage, and to begin measuring the energy usage of ICTs in South Africa. Only when we understand the magnitude of the problem can we begin demonstrating efficiencies.

Chapter 2: Energy and Literature review

Failure to reverse trends that threaten future quality of life will steeply increase the costs to society or make those trends irreversible

- European Heads of State and Government, Gothenburg, 2001

Parents with a child star, who achieves excellent marks at school, or is the schools' sports star, knows that when that child misbehaves, that naughtiness is overlooked. The reason is because the parents, consciously or unconsciously, weigh up the good points against the bad. ICT's have been a mechanism for development (Dutta, Lopez-Claros and Mia, 2006). This has allowed their energy consumption to go unchecked, because the good points have outweighed the bad points. This chapter explores the positive contribution of ICT's to the world's energy consumption, and then looks at what factors could affect the energy consumption of the ICT's themselves.

Effect of ICTs on energy consumption

The effects of ICTs on energy consumption are not easily estimated. Erdmann et al (2004) performed a study to gauge the overall impact of ICT's on energy consumption. The results of the study are shown in Figure 1 below. They maintained that total energy consumption is closely linked to the level of economic activity, changes in transport patterns and energy consumption of buildings.

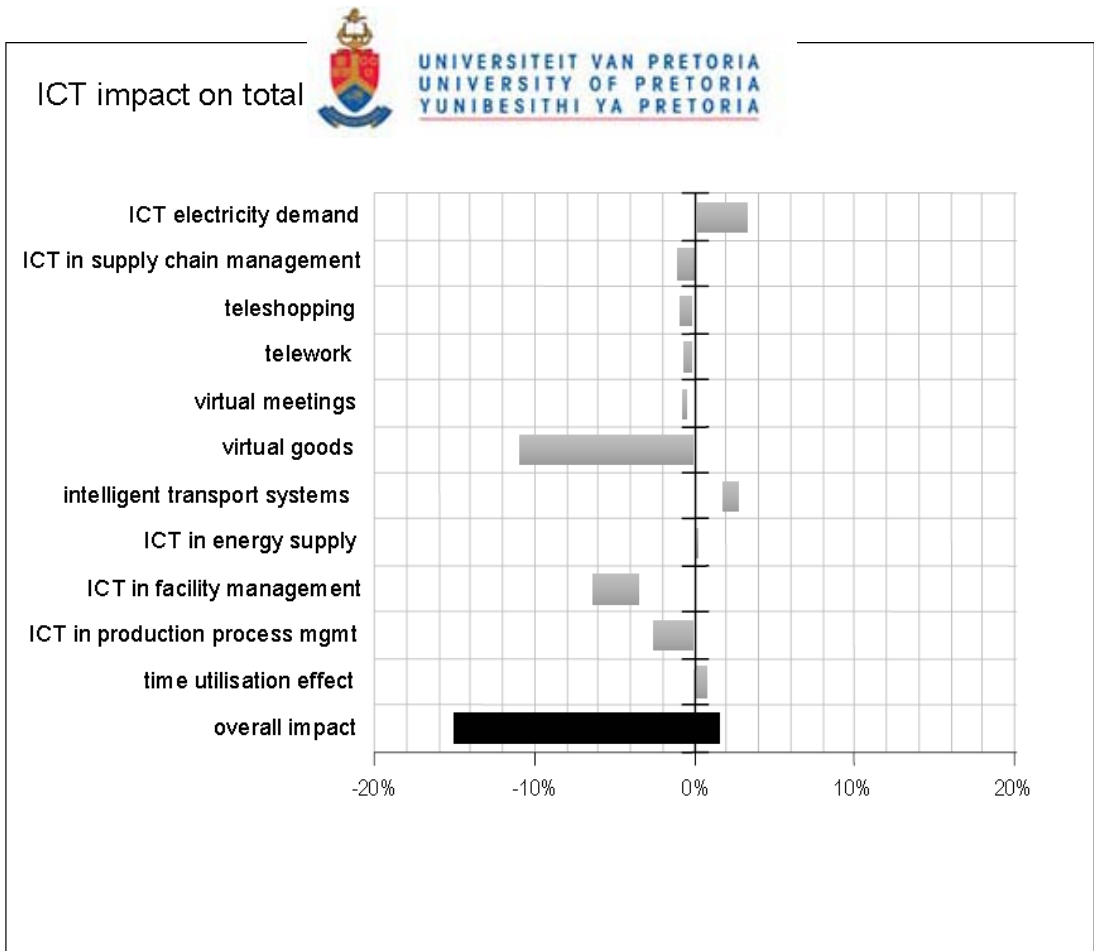


Figure 1 ICT impact on total energy consumption.

SOURCE Erdmann L, Hilty L, Goodman J, Arnfalk P (2004) “The future impacts of ICTs on environmental sustainability”

There is no simple overall strategy for minimising energy usage by means of ICTs. Figure 1 shows how the overall effect of ICTs is the reduction of energy consumption. If ICT’s can reduce absolute energy consumption despite strong GDP growth and high employment, it is necessary to find a way of promoting the environmentally positive impacts of ICTs, while inhibiting the negative ones (Erdmann et al, 2004). For this reason, the negative effects of ICT’s, in particular the electricity demand of ICT’s and the growth thereof has been downplayed.

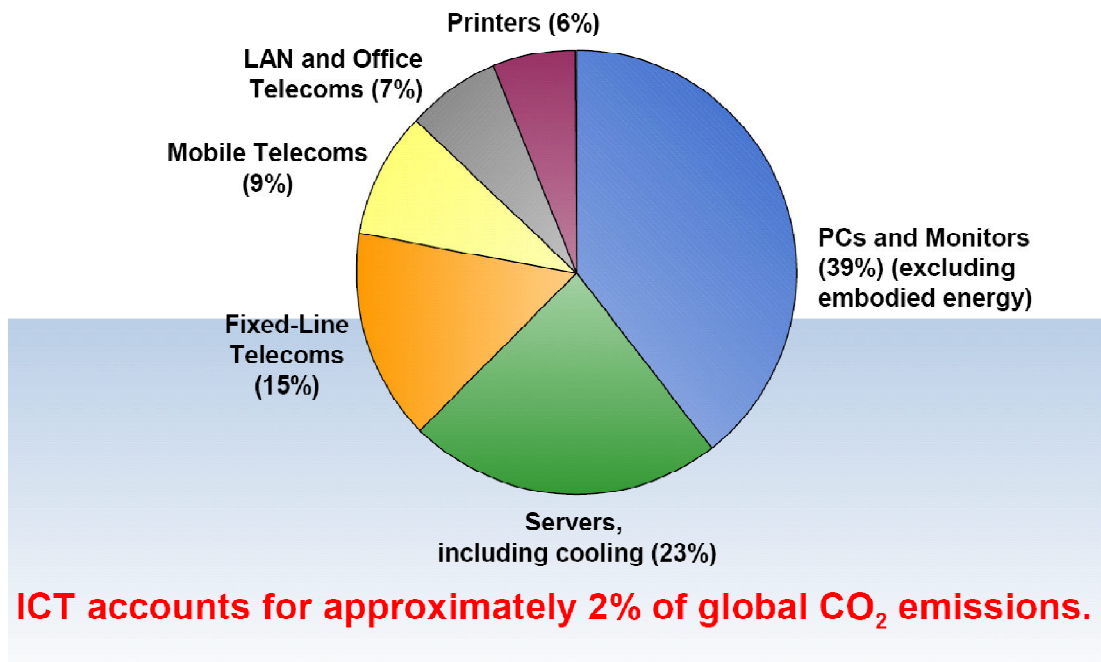


Figure 2 ICT's global CO₂ emissions. Source: Mingay S (2007b) "Green IT: A New industry shock wave"

Figure 2 illustrates how the different ICTs contribute to global carbon dioxide emissions (Mingay, 2007a). 23 percent of the 2% of global carbon dioxide emissions is estimated to be caused by servers and their required cooling. This is cause for concern, especially when the growth rates of the energy consumption are taken into consideration. It appears that the time has come to start actively managing the energy usage growth rates down.

Data Centre Energy Consumption

The US EPA report to Congress estimated that the energy used by servers and data centres in the US consumed about 61 billion kilowatt-hours (kWh) in 2006, 1.5 percent of total US electricity consumption, for a total electricity cost of \$4.5 billion.

This is double the ele



forecasted consumption at

the current usage rates will be double again in 5 years time.

HP (2008) agrees with the US EPA estimations of usage in the US, but there are slight differences. HP (2008) claims that the electricity use of servers and data centres doubled between 2000 and 2005 (not 2006 as the EPA report declares). HP (2008) sourced the independent data corporation (IDC) data for estimations. These are also based on the installed base, shipments and power use on the most popular models. HP (2008) claims that in 2005, data centre and servers used 1.2percent of electricity sales (not 1.5 as the EPA report) costing \$2.7billion (not \$4.5billion as in the EPA report).

Forge (2007) estimates that the UK had total electricity generating capacity of some 77.4 gigawatts in 2005-06, of which 3.9 gigawatts may be attributable to data centres and server electricity usage. This indicates that data centers consume around 5 percent of the country's maximum generation capacity. Forge (2007) estimates that the UK demand for data center space may spiral by 45 percent by 2010 at current growth rates under market pressures. There may be a corresponding increase in energy usage, but use of energy per square meter will probably increase by 2010, as a result of virtualization and consolidation exercises, driving energy consumed up by 45 percent.

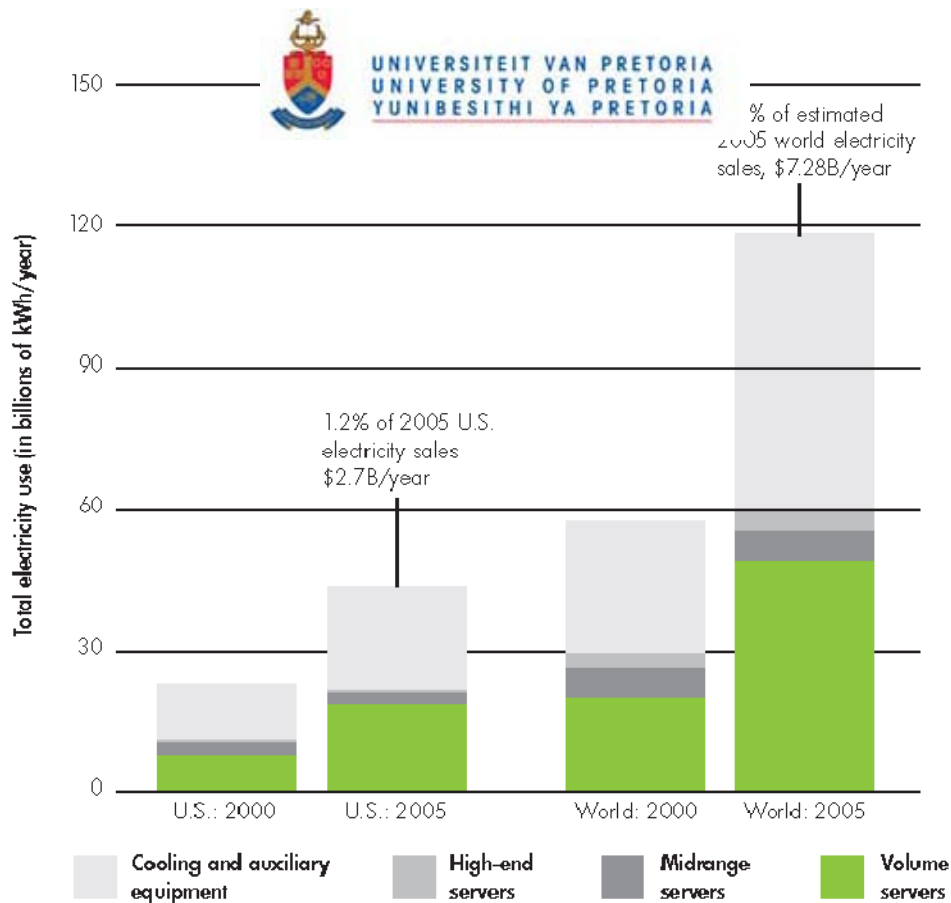


Figure 3 Total electricity use in US and the world 2005 Source: HP (2008) Energy Efficiency in data centres

These estimates are exactly that. Accurate data centre energy consumption is difficult to quantify currently because of the complexity of the environment; the many factors: business, IT and data centre, which affect the consumption; and the maturity of the proposed measurements.

Business factors that affect data centre energy consumption

There are some data centre energy consumption factors that are influenced by the decisions of the organization. The research that underpinned the business factors identified in this report is tabulated in Table 1.

Table 1 Literature review of business or policy actions

BUSINESS FACTORS	Uptime Institute	The Green Grid	Gartner	The Alliance	IBM	SUN Microsystems	US EPA	Other literature
Planned business demand	Brill, 2008a		Rowse-Jones A and Mingay S, 2008		IBM Global Technology Services, 2008	Black et al, 2007	US EPA, 2007	Forge, 2007
Unplanned business demand	Brill, 2008a		Rowse-Jones A and Mingay S, 2008		IBM Global Technology Services, 2008	Black et al, 2007	US EPA, 2007	Forge, 2007
Roll out of new applications	Brill, 2008a					Black et al, 2007		Forge, 2007
Consolidation of data centres	Brill, 2008a				IBM Global Technology Services, 2008			Loeffler, 20
Government or regulatory compliance	Brill, 2008a			Loper & Parr, 2007		Black et al, 2007	US EPA, 2007	
Convergence of IT and Building Facilities	Ulchne (2008)	Y						Stinnes, 2008



Business demand



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The growth in demand for computing resources has resulted in growth of the number of data centres, and hence growth in the energy consumed by servers and the power and cooling infrastructure that supports them (US EPA, 2007). This increase in energy use has the following consequences:

- Increased costs for business and government
- Increased emissions, including greenhouse gases, from electricity generation
- Increased strain on the existing power grid
- Increased capital costs for expansion of data centre capacity

The US EPA (2007) claims that the demand of the data centre is driven by several contributors, including:

- Increased number of electronic transactions for banking / financial services
- Growth of internet communication and entertainment
- Shift to electronic medical records for healthcare
- Growth in global commerce and services
- Adoption of satellite navigation and electronic shipment tracking in transportation

Improved data centre energy cost improves a company's bottom line. IBM Global Technology Services (2008) reported that IBM data centers account for 6 percent of total floor space but are responsible for 30 percent of energy cost. Furthermore, data centre energy costs grew 18 percent in 2007. This growth in costs should justify the investigation of efficiency initiatives within the data centre.



data centre energy consumption and provide a benchmark. IBM found that 28 percent of every dollar spent on energy was actually used by the IT equipment. The rest was spent on air-conditioning and other infrastructure. HP (2008) appears to concur with this declaration (see figure 3).

Most of the literature, including IBM Global Technology Services (2008); US EPA (2007) and Sun Microsystems CIO2CIO Perspectives (2008); recommend that business leaders manage, measure and enhance energy consumption of their data centres, and potentially automate these functions for energy consumption. Innovative energy-management software enables energy billing metrics necessary to help control data centre's energy consumption.

Businesses, operating in an age where climate change is viewed as ominous by stakeholders, want to make efforts to build environmental branding to be viewed positively by these stakeholders. In addition, they are concerned about rising energy costs, and higher compliance and insurance costs (IBM Global Technology Services, 2008; HP, 2008; Rowsell-Jones and Mingay, 2008)

Revenue and profitability remain paramount in the minds of decision makers' when considering data centre efficiency. The data centre is the work horse which must produce the goods. If business demands more, the data centre must produce more. The costs and efficiency in the delivery of those goods is currently secondary to service delivery. At the moment, there seems little to indicate that a happy middle ground has been reached.



The rollout of new software may have three side effects which may affect the efficiency of the data centre negatively. Firstly, new software may require upgraded hardware in order to run optimally. The upgraded hardware traditionally was more power-hungry than the old hardware (Forge, 2007). However, this is currently changing as new hardware models are more energy efficient (IBM Global Technology Services, 2008; HP, 2008; Sun Microsystems, 2008), and software is more sensitive to energy consumption. Secondly, the old software is kept operational whilst the new software is implemented. This means double the hardware running in the data centre until the old systems are switched off, which inevitably takes longer than anticipated. Sun Microsystems have introduced dynamic infrastructure to redefine the data centre as flexible, scalable and adaptable to deal with new applications deployed with existing infrastructure (Black, Carolan, Combs, Couling, Graham, Hartman, Ho, Hudelot, Le Sueur, Lofstrand, Nelson, Read, Savit and Steiner, 2007).

Thirdly, operating system upgrades may make applications and utilities obsolete when there are incompatibility challenges (Forge, 2007). These three reasons cry out for proper investigation into the total cost of ownership of any new proposed software to be rolled out into the organization.

Consolidation of data centres

IBM Global Technology Services (2008) recommend consolidation of data centres to achieve space savings and increased manageability. Building or upgrading a new data center provides the perfect opportunity to rationalize the data center

strategy as a way for



operational savings, including energy-efficiency savings. Lochner (2008) suggests that the consolidation of physical data centres could result in savings when servers share cooling and back up systems.

Government compliance

Erdmann et al (2004) declared that the marked growth in the share of renewable energy sources in electricity generation is mainly being driven by policy incentives. If ICTs are to enable a decrease in absolute energy consumption, policy must be designed so that it promotes the environmentally positive impacts of ICTs, whilst inhibiting the negative ones.

The US EPA report to Congress (US EPA, 2007) investigated incentives available for energy efficient products, and the adoption of similar programs for data centre efficiency. The report also made recommendations for potential incentives and voluntary programs.

Incentives, as a means to manage energy efficiency, appear to be an idealistic approach to such a major issue such as sustainability. It seems just a matter of time before regulation overrules incentives. We can already bear witness. In July 2008, the UK government wrote to 10,000 businesses to warn them that they could be affected by the Carbon Reduction Commitment—a scheme that requires large businesses to purchase yearly carbon allowances for their anticipated energy usage. Unused allowances can be redeemed at year's end, which is an incentive to reduce energy consumption (HP, 2008).



report on potential government measures that would improve energy efficiency of data centres. The report entitled “Energy Efficiency in Data Centers: A New Policy Frontier” highlights 5 potential measures that governments could spearhead to improve data centre energy efficiency.

1. Metering data center energy use – Governments should encourage sub-metering of data centers to help isolate energy efficiency opportunities among various loads and over time.
2. Energy performance measurement – Government should support efforts to develop server and power supply energy performance metrics.
3. Energy performance standards – Governments should impose minimum energy performance standards for power supplies at the 80-Plus level or better. Once performance measures have been established for server power supplies, governments should consider adoption of minimum energy performance standards.
4. Building codes – Governments should ensure that data center best practices are included in commercial building codes. The federal government should work with ASHRAE to ensure inclusion of data center systems that ensure a minimum of energy waste in commercial building standards including an analysis of the sizing of the cooling systems for server areas.
5. Financial incentives – Where energy performance measures are obtainable, systems are comparable, and budgets are available, governments should establish tax and/or utility incentives for servers, power supplies and other



Convergence of IT and Building Facilities

IT teams and the teams who manage the data centre are often within different reporting structures. This means that there is often no structural or procedural mandate for formal interaction with each other (Ulichnie, 2008). Furthermore, the Building Facilities team is responsible for payment of the electricity and energy bills. The IT teams make the decisions that affect the data centre energy efficiency.

Global trends that affect the built environment include population growth, urbanisation, energy consumption, and the convergence of working, living and playing spaces. Population growth doubled since 1950; urbanisation quadrupled since 1950; buildings consume more than 50 percent of the world's electricity; and 60 percent of the space is wasted (Stinnes, 2008). IT plays a huge part in modern building management. Environmental management systems include the monitoring of carbon dioxide levels in the building; occupancy sensors; dynamic cooling and heating, white noise adjustments; digital signage, power monitoring and security monitoring. In addition, tele-and video conferencing and wireless technologies all require IT servers and power to feed them. The convergence of IT and Buildings thus, also has an effect on the data centre energy consumption.

These business-related factors identified may affect data centre energy consumption. This research will ask experts in the area of data centre management which of these factors are relevant to South Africa.



Table 2 Literature review of IT management factors

IT MANAGEMENT FACTORS	Uptime Institute	The Green Grid	Gartner	The Alliance	IBM	SUN Microsystems	US EPA	Others
Simplify: Consolidate or Virtualise servers and or storage		Right size server farms: Blackburn, 2007	Virtualisation for server consolidation Kumar, 2008		Increase efficiency of servers and storage devices: IBM Global Technology Services, 2008	CIO2CIO Perspectives, 2008; Consolidate storage: Black et al, 2007		Consolidate servers: Forge, 2007
Improve IT asset Management capabilities; Analyse the impact of energy efficiency on product performance, computing functionality, reliability, speed, features and cost	McKinsey & Co, 2008					CIO2CIO Perspectives, 2008 Black et al, 2007	Rationalise software: Forge, 2007	Forge, 2007
Enable Server Processor Power-Saving Features		Blackburn, 2007	Processor design and server efficiency: Kumar, 2008		Global Technology Services, 2008	Black et al, 2007		Loeffler, 2007
Turn off servers when not in use or Decommission old systems that have outlived usefulness		Blackburn, 2007			Global Technology Services, 2008	Black et al, 2007	US EPA, 2007	Loeffler, 2008
Procurement decision to consider energy efficient micro chips and servers		Blackburn, 2007				Black et al, 2007	US EPA, 2007	Forge, 2007



IT management makes decisions that affect the energy consumption of data centres. These decisions include purchase decisions, operations decisions and management decisions. The outcomes of these decisions constitute IT management factors that affect data centre energy efficiency. These factors have been identified in the literature summarised in Table 2.

Server consolidation and virtualisation

IBM Global Technology Services (2008) indicated that IT management is responding to growth in business demand by building more data centres: IT management are increasing both the numbers and the density of their servers and storage devices. Much of the research indicated that server consolidation and virtualisation is a key factor in reducing energy consumption. Virtualising servers and storage devices can increase processing loads and boost individual server utilisation rates. Virtualisation can increase available storage space and reduce the over-allocation of resources.

Increased energy efficiency can not only help reduce a company's current energy costs but can also make energy previously used by the physical infrastructure available to power new server, storage and communications equipment as it becomes needed to support business growth.



implementing blade servers, which provide higher density computing for the power consumed. Each blade uses shared power supplies, fans, networking and storage with other blades. Consolidation of storage works as follows: the larger the disk drive, the slower its operating speed, the more efficient its energy consumption. Loeffler (2008) recommends that high speed drives are only used where absolutely necessary. Furthermore, larger disk drives are more efficient. Therefore, IT management could consider consolidating storage to improve utilisation and warrant the use of larger drives.

Forge (2007) calls for the dynamic management of hardware and software; applications across servers to reduce data centre energy efficiency. Black, Carolan, Combs, Couling, Graham, Hartman, Ho, Hudelot, Le Sueur, Lofstrand, Nelson, Read, Savit, Steiner (2007) state that virtualisation enables organisations to consolidate multiple workloads from existing systems onto a smaller number of more powerful servers. This would allow workloads to be created and re-allocated across servers dynamically.

Some virtualisation techniques allow legacy applications to be transitioned into a virtualised environment without re-installing operating system or application software. This enables the retirement of obsolete, energy-inefficient servers, whilst still supporting the mission-critical software that runs on them. However, virtualisation presents new challenges, specifically around the management of the vast array of ICT equipment, such as servers, middleware, networks, and storage, as a system.



Consolidation of servers and virtualisation requires that IT assets and their used and available capacity, are closely monitored and managed. McKinsey & Co. (2008) highlights poor application design and planning; and poor capacity management as major constituents of data centre energy inefficiencies.

Blackburn (2008) insists that all running servers should be identified and their business purpose and power consumption documented as part of the asset management required for server consolidation.

Power saving features

Blackburn (2008) suggested that data centre energy consumption can be reduced through enabling the server power-saving features. Loeffler (2008) explains that newer technologies are processing higher loads for less power. But, several CPU's have a power management feature that optimises power consumption by dramatically switching among multiple performance states (frequency and voltage combinations) based on CPU utilisation, without having to reset the CPU. When the CPU is operating at low utilisation, the power management feature minimises the wasted energy by dynamically ratcheting down processor power states (lower voltage and frequency) when peak performance is not required. Adaptive power management reduces power consumption without compromising processing capability.



Loeffler (2008) recommends that idle IT equipment be turned off. Underutilised equipment should be identified and powered down. Ineffective software that uses excessive CPU cycles should also be identified and removed from the data centre in order to reduce the unnecessary energy consumed by these machines.

Blackburn (2008) concurs that server are often kept available when they are not required to be operational 24 hours a day. Individual servers may be powered down for certain periods of the day, for example, servers executing backup software are normally only required at night and branch-based servers are normally only used during the day.

Blackburn (2008) suggests that IT management decommission old systems that provide no useful work, especially older servers that have fallen out of use but have not been decommissioned. New servers available offer better performance with significantly reduced energy demands.

Loeffler (2008) recommends that IT management consider energy efficient CPUs and power supplies when making IT equipment purchases. After the CPU, the highest energy consuming IT component is the power supply unit (PSU):

- a. PSU converts AC to direct current
- b. PSU uses about 25 percent of the server's power
- c. The typical PSU operates at 60- 80 percent efficiency

These IT management factors, such as server energy efficiency, if implemented. This report will investigate whether these factors could contribute to energy efficiency in South African data centres.



Data Centre Management factors that affect data centre energy efficiency

There are some factors attributable to the management of the data centre that affects data centre energy efficiency (see table 3 for a literature summary). As IT equipment releases heat during processing, cooling of the equipment is vital to prevent servers and equipment from over-heating. However, over time, the costs of cooling the data centre have grown to the extent that cooling costs have overtaken the cost of the equipment over the life-cycle of the equipment (see figure 3).

Modular design of the data centre

The data centre is a changing organism (Kumar & Dawson, 2007). New equipment is housed in the data centre, and old equipment is removed. Large equipment is replaced with smaller units. The modular design of a data centre can improve the energy consumption through reducing the impact of these changes to the cooling and power load sharing.

Table 3 Literature review of data centre management actions

DATA CENTRE MANAGEMENT ACTIONS	Uptime Institute	The Green Grid (Blackburn, 2007)	Gartner	The Alliance	IBM	SUN Microsystems	US EPA	Others
Upgrade data centre or build a new modular one			Modern design characteristics :Kumar, 2008 Kumar & Dawson, 2007		IBM Global Technology Services, 2008	Scalability and security: Black et al, 2007		
Measure data centre energy use and performance – measure, manage and enhance	McKinsey & Co, 2008	Identify the culprits, Blackburn, 2007	McGuckin, 2008; (Kumar, 2008)	Loper & Parr, 2007	Diagnose: IBM Global Technology Services, 2008	CIO2CIO Perspectives, 2008 Black et al, 2007	Energy performance standards: US EPA, 2007	
Innovative cooling techniques			(McGuckin, 2008) (Kumar, 2008)		IBM Global Technology Services, 2008			Gre et a



This is not always practical. Data centres are built with the intention to last for 10-15 years use, whilst equipment may be replaced every two to four years. Timing the change suitable to all stakeholders may be tricky. Furthermore, this may require downtime, and stakeholders are often reluctant to agree to downtime for critical applications.

IBM Global Technology Services (2008) highlights that older data centres may not be able to power and cool the newer IT equipment—especially blade servers—in an energy-efficient manner. Greenberg, Mills, Tschudi, Rumsey & Myatt (2006) recommend right-sizing of the design of electrical and mechanical systems to operate efficiently when running below design specifications, yet are scalable for increases in load when required. McKinsey & Co. (2008) agree that this is important, and attributes data centre inefficiency to poor power and cooling design, amongst others.

Cooling and air flow

IBM Global Technology Services (2008) recommends the following data centre management actions to improve data centre energy efficiency: Reducing recirculation and bypass of cooling air, increasing computer room air conditioner air discharge temperatures, adjusting indoor temperature and relative humidity, and improving the efficiency of the uninterruptible power supply (UPS).

Cooling has become a major problem in many data centers (Kumar, 2007). Rack enclosures can accommodate 60 to 70 units equating to 20,000 watts to 25,000

watts of power per ra



equipment power, there is a

need for another 50 percent to 60 percent for air conditioning equipment.

Appropriate and efficient cooling can enable and accelerate the growth of IT capacity by making it possible for the data center to increase its use of blade servers.

McGuckin (2008) recommends the following actions to improve the cooling: coordinate computer room air conditioning units; Improve underfloor airflow; Implement hot and cold air isles, and containment; Install temperature sensors; Raise the temperature in the data centre; Install variable speed fans and pumps; Exploit free cooling; Kumar (2008) suggests that a combination of heating and cooling will improve energy efficiency. Greenberg et al (2006) expands to suggest that air management can be optimised by emphasising control and isolation of hot and cold air streams

Greenberg et al (2006) further makes the following recommendations: that the central chiller plant be optimised to maximise overall cooling plant efficiency; the data centre be designed for efficient air handling in order to operate efficiently both at inception and as data centre load increases over time; capitalise on free cooling using air side or water side economisers operating with or in lieu of compressor based cooling, improve humidification systems and controls with alternate humidity control and the use of direct evaporative cooling; specify efficient UPS and IT equipment power supplies; improved operation and configuration of UPS; onsite power generation; employ direct liquid cooling of racks and computers, for energy and space saving; reduce standby loss of standby generation (engine heater of generator); and improve design, operations and maintenance processes, to result

in more functional, re
cycle.



entres throughout their life

Data centre management quite obviously has a huge part to play in the energy consumption of their environments. There is much that these managers can do, but require the buy in and approval of both IT management and business in order to implement energy efficiency initiatives for the data centre..

Summary

Actions of specific stakeholders can influence data centre energy consumption. There is no single factor at play in managing or improving data centre energy efficiency. This is one issue which requires business, IT and data centre management to work together in order to improve the energy consumption of a data centre.



*You never change things by fighting the existing reality.
To change something, build a new model that makes the existing model obsolete
- Buckminster Fuller*

Purpose of the research

This research seeks to determine the factors that are causing a fluctuation of energy consumption of data centres in South Africa. Based on the literature review, the following propositions have been formulated

Proposition 1

Proposition 1: South African companies are aware of their data centre energy consumption

- Measurement of data centre energy consumption is currently in infancy (Blackburn, 2008; Mingay, 2008).
- Organisations should begin to measure their data centre energy usage through monitoring and modelling tools (IBM Global Technology Services, 2008; Mckinsey & Co, 2008; Kumar, 2008).

Proposition 2

Proposition 2: The following factors contribute to data centre energy consumption:

Business factors

- Planned business demand causes an increase in data centre energy consumption (US EPA, 2007; Kumar, 2007; Brill, 2008b)



- Unplanned business use in data centre energy consumption (US EPA, 2007; Kumar, 2007; Brill, 2008b)
- Consolidation of data centres causes a reduction in data centre energy consumption (IBM Global Technology Services; 2008, Brill b, 2008; Kumar, 2007)
- Convergence of IT and Building Facilities causes an increase in data centre energy consumption (Ulichnie, 2008; Brill, 2008b)
- The roll out of new applications causes an increase in data centre energy consumption (Brill, 2008b; Kumar, 2007)

IT management factors

- Server density through consolidation or virtualisation causes an increase in data centre energy consumption (Kumar, 2007; IBM Global Technology Services, 2008; Loeffler, 2008)
- IT Asset management capabilities causes a reduction in data centre energy consumption through optimisation effort as a result of improved management (McKinsey & Co, 2008)
- The enabling of server power savings features causes a reduction in data centre energy consumption (US EPA, 2007; Loeffler, 2008; Kumar, 2008; Blackburn, 2007)
- Turn off servers not in use and decommission old or redundant systems in order to reduce data centre energy consumption (Loeffler, 2008)
- Procure energy efficient microchips and servers to reduce data centre energy consumption (Kumar, 2007; Loeffler, 2008)



- Measure, manage and enhance data centre energy use and performance to improve data centre energy consumption (McKinsey et al, 2008; McGuckin, 2008; Mingay 2008)
- Modular design reduces wastage and thereby reduces data centre energy consumption (Greenberg et al, 2006; Kumar, 2008; Loeffler, 2008)
- Innovative cooling reduced cooling costs and thereby reduces data centre energy efficiency (Greenberg et al, 2006; Kumar, 2008; Loeffler, 2008)

Proposition 3

Proposition 3: The following factors motivate South African organisations to implement data centre energy efficiency initiatives:

- In the short term
 - Cost savings through reduced energy usage (Brill, 2007a; Mingay, 2008, Kumar 2007; IBM Technology Services, 2008)
 - Best practice implementations imply reduced costs through efficiency gains (McKinsey et al, 2008; Brill, 2008a; Anderson et al , 2008)
 - Consideration of customer environmental awareness for organisational branding (Brill, 2008a; Mingay, 2008)
 - Environmental consideration and genuine concern for climate change (Brill, 2008a; Mingay, 2008)
- In the long term
 - Government or regulatory consideration (Brill, 2008a)
 - Good business sense as efficiencies imply reduced costs (Brill, 2008a; Mingay, 2008; Kumar, 2007)



*Today's problems cannot be solved
If we still think the way we thought when we created them
- Albert Einstein*

The research seeks to ascertain the various factors that contribute to data centre energy consumption in South Africa. This was done in order that businesses can prioritise future projects with positive effect on data centre energy efficiency, and minimise or optimise projects with a negative effect on data centre energy efficiency.

This research methodology is based on exploratory research techniques (Zikmund, 2003) with the view of initiating further, more rigorous and comprehensive studies into the energy consumption of ICT's in South Africa. Comprehensive research has been undertaken in the US and UK where the phenomenon of data centre energy efficiency is priority because of the high costs of electricity and shortage of space (Mingay, 2008). Zikmund (2003) supports the use of exploratory research in areas that have comparatively little research findings.

Subject matter experts were interviewed telephonically with the view to concept-test (Zikmund, 2003) factors affecting data centre energy consumption that were identified through the literature encountered on the subject

Proposed Population and Unit of Analysis

The population of relevance is defined as the various individual stakeholders involved in the data centre and / or IT management spaces. The stakeholders can be divided into 3 broad categories, namely, IT management, data centre management, and energy efficiency experts. Within this space, key stakeholders were approached to participate in this research project and refer others who could make a meaningful contribution.

The unit of analysis is the perception of the stakeholders who were interviewed.

Size and Nature of Sample

The primary method of sampling was non-probability, judgemental sampling (Albright, Winston and Zappe, 2003). Sixty people were approached via telephone and e-mail to participate and be interviewed. These stakeholders were sourced from the following mechanisms:

1. The CRF Publication on the Top ICT companies in South Africa identified the top ICT companies in South Africa based on defined criteria of success (Top ICTe companies 2005/6, 2007). The macro criteria of success included financial stability, success in its markets, innovative strength and public profile or media presence.
2. A national IT publication – ITWEB, hosted a Green IT Summit at the Dimension Data Campus in Sandton, South Africa in August 2008. The members and attendees were approached to respond to the research

report. These r



topic of data centre energy

efficiency by way of attendance

3. Referrals from these individuals who agreed to participate

Nineteen stakeholders eventually agreed to be interviewed. This number was deemed to be sufficient because of the size of the South African data centre market, and maturity of the subject of data centre energy management in South Africa. Ibeh & Brock (2004) concur that research response rates in Sub Saharan Africa are often much lower than in developed countries.

Data collection, Data Analysis and Data Management

Data collection

Sixteen telephonic and three personal interviews were conducted with the stakeholders who agreed to be interviewed. The questionnaire may be viewed in appendix I. The personal interviews took place with the Central Energy Fund and two of the IBM stakeholders, who invited the researcher to visit one of the IBM data centres Johannesburg, The interviews were semi-structured and provided suggested answers. The respondents were asked for additional feedback if deemed relevant.

Stakeholders were divided into the three categories which provided different views on the topic of data centre energy consumption.

IT Management includes successful and sustainable ICT companies in South Africa. These companies were selected because IT companies ICT usage and trends better than ICT users in other industries.



Energy efficiency experts have a vested interest in providing solutions that are environmentally sustainable. These individuals understand the dynamics of either energy in South Africa, or ICT energy efficiency

Data centre management manage the hosting environment of ICT equipment. The perspectives of these stakeholders may be different from those of IT management because their accountabilities are different to those of IT management.

Data Validity and Reliability

Pre-test

Pretesting of the questionnaire was undertaken with two colleagues from the researcher's experience who currently manage data centres and were willing to be interviewed. The test checked content relevancy, sequence, form and layout, question difficulty and instructions.

The pre-test was be conducted by personal interviews. The following changes were implemented as a result of the first round of pre-tests.

1. The original questionnaire had 12 sectors for the respondent to select from.

Most of these were not relevant in this research, such as mining,

government, h



h were deemed irrelevant

were removed in the final version of the questionnaire.

2. It was decided to gently broach the subject of data centre energy consumption by first enquiring about the energy usage of the entire organisation. Hence a further question on this issue was included.
3. The question (Q8) which asked which actions caused the increase or decrease of usage was altered to remove the assumption that the interviewee knew whether usage was increased or decreased in following questions. The question was altered to enquire about IT action and Business actions and whether they would increase or decrease data centre energy usage.
4. A gap was identified in the questionnaire. There was no opportunity to assess the reasons for implementing energy saving actions. This question was included at this stage.
5. The options under IT actions included Data centre consolidation – this was removed because the option was included under business decisions
6. The options under Data centre management actions included standby losses. This was removed as it added complexity to the flow of the questionnaire.

Potential research Limitations

The measurement and standardisation of data centre energy consumption has not matured globally. This research will exclude specific measurements of data centre energy efficiency.

The only sectors included in this research were banking, retail and energy. These were identified as the high ICT energy users by Gartner (Mingay, 2008). Although government is also a huge user of ICT, this sector was excluded because of accessibility reasons.

The researcher could not find any South African ICT energy usage numbers. South Africa has electricity and energy usage estimations for the manufacturing and industry sectors, but the ICT usage numbers are currently absorbed with the other sectors.

Building constituents and energy costs thereof have been omitted in this study. Potentially the energy cost of construction data centres and the disposal of waste as a result of data centre energy usage could be interesting. This was not considered relevant for this study.

Further, research could uncover ways in which ICT could support management of energy savings or waste management. ICT could perhaps contribute more towards energy savings and waste produced during the life cycle of ICT's. This has also been excluded for reasons of relevance at this time.

The energy cost of the full life-cycle of ICT's in South Africa could prove useful for total cost of ownership calculations. This has been excluded for purposes of this study.



*Any fool can make things bigger, more complex, and more violent.
It takes a touch of genius - and a lot of courage - to move in the opposite direction
- Albert Einstein*

Structure of Data Analysis

This chapter will present the results from the interviews. The structure of data analysis followed is described below:

1. Clustering of responses per propositions;
2. Analysis of interview notes

Sample Description

The original list of proposed interviewees included sixty data centre and IT managers from the top 10 ICT companies in South Africa (CRF, 2007), as well as and data centre energy efficiency experts, which included research analysts, and technical solution architects. However, accessibility and availability of the required stakeholders presented a challenge that required an adaptation of the proposed sample. Ibeh & Brock (2004) agree that the research response rate, especially in Sub Saharan Africa, is often low.

Nineteen managers and professionals eventually agreed to be interviewed. Six respondents represented three companies which are in the business of hosting data centre space. One respondent represented a company which is in the business of selling internet hosting space.



The questionnaire was based on a survey undertaken by the Uptime Institute (Brill 2005). The survey was altered to cluster questions applicable to South Africa as follows:

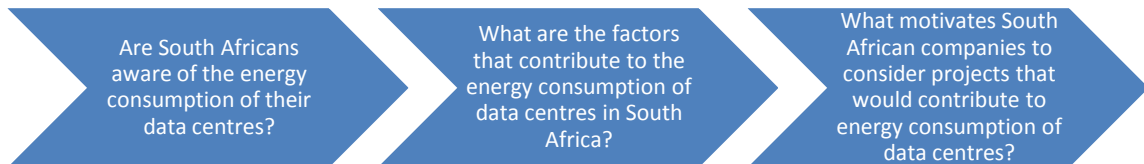


Figure 4 Clustering of questions

The responses were recorded on a spreadsheet as per the propositions: awareness of data centre energy consumption; factors that affect the data centre energy consumption; and motivation for implementing or refusing energy efficiency initiatives.

Analysis of Interview notes

Zikmund (2003) describes the choice technique as a measurement task that identifies preferences by requiring respondents to choose between two or more alternatives. This technique was used during the interviews to identify the suggested answer which was perceived to be more relevant. If there was more than one selected answer for each factor identified, the interviewee was requested to rank the answers in order of most relevant to least relevant of the selected answers.

Once the responses



tified. . Although Zikmund

(2003) expressly states that exploratory research is not quantitative, Fontana and Frey (2005 in Little, 2006) explore the possibility of quantifying qualitative data from interviews.

Descriptive statistics of responses was then performed on the data to summarise the responses. Zikmund (2003) explains that descriptive statistics serve to describe or summarise the sample data. The summarised data was then presented in bar graphs.

Presentation of results

The summarised data is presented in bar graphs, which illustrate results of the frequency tables

Aggregated results: Contextualisation of the respondents

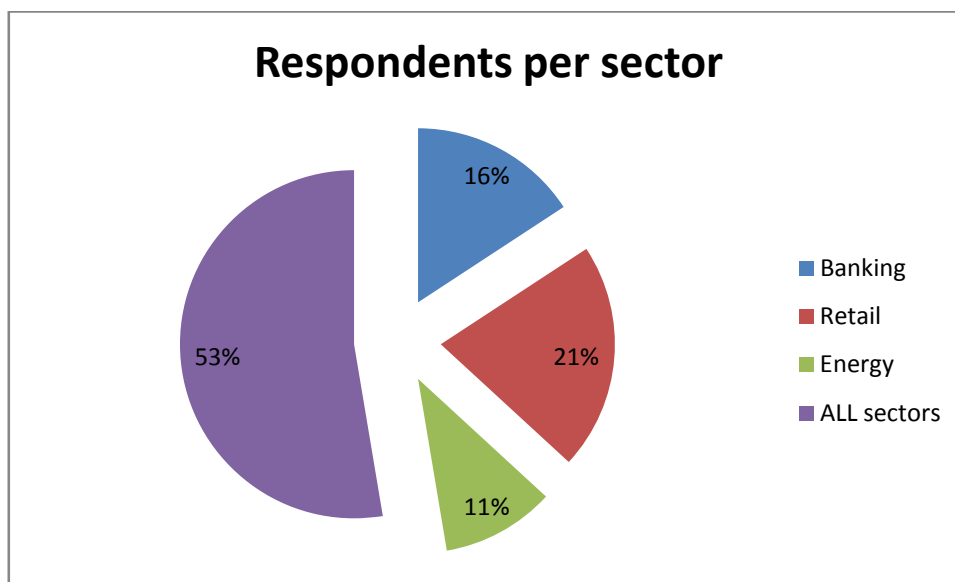


Figure 5 Respondents per sector

The results of the responses to the contextualisation questions are presented as pie graphs. Figure 5 illustrates the number of selected responses which were in order to contextualise the respondents' backgrounds or sector experience. The respondents who selected ALL sectors understood that their business serviced more sectors than were identified in the options forwarded in the question.

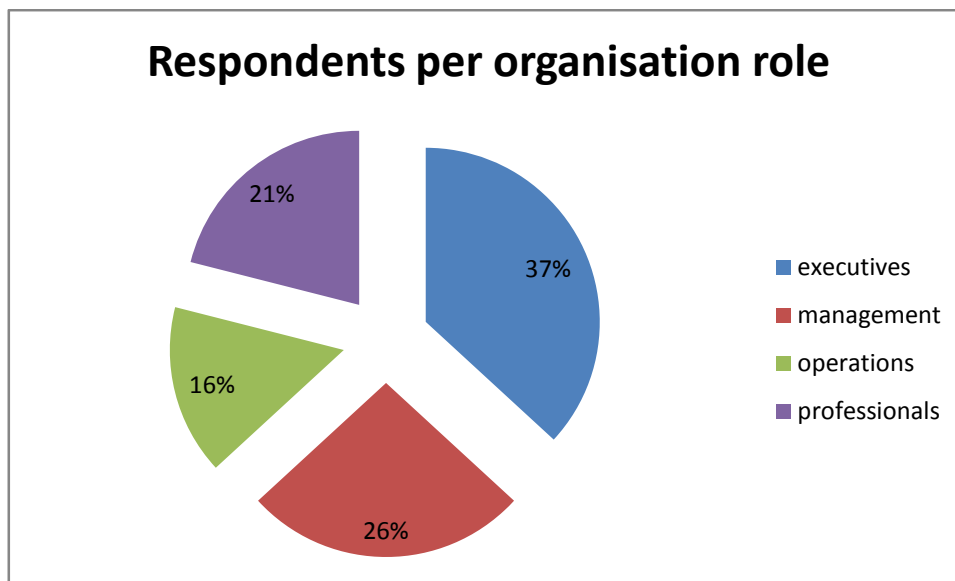


Figure 6 Respondents categorised per role in the organisation

Executives formed the majority of the respondents, though the rest of the respondents were more or less balanced between management, operations and professionals. Figure 6 shows the split of all the respondents based on their roles in their respective organisations.

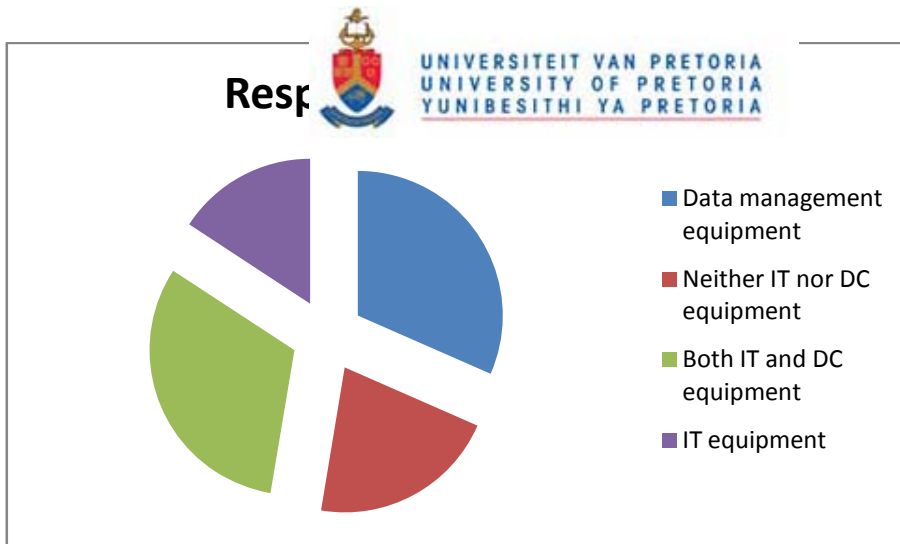


Figure 7 Respondents' selection of purchases as part of their role

The questionnaire contained a clarifying question about the role played by the participant. The purchases authorised by the respondent indicated further granular detail of the role within the organisation. Figure 7 illustrates the summed responses of the interviewees. One is tempted to compare the purchases with the role in the organisation, but there will not be a like for like comparison, as different roles have different purchasing mandates.

Aggregated results: Level of awareness of energy consumption

Organisational energy usage in total

The respondents' perception of their organisational energy usage is depicted by pie graph below, in figure 8.

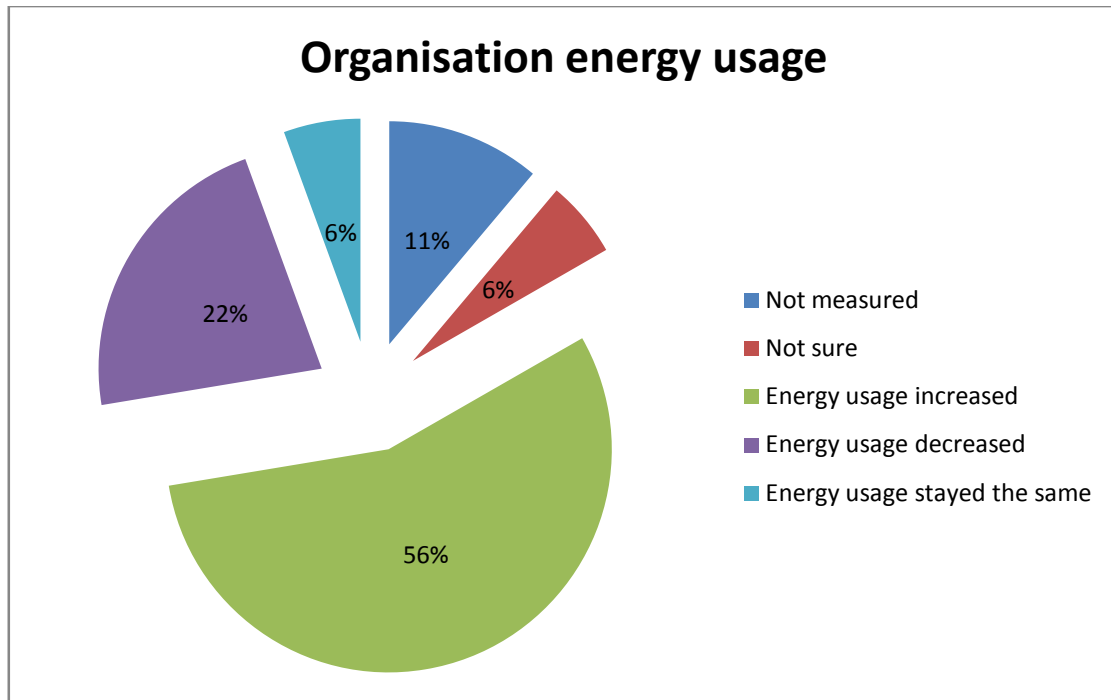


Figure 8 Respondents perception of their organisations' energy usage

The respondents who were sure that their organisations did not measure energy consumption of the entire organisation selected “Not measured”. This was different from those respondents who were not sure whether their organisations measured energy usage or not. These respondents selected “Not sure”. Fifty six percent of respondents agreed that total organisation energy consumption had increased over the last twelve months (See figure 8).

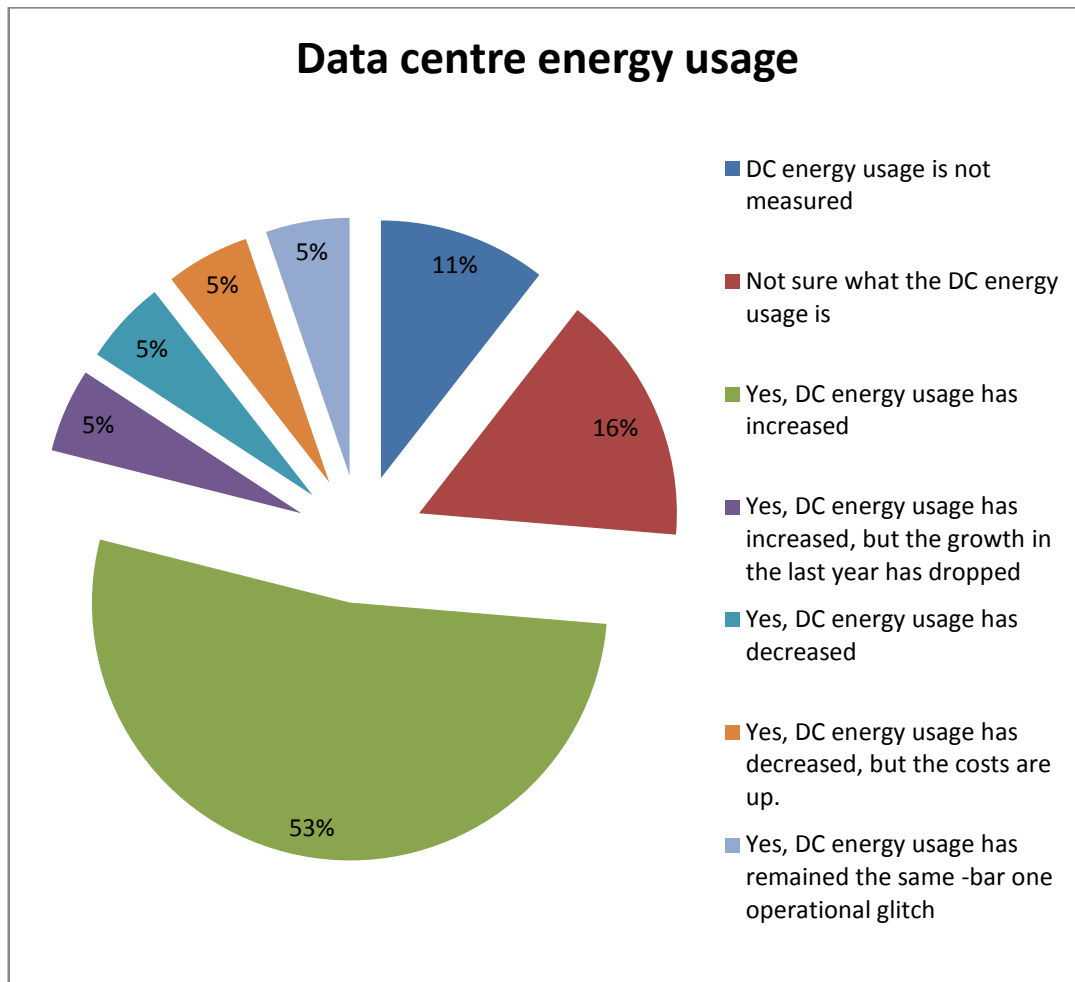


Figure 9 Data centre energy consumption

When asked how their data centre energy consumption trends tracked in the last twelve months, the majority of the respondents declared that their data centre energy had increased. The summed responses are illustrated in figure 9.



A confirmation question enquired about the method of measurement of data centre energy consumption. The results are illustrated in figure 10.

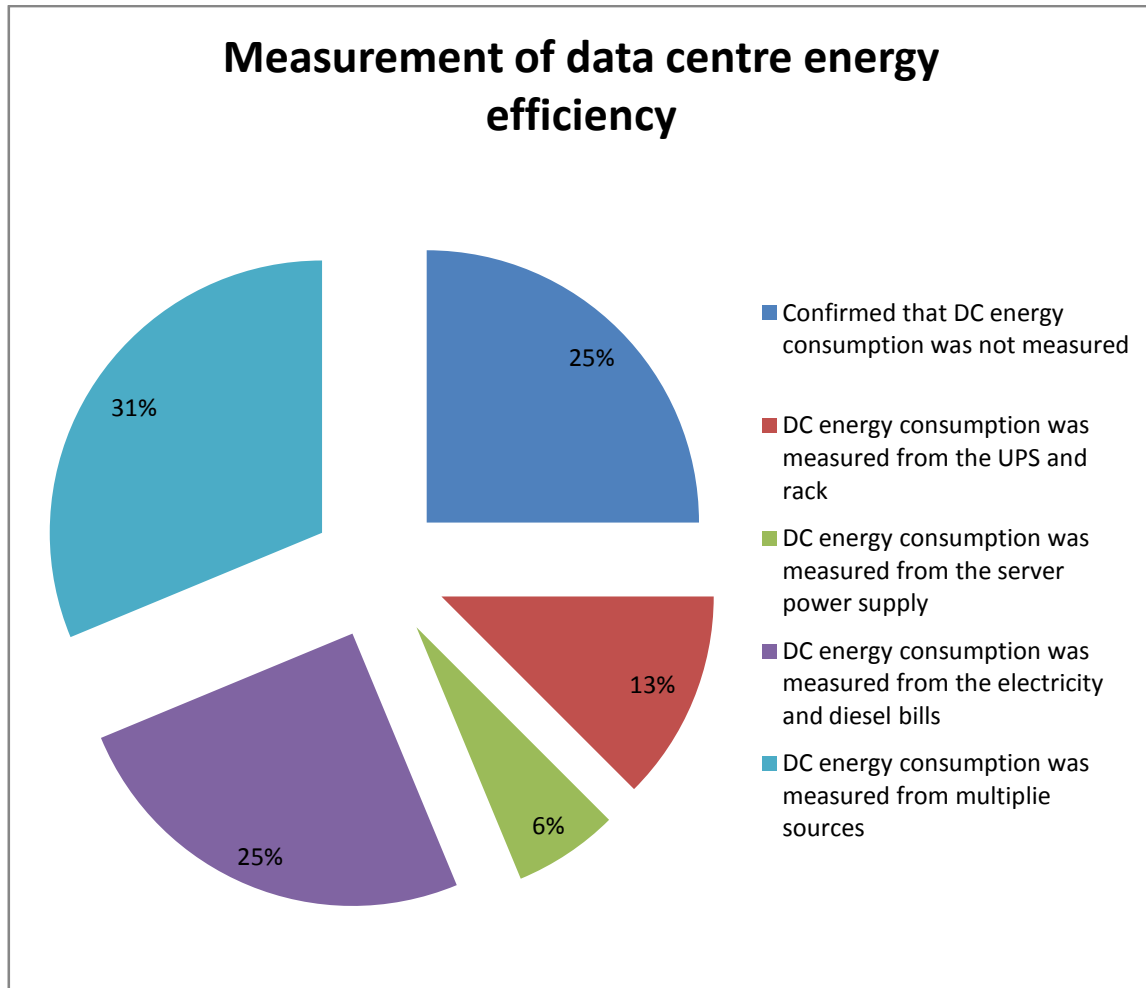


Figure 10 Measurement methods

Figure 10 shows that thirty one percent of the respondents confirmed that their organisations measured data centre energy usage from multiple sources. This number may be high because of the relatively high number of interviewees who are in the business of outsourcing data centre capacity. These organisations would have to be able to measure their energy usage for billing purposes. Furthermore, one quarter of the respondents admitted that data centre energy usage was not

measured, and another diesel bills.



assumption from the utility or

Aggregated results: Factors that contribute to data centre energy consumption

Screening alternatives is a form of research which precludes investigating all alternatives (Zikmund, 2003). In order to determine which factors contributed most to data centre energy consumption, the respondents were asked to rank their selections from most relevant to least relevant.

Business Factors

These describe the outcomes of decisions made by the business as a whole. In general, the responses indicated that these business driven factors would increase the data centre energy consumption.

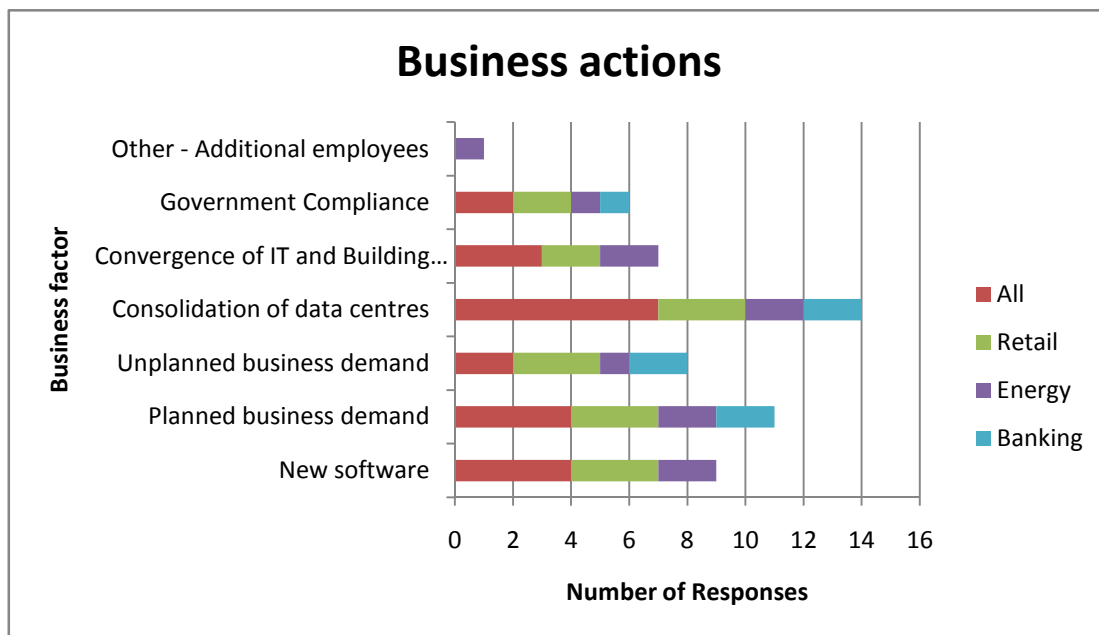


Figure 11 Business factors that affect data centre energy efficiency

The responses were  identified. The purpose was to distinguish whether the roles and sectors had a bearing on the answers or perceptions selected.

Figure 11 illustrates the aggregated perceptions of the interviewees about which business factors affect data centre energy efficiency. The one factor which appears to have attracted the highest number of votes is the consolidation of data centres. Most respondents feel that this business factor would affect the energy consumption the most. The following to factors attract the next amount of votes: planned business demand; followed by the rollout of new software. These three indicate the business actions which most affect data centre energy consumption, based on the responses of the stakeholders interviewed.

IT Management Actions

The results of the aggregated responses regarding IT management factors that affect data centre energy efficiency is illustrated in figure 14. The majority of the respondents indicated that IT management actions would have the effect of reducing the data centre energy consumptions. One respondent indicated that the decrease caused by these actions would not be significant to influence the overall energy consumption, especially with the increase in demand for higher processing speed and more heat generated through this additional processing power. Another respondent commented on the dual option of server consolidation and virtualisation, and stated that these were different options in his view. Server consolidation is not the same as virtualisation, and vice versa. He meant that servers could be consolidated on a single existing server, or a group of servers,

through optimisation



ent. Virtualisation involves

dynamic management of the hardware to create virtual servers. With virtualisation, there would be no need to have a hardware server for each and every application server.

Two respondents declared that the consolidation of servers and storage had the effect of increasing energy consumption in their data centres (compared to the other respondents who claimed that consolidation and virtualisation would reduce data centre energy usage). One respondent mentioned that a hardware upgrade would increase power usage of the data centre because of the increased power requirement of the additional processing of the new machines.

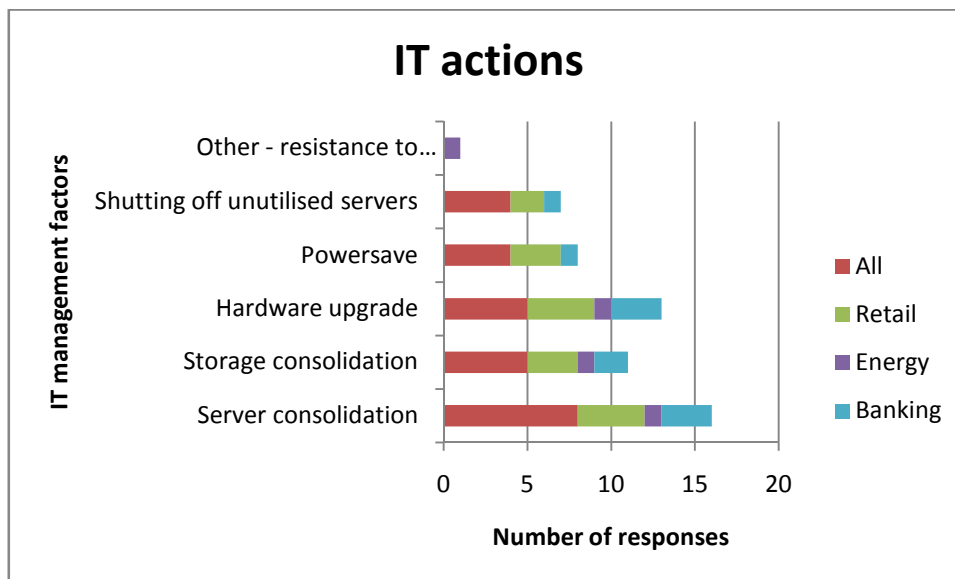


Figure 12 IT management factors affecting data centre energy efficiency

Server consolidation, hardware upgrades and storage consolidation are the three factors which were identified by most respondents as the IT management actions which most affect data centre energy efficiency.



The aggregated responses depicting the favoured data centre management factors that affected data centre energy efficiency is illustrated in figure 13. The majority of the responses indicated that the data centre management actions would reduce the energy consumption of the data centre.

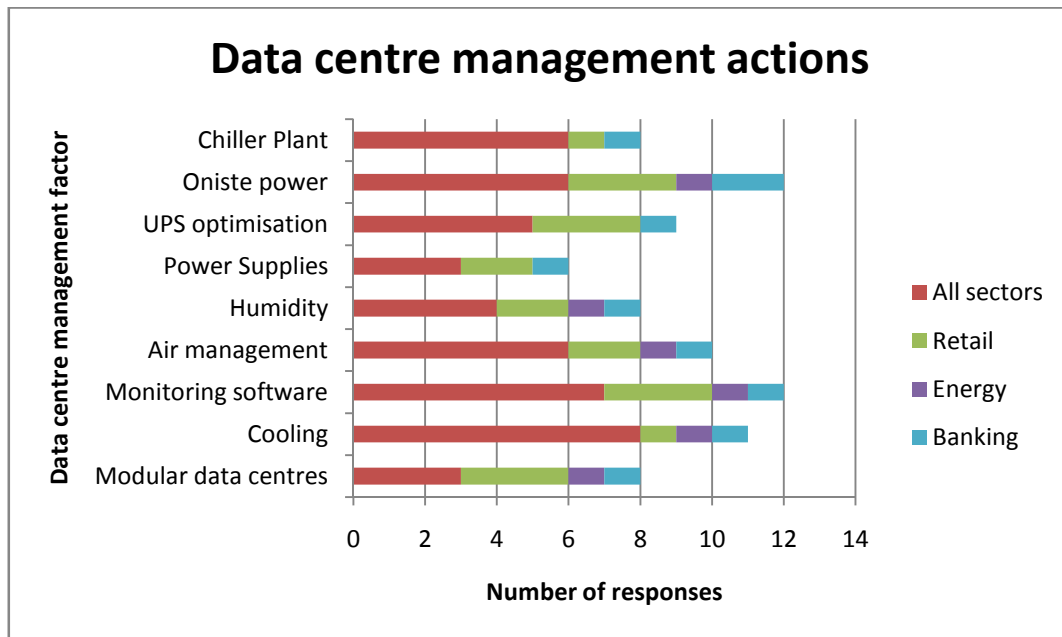


Figure 13 Data centre management factors that affect data centre energy consumption

One respondent indicated that the effect of cooling or humidity could be either to increase or decrease the energy consumption, depending on circumstances. One respondent mentioned that a power generator would increase the total energy bill, when factoring the diesel bill into the total energy cost.

Onsite power; monitoring software and cooling were the three factors which attracted the highest number of selections. This implies that there is consensus amongst the respondents of the importance of those selected data centre management factors of affecting data centre energy consumption.



Reasons for not implementing energy efficiency initiatives

The question was asked was why organisations may not have considered some of the options available in terms of optimising data centre energy efficiency. The results are illustrated in figure 14.

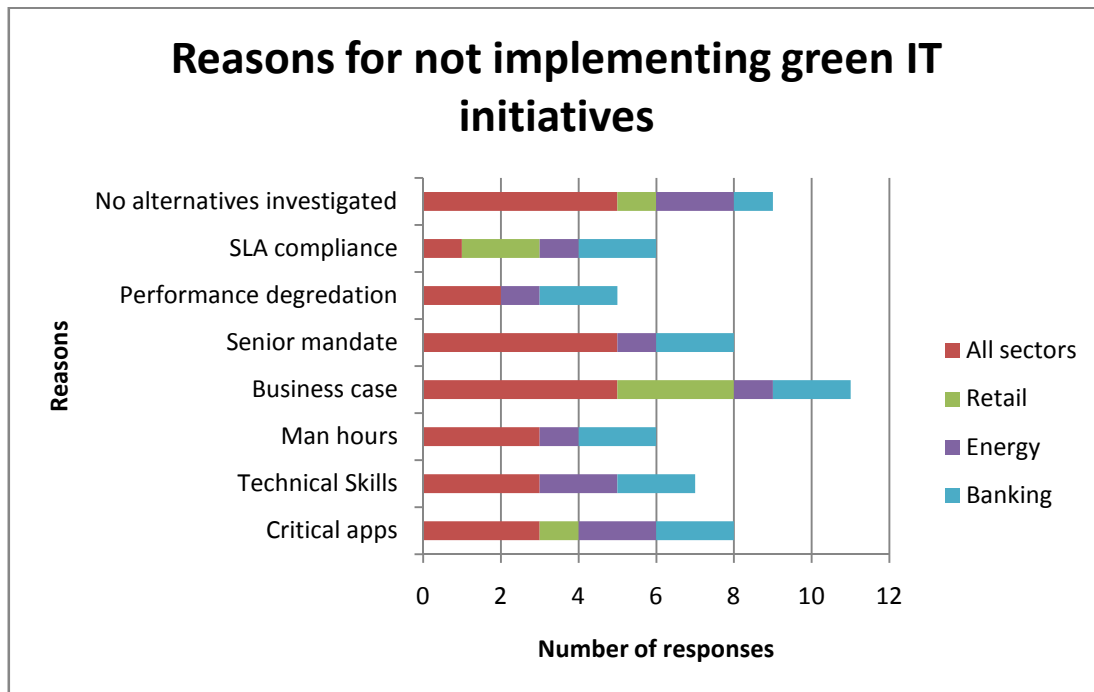


Figure 14 Reasons for not implementing initiatives

The three popular choices were:

- The business case for the energy efficiency project was unjustified. This included reasons of high costs or no budget;
- There had been no investigation into energy efficiency alternatives; and
- Stakeholders were unsure about the impact of any energy efficiency projects on critical applications .

Once the reasons for not implementing green initiatives had been understood, the question was asked why organisations had implemented some of the actions mentioned earlier. The results are reflected in figure 15.

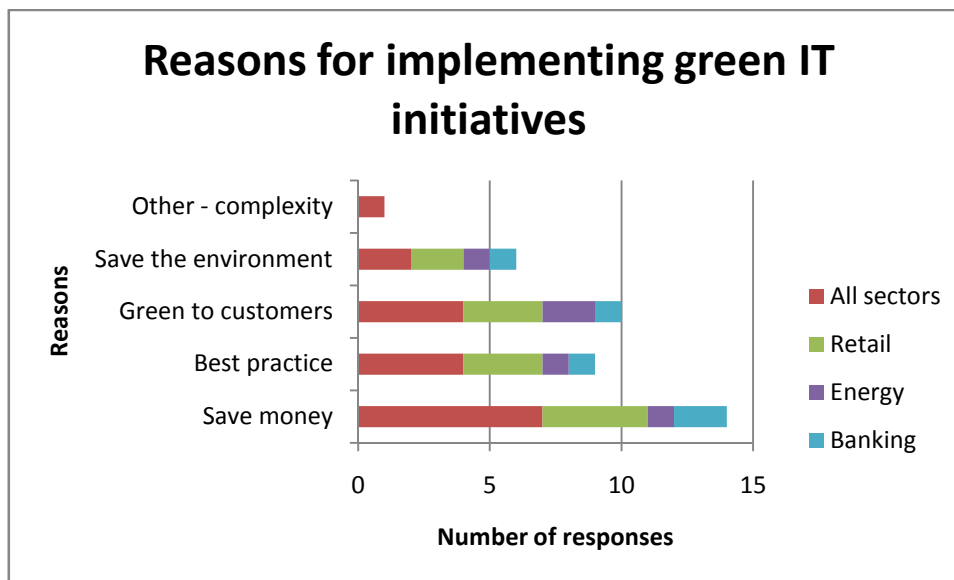


Figure 15 Reasons for implementing initiatives

The results in figure 16 show that most organisations implement energy efficiency initiatives in order to save money; the next popular reasons is to appear as green to customers, either because customers are demanding environment consideration in delivery of products, or because reputation had been damaged, and energy efficiency initiatives help gain favour in the public eye; Finally, respondents were concerned with implementing best practices as their data centre, and hence considered energy efficiency projects;



The reasons cited for either implementing or refusing energy efficiency projects may be short term focused. The respondents were asked to select reasons that organisations would consider energy efficiency projects in the long term, specifically five to ten years. The results can be seen in figure 16.

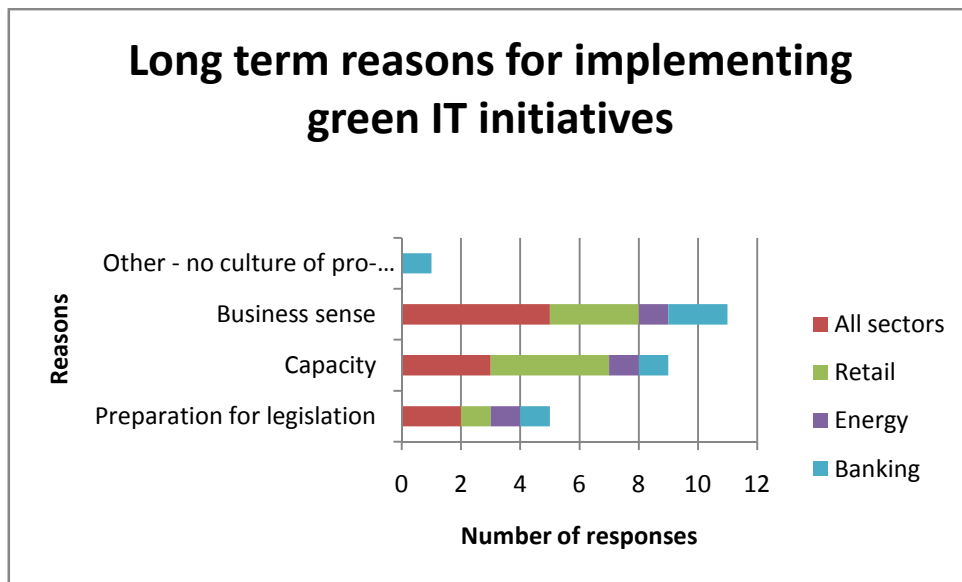


Figure 16 Reasons for implementing energy efficiency projects in the long term

Once again money is the best reason for implementing energy efficiency initiatives in the long term (see figure 16). The respondents concluded that it made good business sense to implement energy efficiency projects in the long term. The next selected reason was data centre space and capacity. Respondents felt that energy efficiency projects were important to ensure that there was sufficient data centre space in the next five to ten years. Finally, respondents were concerned about future legislation that may force them to consider these initiatives in order to reduce or contain their energy consumption in the long run.



A clarifying question was then asked of the respondents to describe their views on further motivation of energy efficiency projects. When asked how seriously their respective organisations took “green” or environmental issues at present the responses showed that most organisations considered energy efficiency projects as a secondary concern. See figure 17

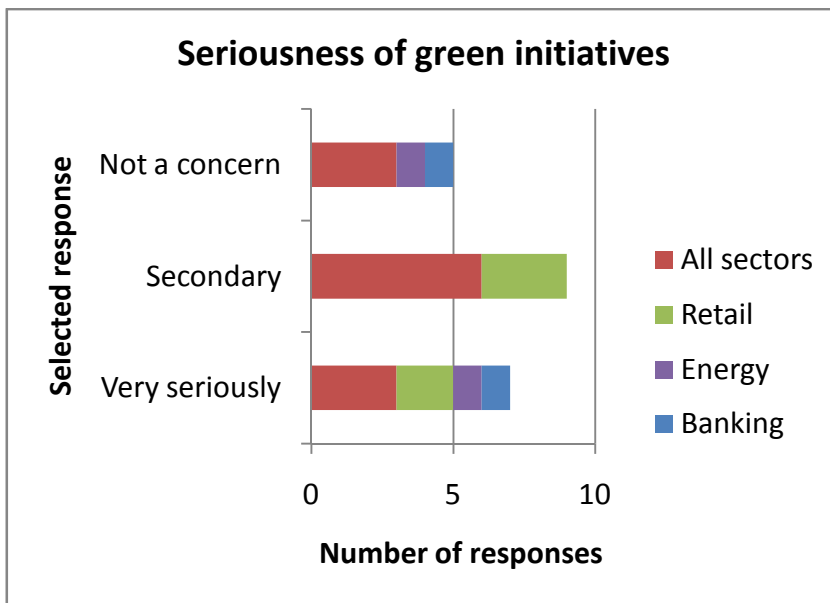


Figure 17 Seriousness of initiatives

Some respondents selected more than one option in this question to indicate a middle ground between the two options. Interestingly, there was a high response rate indicating that organisations take energy efficiency projects very seriously, especially in the retail sector, where customer perceptions are extremely sensitive to environmental issues.



“Economics and a reliance on science and technology to solve our problems has led to an unsustainable situation where continued growth in consumption is required for governments and business to be considered successful. This is a form of insanity. Economics is at the heart of our destructive ways and our faith in it has blinded us” Dr David Suzuki

Preamble to discussion

The data presented in the previous chapter showed that IT executives are aware that the energy consumption of data centres in South Africa could be improved by efficiency initiatives. The factors which affect data centre energy efficiency, which were identified in Chapter 2, resonated with their responses and feedback. The propositions made in chapter 3 are now presented with a review of the literature with the survey responses.

Proposition 1: South African companies are aware of their data centre energy consumption

Globally, the measurement of data centre energy consumption and energy performance management is currently in its infancy stages (Blackburn, 2008; Mingay, 2008). There are no standards in place for this type of measurement as yet (HP, 2008).

In 2007, the Green Grid defined a metric called the Power Usage Effectiveness (PUE) and its reciprocal centre infrastructure efficiency ratio (DCiE) in order to assess the amount of power used by a data centre to deliver a certain amount of

power to the IT equipment and to remove the waste heat generated by that equipment (Anderson et al, 2008). The Green Grid later called for a new measurement that would quantify the useful work produced by a data centre in relation to the power it consumes. This metric is called the Data centre productivity metric (Anderson et al, 2008).



The respondents made no mention of utilizing either of these benchmarks in terms of assessing their data centre energy usage. South African responses indicate that experts in the field have a rough estimate of energy usage through the energy bills received by the organisation, but mostly, only those organisations which are in the business of outsourcing data centres or server hosting space are aware of their energy usage in detail. Even these measurements are for billing purposes, and not specifically optimisation purposes.

More than half the respondents indicated that their data centre energy consumption has increased in the last twelve months (figure 9). More than half the respondents admitted that data centre energy consumption was not measured, or was measured only through a view of the electricity (and diesel) bills (figure 10). This confirms that data centre energy consumption measurements are still in the infancy stages of development. South African companies are thus, not fully aware of their data centre energy consumption as this stage. This will probably become more important to organisations when the price of electricity in South Africa increases, as well as when global pressure builds for countries to improve greenhouse gas emissions.



Business factors

Business factors are those factors that are influenced by the business as a whole. According to the results of the interviews held, data centre consolidation is the biggest business factor affecting data centre energy consumption. The research in chapter 2 indicates that the consolidation of data centres causes a reduction in data centre energy consumption (IBM Global Technology Services; 2008, Brill b, 2008; Kumar, 2007).

The majority of the respondents indicated that the consolidation of data centres caused the biggest impact to data centre energy efficiency (figure 11). However, there was some disagreement from the respondents when asked whether the consolidation increased or decreased the energy consumption.

The respondents, who claimed that the data centre energy consumption would be reduced, concluded that they had recently implemented consolidation exercises, and that the effect was a reduction in energy consumption because of optimisation of the facility, servers and processes.

The respondents who thought that there would be an increase in energy consumption, said so because they believed that data centre space would be more concentrated so that usage per square meter would be much more than in an un-optimised environment.

The second most selected response (figure 11) indicating the business factor which affected data centre energy consumption was planned business demand. Planned business demand causes an increase in data centre energy consumption (US EPA, 2007; Kumar, 2007; Brill, 2008b). The US EPA report mentions that demand for data centre space would be increased by the increased number of electronic transactions for banking / financial services; growth of internet communication and entertainment; the shift to electronic medical records for healthcare; growth in global commerce and services; and the adoption of satellite navigation and electronic shipment tracking in transportation. These would constitute planned business demand.

The majority of respondents agreed that planned business demand would increase the data centre energy consumption of their data centres. The respondents who are in the business of outsourcing data centres added that they were pleased with the additional energy consumption, because it meant that their revenues were increased as well.

The third business factor, as per the respondents' perceptions, which contributes to data centre energy consumption, was identified as the rollout of new software (figure 11). The roll out of new applications causes an increase in data centre energy consumption (Brill, 2008b; Kumar, 2007). The majority of the respondents indicated that rollout of new software would increase data centre energy consumption (see figure 11). However, one respondent argued that the new versions of a software rolled out, resulted in a saving of between 10 and 15 percent because of the inbuilt policy of shutting down unutilised machines.

Three factors received the most selection as business factors which affect data centre energy consumption. In South Africa, the view is that data centre consolidation is the main factor which affects data centre energy consumption, either to increase or decrease the consumption, depending on the situation; planned business demand was identified as the factor which drives up data centre energy consumption, and the rollout of new software also drives up consumption.

TO a lesser degree, respondents agreed that unplanned business demand would increase their data centre energy consumption (figure 11). The respondents from the energy sector concurred that the electricity shortage and load shedding experience in early 2008 caused additional energy consumption of the data centres, because electricity management software packages were installed, as well as software to allow purchasing of electricity via the internet. The literature in chapter two concurs that unplanned business demand causes an increase in data centre energy consumption (US EPA, 2007; Kumar, 2007; Brill, 2008b). Eight of the nineteen

Convergence of IT and Building Facilities causes an increase in data centre energy consumption (Ulichnie, 2008; Brill, 2008b). This business factor does not appear to be relevant to the respondent at this time. The view of the some of the respondents was that convergence would take a longer time to affect South African data centre energy usage.



IT management factors

Server density through consolidation or virtualisation would result in a decrease in data centre energy consumption as a result of optimisation and shared resources (Kumar, 2007; IBM Global Technology Services, 2008; Loeffler, 2008).

Respondents agreed that this was the one IT factor which would have the biggest impact on data centre energy consumption (figure 12). Most of the respondents agree that there would be savings in energy consumed at the data centre if server consolidation exercises or virtualisation exercises were undertaken. One respondent commented that consolidation and virtualisation are separate issues.

One respondent argued that savings realised through virtualisation were not significant. Consolidation yields much better savings. A recent exercise consolidated 125 mail servers into 20 mail servers worldwide, which included 45 mail servers into 5 mail servers in Africa. This yielded dramatic savings in energy consumption.

Hardware upgrade was selected as the next most important factor affecting data centre energy consumption in South Africa (figure 12). One respondent saw a 30 percent saving in energy consumption as a result of the CPU efficiency of the new hardware purchased with its virtualisation project. Server consolidation or virtualisation projects often involves the purchase of new hardware. The literature advises IT management to procure energy efficient microchips and servers to

reduce data centre energy consumption (Loeffler, 2008). The same principles would apply to storage consolidation.



Loeffler, 2008). The same

Although the respondents have not selected IT Asset management as a serious factor in reducing data centre energy efficiency, the literature claims that IT Asset management capabilities causes a reduction in data centre energy consumption through optimisation effort as a result of improved management (McKinsey & Co, 2008). One respondent in the expert category of respondents highlighted poor asset management as a fundamental flaw in the current management of IT assets, which would have a direct bearing on the energy consumption of data centres. Better managed assets would lead to optimised usage of assets and their energy consumption.

The enabling of server power savings features causes a reduction in data centre energy consumption (US EPA, 2007; Loeffler, 2008; Kumar, 2008; Blackburn, 2007). Eight of the nineteen respondents agreed.

Turn off servers not in use and decommission old or redundant systems in order to reduce data centre energy consumption (Loeffler, 2008). Seven of the nineteen respondents agreed.

The results show that IT management can do much to optimise data centre energy efficiency, particularly when considering consolidation and virtualisation projects, and the procurement of energy efficiency servers for these purposes.



Data centre management factors are those which are the outcomes of data centre management decisions. Onsite power was the most selected data centre management factor (figure 13). Eleven of the nineteen respondents selected this option as an indication of the backup power and generators that have been installed in case of electricity failure. The respondents indicated that Eskom's load shedding exercise in the beginning of the year forced them to invest in alternate power, hence, the high number of responses on this issue.

Monitoring software was the next most selection data centre management factor (figure 13). The literature in chapter two advises management to measure, manage and enhance data centre energy use and performance to improve data centre energy consumption (McKinsey et al, 2008; McGuckin, 2008; Mingay 2008). Ten of the nineteen respondents agreed to use of environmental management systems. One of the experts in the fields of data centre energy management mentioned that very few South African companies were utilising data centre energy performance metrics.

Cooling was selected as the third most important data centre management factor affecting data centre energy consumption (figure 13). Innovative cooling reduces cooling costs and thereby reduces data centre energy efficiency (Greenberg et al, 2006; Kumar, 2008; Loeffler, 2008). Cooling costs are higher than the hardware cost of the equipment in the data centre over the life-time of that equipment (Kumar, 2007). Hence, cooling presents a huge opportunity for efficiency. Some of

the innovative ways
chapter 2.



l by cooling were listed in

Air management is one of the innovative ways of cooling in a data centre. The use of hot air isles and cold air isles is a case in point. This initiative has been shown to reduce cooling costs (Greenberg et al, 2006; Kumar, 2008; Loeffler, 2008). Although 10 respondents selected air management as a data centre energy optimising factor, few agreed to have implemented hot and cold air isles. The reason cited for not changing the status quo to optimise the layout of the racks, was that downtime would be required, and business would not agree.

The next most selected data centre factor is UPS configuration and optimisation (figure 13). The configuration and optimisation of the UPS, was selected by nine respondents as influencing data centre energy consumption positively. Respondents commented that this one the one factor within the control of the data centre management team that could produce positive results. However, one of the energy efficiency experts admitted that few companies in South Africa are doing this well.

Modular design reduces wastage and thereby reduces data centre energy consumption (Greenberg et al, 2006; Kumar, 2008; Loeffler, 2008). Although eight of the nineteen respondents agreed that modular design would reduce data centre energy usage in the form of savings through optimization of the data centre, none agreed to actively change existing data centres to be modular. Respondents conceded that plans in progress to upgrade or build future data centres would

involve a modular design
not justified.



existing data centres was

Data centre management factors have a large role to play in data centre energy efficiency. At present, there are two opposing views from the respondents interviewed. One view is that the data centre is strategic for the business, the availability is paramount and hence, approval for downtime is difficult to get approved. Data centre management will get whatever they request, as long as capacity is unhindered. The other view is that the business is cost conscious and new energy efficiency initiatives have to justify the investment above all the other organisational initiatives in the pipeline. These interesting dynamics seem difficult to reconcile, yet pressure from government or customers will help the organisation decide.

Proposition 3: The following factors motivate South African organisations to implement data centre energy efficiency initiatives

These factors provide the understanding for what motivates South African businesses to consider data centre energy efficiency initiatives.

Literature claims the most prominent reason is cost savings through reduced energy usage (Brill, 2007a; Mingay, 2008, Kumar 2007; IBM Technology Services, 2008). Thirteen respondents saw this is the major reason for implementing data centre energy efficiency measures in the short term. (figure 15). Eleven respondents confirmed that money was the major reason for not implementing


these initiatives as v  confirm that South African organisations are sensitive to cost, and therefore need to be sure of the return of their investments of data centre energy efficiency.

The second most selected factor which motivates South African organisations to consider data centre energy efficiency initiatives is probably linked to the first. Best practice implementations imply reduced costs through efficiency gains (McKinsey et al, 2008; Brill, 2008a; Anderson et al, 2008). Nine respondents selected best practise as a reason for implementing these initiatives in the short term (figure 15).

The third main reason for consideration of data centre energy efficiency initiatives or the lack thereof, is that the alternative energy efficiency initiatives have not been investigated. Employees in companies are kept busy with operations and the South African challenges, so that outside or external issue have to be championed by a senior executive to gain momentum within an organisation. Without that sponsorship, the status quo remains. This reason ties in with the next selected motivational factor, which is the lack of executive support or mandate for these initiatives (figure 14). A probable reason for the lack of support is the fear of what these initiatives will have on critical applications, the next selected factor (figure 14). The novelty of these energy efficiency solutions have to demonstrate reliability before executives would want to commit to these projects.

Other motivations

Another factor identified is the consideration of customer environmental awareness for organisational branding (Brill, 2008a; Mingay, 2008) In the short term, retail

respondents agreed  an important factor when considering environmental projects. The results for the retail sector illustrate concern over cost and customer perception.

Few respondents selected environmental concern as the main motivator for considering these initiatives. The literature suggests that some organisations have environmental consideration and genuine concern for climate change (Brill, 2008a; Mingay, 2008) In the short term, this was not a concern for the respondents, except those in the energy sector. This may be specifically symptomatic of the load shedding experience, which has left the sector bruised in the public eye.

The business justification was selected as the most appropriate long term motivator for considering energy efficiency initiatives; followed by concern about data centre capacity (figure 16). Few respondents agreed that government or regulatory consideration (Brill, 2008a) was a factor when considering data centre energy efficiency projects for the long term.



The government sector input is excluded. Since government is a big user of ICT, input from this sector would have been useful. However, some of the “retail” and “ALL” sector respondents commented that they do deliver services to government as a customer.

The sample size may be viewed as too small. However, in the US, there are many data centre experts, and a huge amount of data centres from which to source respondents. South Africa does not enjoy the same scale. Furthermore, Ibeh & Brock (2004) confirm that research response rates in Sub Saharan Africa are often much lower than in developed countries. This was addressed by concentrating efforts to interview key stakeholders who could provide valuable input into the research.



Energy Efficiency of data centres has become quite topical in the IT arena currently. The respondents were willing to share their comments and insights quite freely, after initial reservation about revealing industry secrets, or intellectual property.

The level of awareness of what data centre energy should be is still far from where it should be, globally as per the literature review, as well as in South Africa, as per the interviews. Data centres managers of global organisations in South Africa appear to be more confident on the issue of measurement and awareness. Local companies appear to be grappling with other priorities, and data centre energy consumption is not one of them. Nonetheless, the experts in the fields appear to know what is required, but it seems that time is required before these initiatives will gain momentum in South Africa.

The factors that affect data centre energy consumption in South Africa. As identified in the literature review, appear to be relevant in South Africa as well. However, the prioritisation of these issues is different in the South African context.

Literature cites planned and unplanned business demand as the main reason for data centre energy consumption (US EPA, 2007). This research shows that the respondents viewed data centre consolidation as the main factor. Perhaps the reason for this difference is the constituency of the sample, who predominantly come from data centre and IT spaces. However, these stakeholders are in an excellent position to understand the factors influencing demand for their services.

Perhaps the reason is  South Africa, which is different from that in the US and the UK. Internet usage is much greater in those countries, based on the sheer volume of the markets. Business demand would therefore be more important in those markets.

IT management factors concur with the global view that server consolidation and virtualisation are top IT factors for data centre energy efficiency.

With regards to motivation for considering data centre energy efficiency initiatives, money appears to still be the top decision making consideration for all data centre energy efficiency initiatives, globally and in South Africa. Yet, many respondents admit to not investigating the options fervently. Again, South African managers have other pressing matters to attend to.



*"In the long term, the economy and the environment are the same thing.
If it's un-environmental, it is uneconomical.
That is the rule of nature"
Mollie Beatty*

Data centre energy efficiency is not yet a priority for South African organisations. Profitability and sustaining the organisation within the South African economic climate remains the focus for these organisations.

The tide will turn. Global pressure will force companies to consider efficiencies in energy consumption. The rising cost of electricity will add to this pressure. Different part of the organisation will have to work together to respond to these pressures. The data centre management teams, the IT teams, the building facilities teams will have to measure energy usage across these organisational silos.

Business

Businesses decisions of the future will have to be made with full cost considerations: economic and environmental. Customer and product decisions will be based on the full life cycle cost of delivering services and products. The IT portion of these costs such as IT network, storage and computing costs; data centre energy costs were previously viewed as sunken costs of doing business. This will have to be reviewed as the cost of delivering services will change with the additional energy costs associated with the additional load to the data centre.

The cost of energy for IT equipment has historically not been managed by IT management. Hence the growth in the energy consumed by IT equipment has not been considered by IT management. Yet, the decisions of IT management directly affect the energy consumed by this equipment. Perhaps IT management should review the full effect of the decisions made regarding IT equipment, and potentially be made accountable for including these energy costs in the calculation of IT services.

Data centre management

The US and the UK are motivated to optimise and standardise data centre energy efficiency. These countries are running out of data centre space, and face growing energy costs. South African data centre managers do not currently face the same challenges, but can be pro-active in preparing for future energy growth restrictions.

Government

Government regulation can increase the energy usage, for example decisions that government have on electronic storage of data for legislation has an impact that has not been considered. Perhaps government should consider the effects of their decisions. In addition, legislation around standards and incentives should support the management of any additional IT requirements. Government can regulate energy consumption to force companies to start measuring and optimising data centre energy efficiency or incentivise companies to consider efficient alternatives.

The collaboration of these roles is crucial to resolving the exponential growth of energy consumption of data centres. We are at the perfect opportune time at this juncture to make an impact on the lives of future generations – and prevent a future catastrophe before it takes hold.

Opportunities for further research

The measurement of data centre energy consumption has not matured in South Africa as yet. This opens up the potential for further research on relevance for South Africa, especially since South Africa currently enjoys relatively cheap electricity and abundant space. Further studies could look at the impact in detail in terms of cost savings estimations and greenhouse gas emissions.

The only sectors included in this research were banking, retail and energy. These were identified as the high ICT energy users by Gartner (Mingay, 2008). Although government is also a huge user of ICT, this sector was excluded because of accessibility reasons. Further research could potentially draw on government and other sectors specific manufacturing, education and government.

The researcher could not find any South African ICT energy usage numbers. South Africa has electricity and energy usage estimations for the manufacturing and industry sectors, but the ICT usage numbers are currently absorbed with the other sectors. Further research could unearth these numbers for improved management and efficiency opportunities.

Building constituents



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been omitted in this study.

Potentially the energy cost of construction data centres and the disposal of waste as a result of data centre energy usage could be interesting. This was not considered relevant for this study.

Further, research could uncover ways in which ICT could support management of energy savings or waste management. ICT could perhaps contribute more towards energy savings and waste produced during the life cycle of ICT's. This has also been excluded for reasons of relevance at this time.



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The semi structured interviews were telephonic and lasted between 30 minutes and 45 minutes. The questionnaire guidelines had suggested answers, though interviewees were urged to include other options and ignore irrelevant suggestions. The questions were:

1. Do you have a view on what your organisation's energy usage was in the last 12 months?
2. Do you have a view on what your data centre's energy usage was in the last 12 months?
 - a. How do you measure energy consumption of your data centre, if you do?
3. Which business actions in your organisation affect the energy consumption of your data centre, in your view?
4. Which IT management actions in your organisation affect the energy consumption of your data centre, in your view?
5. Which data centre management actions in your organisation affect the energy consumption of your data centre, in your view?
6. What are some of the reasons your organisation does not consider IT energy efficiency initiatives right now?
7. What motivates your organisation to implement IT energy efficiency initiatives?
8. What would motivate your organisation to consider energy efficiency initiatives in the long term, perhaps 5 to 10 years?
9. How would rate communication between IT and data centre management or building facilities teams?
10. How well do you think IT is managing its assets?



I am conducting research on energy consumption of data centres. I am trying to determine the level of awareness of data centre energy consumption in South Africa; factors influencing data centre energy consumption; and which strategies have been deployed to reduce energy consumption in companies aware of the issue of rising energy usage of data centres.

Our interview will take about 45 minutes, and will help us understand how managers and experts view data centre energy consumption. Your participation is voluntary and you may withdraw at any time without penalty. Off course all data will be kept confidential, and only aggregated results presented in the final report.

If you have any concerns, feel free to contact me or my supervisor. Our details are provided below.

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Signature of Participant: _____

Date: _____

Signature of Researcher: _____

Date: _____