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GREEN INFORMATION TECHNOLOGIES:
IMPLEMENTING BEST PRACTICES IN SMALL BUSINESSES

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Abstract

The aim of this project is to evaluate sustainable or "green" technologies to determine both their financial and environmental value to small businesses, and to determine best practices. This project focuses on the current state of the best practices as it relates to green IT. This information was developed based on the current literature as well as interviews with local IT professionals. Following this understanding of best practices, a local telecommunications company was ‘audited’ and a summary of recommendations were developed. Inferences, implications and results are presented and discussed.

Acknowledgements

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I. Introduction

Motivated by rising energy costs, more businesses are trying to becoming "green" and/or, trying to reduce waste and become more energy-efficient. It seems that almost everyone, from individuals to companies, to entire nations, is trying to become more energy efficient. At the least, people and businesses who are not trying to become green are more conscious of the amount of energy they consume and the impact on their bottom line. More organizations are reducing their carbon footprint by doing things such as using hybrid vehicles, replacing incandescent light bulbs with fluorescent bulbs (CFL) or LEDs (light-emitting diode), and using less paper. In the past, businesses would hardly have given a thought to the amount of carbon dioxide emitted to conduct daily operations.

Currently, many businesses are doing everything within reason to "green" their operations with the significant driver of reduced costs. For many businesses, the greatest opportunity to reduce costs may be by greening their IT (Information Technology) systems. This project focuses on the current state of the best practices as it relates to green IT. This information was developed based on the current literature as well as interviews with local IT professionals. Following this understanding of best practices, a local small firm was 'audited' and a summary of recommendations was developed to assist smaller firms become more 'green" as well as increase their bottom line.

A. Environmental Impact of IT

Technology can both help save and pollute the environment. As organizations continue to grow, so do the IT systems and the energy required to run them. Datacenters require significant electricity to operate; both to run the servers, and to run the air cooling units. This electricity must be generated, usually via coal-fired or nuclear power plants, which take a toll on the environment. Additionally, the manufacturing process for components like servers, air cooling units, networking equipment and cabling, has an effect on the environment. Also, this equipment must eventually be scrapped. Since computers and information technology play such a pervasive role in society, there are abundant opportunities for green IT to reduce energy consumption, reduce costs and reduce waste.

B. Project Overview

This capstone project has three major components:

1. Definitions and a review of the literature in the field in order to provide the current state of green IT and a background for the remainder of the paper
2. Synthesizing the practices of key players of the green IT movement and
3. Evaluating current practices of a local business and making recommendations.

The project involves investigating and learning about how the major technology vendors are implementing green IT into their best practices, and then taking this knowledge to make recommendations on the best ways for small businesses to implement green IT. The majority of this research is covered in the literature review. The literature review discusses and synthesizes published information about what the major companies are actually doing to implement green IT, and also incorporates what the current academic literature suggests are current best practices for green IT. For this study, the "major companies" means companies such as: IBM, Microsoft, Cisco, Dell, EMC, HP, VMware and Google.

In addition to the literature review, additional research came from interviews of experts from companies that are investing significant resources into green IT. A questionnaire was developed for these interviews. This questionnaire was used to evaluate why the companies are investing in green IT, whether their green initiatives have been successful financially and environmentally and to learn their best practices.

Becoming knowledgeable in the domain of green IT is be a major benefit of this project. Researching the efforts of larger organizations was the first step for this project. This involved reviewing the current literature on green IT and interviewing industry professionals. After the research phase and interview phases, the project summarizes and synthesizes best practices for green IT, evaluated a local small business' green IT efforts and provides recommendations to small businesses on how to implement green IT solutions.

II. Definitions

This section will establish common industry terms used for this study. A good starting point is the definition offered by Lamb (2009) where he states that green information technology, (green IT), also known as "green computing," is "the study and practice of using computing resources efficiently." Expanding the Lamb definition, IBM offers a more comprehensive definition of green IT as:

> "Green IT is comprised of initiatives and strategies that reduce the environmental footprint of technology. This arises from reductions in energy use and consumables, including hardware, electricity, fuel and paper – among others. Because of these reductions, green IT initiatives also produce cost savings in energy use, purchases, management and support, in addition to environmental benefits. Beyond cost savings and

environmental benefits, some initiatives may address stakeholder and regulatory needs and demands". (IBM Corporation, 2009)

Likewise, Gartner defines green IT as: "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, Green IT: The New Industry Shock Wave, 2007)

Murugesan (2008) subdivides green IT into four areas: They are: green use, green disposal, green design, and green manufacturing. As this project will focus on best practices primarily for small businesses, green design and green manufacturing will not be explored.

Two of the most effective, and most popular, green IT practices are:

1. Virtualization/consolidation, and
2. Cloud computing.

Other common terms found when discussing green IT are:

Blade server: A chassis housing that contains multiple, modular electronic circuit boards (blades), each of which includes processors, memory, storage, and network connections and can act as a server on its own. The thin blades can be added or removed, depending on needs for capacity, power, cooling, or networking traffic. Blade servers can provide a host of benefits to organizations, including more efficient use of space and energy (Lamb, 2009). Figure 1 shows a blade chassis with a blade pulled out on the left.

Figure 1

 (Microsys, 2011)

Carbon footprint: the amount of greenhouse gases and specifically carbon dioxide emitted by something (as a person's activities or a product's manufacture and transport) during a given period (Merriam-Webster, 2012).

Cloud computing: According to the NIST, Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. This cloud model is composed of five essential characteristics, three service models, and four deployment models (Mell & Grance, 2012). Lamb defines cloud computing more simply as "a style of computing where IT applications and business functionalities are provided as services and accessed through the Internet" (Lamb, 2009).

Fat Client: Any workstation computer other than a thin client. Fat clients are what most people use as a personal computer. Fat clients generally include not only the hardware such as hard drives, but also individual licenses of software.

IT (Information Technology): The study, design, development, implementation, support, or management of computer-based information systems, particularly software applications and computer hardware (Lamb, 2009).

Kilowatt hour (KWH): A basic unit of electric energy based on using power of 1,000 watts for one hour. The kilowatt hour is the energy delivered by electric utilities that is usually expressed and charged for in kWh (Lamb, 2009).

Software as a Service (SaaS): Software that is owned, delivered and managed remotely by one or more providers. The provider delivers an application based on a single set of common code and data definitions, which is consumed in a one-to-many model by all contracted customers anytime on a pay-for-use basis or as a subscription based on use metrics. In a SaaS implementation, the vendor takes care of the support, training, infrastructure and security risks in exchange for recurring subscription fees (Symantec, Inc., 2011).

Terminal server: Hardware or software that connects terminals to a host computer. Years ago, a terminal server was part of a mainframe or a stand-alone front end processor attached to the mainframe (PC Mag, 2012).

Thin client (client virtualization): A computer (client) in client-server architecture networks, which depends primarily on the central server for processing activities. This is contrasted with a "thick" or "fat" client that does as much processing as possible and passes only data required for communications and archival storage to the server. This is a similar concept to terminals used to connect to a mainframe before the advent of the PC (Lamb, 2009).

VDI: Virtual desktop infrastructure. VDI is the practice of hosting a desktop operating system within a virtual machine (VM) running on a centralized server. VDI is a variation on the client/server computing model, sometimes referred to as server-based computing. The term was coined by VMware Inc. (Rouse, 2007)

Virtual machine: a self-contained operating environment—software that works with, but is independent of, a host operating system. In other words, it's a platform-independent software implementation of a CPU that runs compiled code (Waters, 2007).

Virtualization: Virtualization lets you run multiple virtual machines on a single physical machine, with each virtual machine sharing the resources of that one physical computer across multiple environments. Different virtual machines can run different operating systems and multiple applications o (Mitchell, 2007)n the same physical computer (VMWare, 2012).

Watt: A basic unit of electric power. Electric energy used is measured in kilowatt hours (KHW) that equate to using 1,000 watts of power for one hour (Lamb, 2009).

III. Benefits of and Motivations for Adopting Green IT

There are many reasons for investing in green computing, including: helping to prevent climate change and pollution, reducing operating expenses, increasing efficiency, improving organizational citizenship, improving public image, compliance with laws and increasing reliability of power.

A. Environmental Benefits

Reducing costs will likely be the primary reason businesses decide to invest in green computing initiatives. This comes as no surprise. What is surprising is that a Forrester research study found that helping the environment was the second-most popular motivation for pursuing green IT, cited nearly as frequently as reducing costs (Mines C. , Brown, Van Metre, & Lee, 2007). This comes as good news, showing that fiscal and environmental values are both responsible for helping companies become greener.

Broadly, the environmental benefits of Green IT include reduced manufacturing needs, reduced electricity needs, reduced carbon emissions and less landfill waste. However, reducing costs will be the prime incentive for small businesses to adopt green IT practices.

B. Financial Benefits

Some businesses implement green practices for environmental reasons, but most implement green IT for the cost savings (Jana, 2008). Russ Klein, vice president and IT research group director for the Aberdeen Group, a division of Harte-Hanks (IBM) states that, "71 percent of midsized companies cited cost reduction as the primary reason to pursue a green IT initiative." This comes as no surprise; few businesses will invest in pricey technology unless it offers a justifiable ROI, regardless of the environmental benefits.

As explained in the following sections, some of the benefits of green IT are: reduced power consumption, government incentives and longer hardware TTF (time to failure). Additionally, businesses can earn goodwill and improve public image by implementing environmentally responsible solutions.

In 2005, the United States government introduced the Energy Policy Act of 2005. Under this policy, companies that reduce a building's total energy and power cost by 50 percent become eligible to claim a tax deduction of $1.80 per square foot on new and/or existing buildings (Energy-Efficient Commercial Buildings Tax Deduction) (Waxer, 2010).

As a result, there has been an increase in companies looking to incorporate green IT to assist in reducing cooling costs and other power saving practices to reduce a building's total energy and power costs by 50 percent or more (Waxer, 2010). This rise can be seen in the 2011

CDW Cloud Computing Tracking Poll. The survey found that 63 percent of IT professionals with access to utility rebates or incentives believed the available incentives are applicable to the specific IT investments their organization is planning and 92 percent of those believe the utility rebates or incentives are a significant factor in their organizations IT purchases decisions." It is important to note, if a building doesn't qualify for the full deduction, it could be eligible for a partial one. "For example, if a building doesn't meet the requirement for 50 percent energy savings, it could still qualify for a $0.60-per-square-foot deduction if renovations reduce energy costs by at least 16.66 percent (Waxer, 2010)."

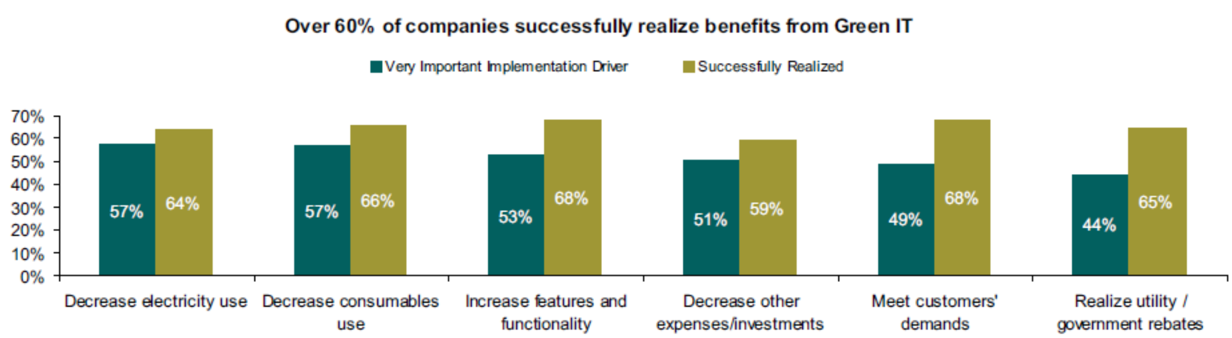
Even with federal tax incentives, green IT initiatives can be costly. For that reason, tax incentives from state governments help alleviate the financial cost of implementing green IT.

States like, New York, Oregon and North Carolina are leading the charge in implementing state tax incentives. New York and Oregon offer tax incentives for green buildings (Waxer, 2010). North Carolina offers a 35 percent tax credit for renewable energy equipment expenditures, such as solar space heating (Waxer, 2010).

Although there are many environmental motivations, financial motivation is the driving-force behind the pursuit of green IT. In a study conducted by IBM Corporation, almost all green initiatives were driven by roughly 60 percent business and 40 percent environmental reasons (IBM Corporation, 2009).

Companies look at two components when identifying financial merit in a green IT practice: capital expenses (CAPEX) and IT operating expenses (OPEX) (Washburn, Yates, & King, 2009). "Green IT can push back or eliminate new capital investments by increasing asset utilization, extending as asset's useful life and or increasing data center space, power and cooling and capacity. Alternatively, OPEX can reduce ongoing expenses, such as power costs, data center cooling costs, hardware license fees, and staffing costs. (Washburn, Yates, & King, 2009).” It is important to note, that many green IT initiatives can yield both OPEX and CAPEX benefits simultaneously. For example, server virtualization reduces the need for further future investment in physical servers. Hence, companies can drastically reduce the number of physical servers used, and there for benefit from reductions in data center energy and cooling costs (Washburn, Yates, & King, 2009). In addition, companies can reduce hardware license fees. These fees are determined based on the number of physical servers; thus, by utilizing server virtualization less hardware licenses are required due to the decrease in physical servers in use (Washburn, Yates, & King, 2009). Finally, companies are able to increase IT staff efficiency and lower staffing costs due to the decrease in physical server maintenance (Washburn, Yates, & King, 2009).

Figure 2



(IBM Corporation, 2009)

IV. Background and Research

This section details and synthesizes the current literature and best practices for green IT. The background and research is divided into three main categories:

1. Virtualization and Consolidation
2. Energy Efficiency
3. Disposal and Recycling

Within each category, both academic research and industry practices will be explored. "Academic research" will be defined as primarily theoretical research, primarily found in academic journals. "Industry practices and research" can be thought of as the green IT techniques and solutions that firms are currently using and reported in trade journals, industry white papers or other company sources.

A. Virtualization and Consolidation

Virtualization is probably the most effective technique most organizations can implement to reduce their IT energy use (Lamb, 2009). Virtualization "refers to technologies designed to provide a layer of abstraction between computer hardware systems and the software running on them" (Waters, 2007). A good analogy for virtualization is carpooling, where people represent virtual servers and the vehicle represents a physical server. Rather than have a separate vehicles for each server, the servers can be "carpooled" together into one physical server. This section will cover server virtualization, cloud computing and client virtualization (thin clients).

1. Server Virtualization

Virtualization allows multiple operating systems (virtual machines) to run simultaneously on a single physical server. This allows servers to be consolidated onto fewer physical machines, which can save server room floor space and energy. Compression ratios of 1 to 8 are common for servers and can even go as high as 1 to 50 (Lamb, 2009). This means that up to 50 virtual servers can fit onto one physical server, depending on the size, power, role and requirements of the servers.

Without virtualization, an organization might have many physical servers, which may be in separate locations, and which all have their own hard disk drives, CPUs, power supply, etc. In most cases, non-virtualized servers are underutilized, with the average company using only somewhere between 5 percent and 25 percent of its server capacity (Waters, 2007). These individual physical servers consume more total electricity, and take up more space than having those same servers virtualized and consolidated onto fewer physical servers. In fact, even when a typical server is idle, it uses 40 percent to 50 percent of its maximum power consumption (Lamb, 2009). With virtual servers, idle time is reduced because computing capacity can be better utilized. Another benefit of virtualized servers is that they generally produce less heat than the equivalent non-virtualized servers. Less heat translates into less workload on the cooling system, thus reducing energy use. Additionally, by using virtualization, fewer raw materials and manufacturing resources are used, since fewer physical servers need to be purchased and then disposed. Furthermore, the cooling systems should last longer, due to lower cooling requirements.

Virtualized machines are also more flexible. System resources can be better allocated and prioritized to the users/applications needing them the most (Lamb, 2009). Virtual servers also help provide redundancy, without the need for extra physical servers. Redundancy is used to manage the risk that if one server fails, the redundant server will take over without much interruption in service (Strickland, 2008).

Finally, virtualized servers help IT departments spend less time on routine administrative tasks like managing server workloads and adding new employees and applications; therefore freeing IT staff to focus on higher value roles (VMware, 2009). Additionally, virtualization can shorten disaster recovery time and increase application availability. The VMware survey states that nine out of 10 IT departments spend at least half of their time doing routine administrative tasks, and that small and medium businesses (SMBs) who have implemented virtualization reported productivity gains with 73 percent seeing significant improvements in time spent on routine administrative tasks (VMware, 2009).

As an example, Crutchfield, a mail-order electronics corporation, had expanded the number of its servers to the maximum capacity of its cooling unit. By virtualizing its servers, Crutchfield was able to cut the heat output of the servers by about 50 percent. This helped them to avoid buying a new cooling unit (Dell, Inc., 2009).

In addition, one can see the financial benefits of server virtualization in the example of Rigel Capital, LLC, Rigel Capital is an investment management firm headquartered in Seattle, Washington. The company has approximately 25 employees and $2.3 billion in assets under management. "For Rigel, the ability to conduct trades in a timely manner is essential. You could lose out on thousands of dollars if you fail to execute a trade within a certain window of opportunity," says John Cassidy, manager of IT services at Rigel. (Case Study: Build Reliability and Security Into Your IT Infrastructure: Case Study: Rigel Capital, LLC)" Therefore, Rigel requires an IT system to have a high degree of availability and reliability.

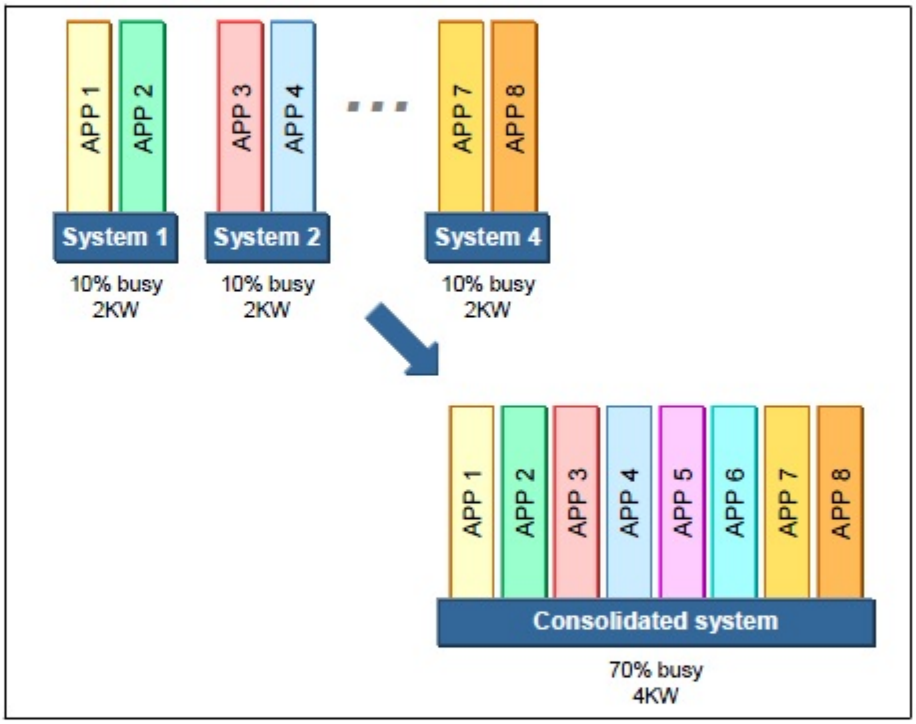
To achieve this, Rigel employed All Covered, VMware VIP Enterprise Partner and began using VMware Infrastructure 3 as the basis for its IT infrastructure. This allowed Rigel consolidate multiple single-use physical servers onto two VMware ESX hypervisors, as well as utilize features, such as VMware HA and VMware Virtual Consolidated Backup to strengthen disaster recovery capabilities and increase availability (Case Study: Build Reliability and Security Into Your IT Infrastructure: Case Study: Rigel Capital, LLC).

As a result, Rigel was able to see cost savings through reduced disaster recovery time, cooling costs in server room and hardware costs. Prior to implementing virtualization disaster recovery time could take as many as eight hours to get their previous three to four servers up and running. Server virtualization decreased disaster recovery time to minutes. This increased the window of opportunity to conduct trades; thus allowing the company the ability to capitalize on thousands of dollars in trades previously lost to disaster recovery time. Lost productivity is a universal issue faced by all businesses that can be decreased through server utilization.

In addition, Rigel was able to capitalize on the cost saving on hardware licenses and energy bills. On the cost-savings perspective of VMware, Cassidy stated, "If we need a new server, we can just create a new virtual machine instead of having to go and spend another $4,000 on a physical server." This elimination of the physical cost of new hardware and licenses allowed Rigel to save thousands of dollars. Lastly, the company was able to decrease cooling costs in their server room by consolidating seven physical servers down to two. (Case Study: Build Reliability and Security Into Your IT Infrastructure: Case Study: Rigel Capital, LLC)"

Figure 3 illustrates server virtualization:

Figure 3



Consolidation of applications from under-utilized servers to a single, more efficient server **(Ebbers, Galea, Shaefer, & Khiem, 2008)**

It is important to note that while virtualization improves the efficiency and utilization of servers, it actually decreases computing power because of the overhead needed to virtualize the servers. Also, while it would save more energy and reduce costs, a company should not virtualize everything onto one server, so as not to create a single point of failure. Additionally, depending on the application, some servers (like ones that have high requirements) need to be left on their own physical server. (Velte, Velte, & Elsenpeter, Green IT: Reduce Your Information System's Environmental Impact While Adding to the Bottom Line, 2008).

2. Cloud computing

This section provides an overview of cloud computing and will explore the energy-saving benefits it can offer small businesses.

Although cloud computing seems like a recent innovation, it has existed for several years. Webmail applications, such as Gmail and Hotmail, are probably the most identifiable examples of cloud computing. Currently however, cloud computing has become more associated with recent and computationally complex applications, such as Apple's iCloud, Amazon's Elastic Cloud Compute and Google Drive (Google Docs).

Lamb (2009) defines "cloud computing" as "a style of computing where IT applications and business functionalities are provided as services and accessed through the Internet." EMC (EMC Corporation, 2012) defines cloud computing as compute resources pooled together and redistributed based on what is needed by users, resulting in a compute environment that can be used or consumed like a public utility. This is opposed to having local servers and/or doing most of the computing on local machines. Baliga, Ayre, Hinton & Tucker (Baliga, Ayre, Hinton, & Tucker, 2010) divide cloud computing into three areas of service: Software, Processing and Storage. Below are current service examples of these three areas, as well as the green benefits a small business can expect from their implementation.

a. Software-as-a-Service (SaaS)

Software as a Service (SaaS) is likely the most recognizable example of cloud computing. SaaS delivers software similarly to the way utilities deliver water or electricity. This allows small businesses to minimize costs through economies of scale and pay-per-use (Symantec, Inc., 2011). An example of software as a service is Microsoft Office 365. This program is essentially the same software as its desktop version, Microsoft Office, with the exception that the software is delivered as a service over the internet. Office 365's use of only a normal broadband internet connection allows small businesses to minimize running costs. Benefits of small businesses using software as a service include a reduction in the need for inefficient workstation computers, workstation electricity usage, and the frequency of workstation replacement.

The benefits of Microsoft Office 365 can be represented in the case study of iLuka, a small British company that specializes in managing the advertising campaigns of large multinational firms at the Summer and Winter Olympics every two years. Prior to implementing Office 365, iLuka was purchasing yearly licenses for MS Office. During the Olympics, the company's employee size grew from roughly 50 to as many as 1000 employees. Thus, due to the nature of their business, they were only able to fully utilize their MS licensing agreement for one month. Microsoft 356 offered iLuka the ability to add users for a specific time period; this allowed them to decrease their monthly MS operating cost. Specifically, they were able to decrease their cost of adding 1,000 new users for a month from £700,000, through their previous licensing agreement, to £15,750 with Microsoft 365 (Flinders, 2012).

b. Processing-as-a-Service

Cloud computing also allows small businesses to obtain processing power via the Internet, on an as-needed basis through programs such as Amazon's Elastic Cloud Compute (Amazon.com). For example, if a student is running a computationally intense application and requires more processing power, he or she can lease extra processing power from Amazon.

The use of processing as a service demands less processing power and less energy from a user's local machine, hence, decreasing the need for power-hungry machines (Baliga, Ayre, Hinton, & Tucker, 2010). However, a server located in a datacenter takes over processing for cloud computing, thus shifting power usage from a user's local computer to the datacenter. Despite this increase in remote server power usage, it is important to note that servers in datacenters are usually virtualized, faster and connected to a more efficient power source, allowing them to use less energy than a comparable PC. Further, this decrease in the need for additional local servers allows small businesses to operate using fewer cooling units for the server room and reduce in-house electricity consumption.

Zynga, a popular online social game company, uses Amazon's Web Services (AWS) as its initial servers when it launches a new game to assess the demand, then moves the servers in-house once demand stabilizes (Babcock, 2012). Small businesses could use a similar strategy to cut expenses and reduce waste.

c. Storage-as-a-Service

Finally, cloud computing allows small businesses the ability to store and sync their files on servers connected to the Internet (the Cloud). Two recognized examples of storage as a service are Google Drive (Google Docs) and Dropbox. Storage Applications, such as the examples, offer three main benefits to small businesses. These programs allow employees to access files remotely, potentially reducing fuel costs. Second, storage applications decrease the need for local hard drive capacity. Hence, small companies utilizing storage as a service could potentially reduce IT capital costs in the long-term, due to their decrease in storage requirements. Finally, cloud storage offers security advantages. Small businesses are often financially limited on the amount of IT security they can provide for their data. Cloud storage allows small businesses the same level of security as fortune 500 companies, such as Google and Microsoft, at minimal cost.

Although there are many benefits to cloud storage, small businesses must assess their specific situation to determine if cloud storage will offer financial savings and environmental benefits. Companies utilizing storage applications only decrease demand on their hard drive, not their processor. All processing is done on the user's local machine (Baliga, Ayre, Hinton, & Tucker, 2010). Hence, from a green perspective, there are minimal energy savings from cloud storage; this is largely due to the transport costs associated with downloading and uploading information. Baliga, et al (2010) confirms this finding, citing that cloud computing can save energy when files are only occasionally accessed due to the transport energy needed for switching and routing the information over the Internet. Therefore, a recommendation for small businesses: When contemplating cloud computing storage as a service, one must consider the expected intensity and frequency of their expected usage. As long as the computing tasks are of low intensity or infrequent, cloud computing may be an option to save energy.

Real World Example of Implementation of Cloud Based System

To research cloud computing and as a part of an internship, during the fall of 2011, I helped "Acme Insurance Co." transition to a cloud-based system. Before this transition, Acme housed their servers and backup system in-house. This required an extra cooling unit to be maintained and run, to keep the servers from becoming overheated. Since the migration to a cloud-based system, Acme no longer needs to operate a separate cooling unit for the server room, and in-house electricity use was reduced. The reduced electricity was mainly from not having to maintain servers in-house and not having to run a separate cooling unit.

3. Thin Clients (client virtualization)

Thin clients are computer workstations in a client-server network, which primarily depend on the central server for processing activities; housing only the firmware and I/O ports required to connect to the monitor, mouse, keyboard, and server and are designed to communicate with the application(s) on the server. All applications run via the server; this allows companies to harness the processing power of “thick” or “fat” client without investing in additional computing power. One example of a thin client is the Cranberry SC21 “Smart Client,” as seen in Figure 4 below:

Figure 4

The Cranberry SC21 computer requires 12-19 watts of energy per hour, as opposed to the average fat client, requiring approximately 175 watts (Roos, 2011) (Cranberry UK Limited, 2010). Deployed across an organization, thin clients can reduce energy consumption by up to ten times. Additionally, a German study found that thin clients could reduce greenhouse emissions by 44 percent (IGEL Technology GmbH, 2008).

The remainder of this section examines the resurgence of the thin client, as well as its emergence as a key player in the Green IT movement.

The thin client has been in existence for more than two decades and offers many potential benefits to small businesses; however, many companies were hesitant to integrate these workstations into their information systems. This reluctance stemmed from the high investment costs of back-end infrastructure technology, such as servers, storage and networking. In addition, early thin clients lacked response time and the ability to integrate into companies existing information systems in comparison to standard workstation computers, capable operating their own applications (Davis, 2008).

Despite the early limitations of thin-client computing, green companies are revisiting this practice as a way to more closely manage energy-consumption and security, as well as decrease total cost of ownership.

Thin-client terminals do not require hard drives and expansion slots, draw less power and require less complex components (Davis, 2008). This reduction in hardware and computing power allows companies to achieve green best practices in comparison to their "thicker" PC peers. Further, thin-client computers take up less space and require fewer raw materials to manufacture. Also, fat clients use more energy while idle, which equates to unnecessary energy usage and take more time to power on. Gartner states that thin clients decrease downtime cost by 70 percent. The energy required to operate results in heat output, which is amplified by the number of workstations (Lamb, 2009). The excess heat puts extra load on the air conditioners. Therefore, companies may be able to decrease their energy consumption and expenses by replacing fat clients with thin clients, depending on how many fat clients are replaced.

Today several large companies serve as noteworthy examples of the financial and green benefits of thin clients, such as HP, Sun Microsystems and Wyse Technology. These companies have been able to utilize the above discussed benefits of thin clients and successfully lower TCO and streamline administrative management and security (Davis, 2008).

However, large companies are not the only business that can benefit from thin clients. General Floor, a New Jersey based small business offers a case study highlighting the financial benefits of thin clients. Matthew Petolicchio, General Floor's IT manager commented on the company's decision to phase out PCs, stating, "It doesn't make sense to waste money and effort on processing and storage resources that users don't really need, so we decided to go another route" (Edwards, 2011).

General Floor expects to save 15 – 20 percent upfront by purchasing thin clients rather than desktops. Petolicchio notes that with fewer critical parts to break down or wear out, a bare-bones thin client can run reliably for up to 10 years, about twice as long as a traditional PC. Thin clients allow for the virtualization of desktops, thus, problems with inner components, such as the hard-drive, mother-board and video card that commonly malfunction are eliminated. This decreases lost productivity, frees up IT support staff to focus on more important issues and decreases total cost of ownership, by not having to repair/replace components as frequently as fat clients (Edwards, 2011).

As mentioned above, General Floor expects to see long term savings through thin client's ability to be centrally managed with minimal effort. Locating the most temperamental technology at the server, reduces the need for client trouble shooting calls, such as cleaning up viruses and updating the operating system. For example, thin clients do not allow users to install or run their own software or to download data to a portable drive or memory stick. Therefore, thin clients offer increased security through their virtual invulnerability to infection by viruses or other types of malware (Edwards, 2011).

Additionally, IT support staff can remotely connect and support thin-clients. This allows small businesses with multiple locations to properly service all IT issues with minimal staffing. A second example of the financial benefits of thin clients is Weissman, Nowack Curry & Wilco, an Atlanta law firm. Joe Steele, the firm's IT director estimates that Wyse Technology thin clients have lowered the organization's support and administrative expenses by at least 70 percent (Edwards, 2011).

To summarize, thin clients offer reduced power consumption, lower heat output, lower purchase cost, smaller form factor, less manufacturing and disposal cost, extended refresh cycles, lower maintenance, improved life time, easier administration and improved security.

B. Energy Efficiency

This section focuses on efforts that have energy efficiency or reduction as a prime benefit. Three main practices are explored: server room upgrades and new builds, PC power management and optimization and printer consolidation. Many small businesses do not realize how much IT contributes to total energy costs. Computers and monitors account for 40 percent to 60 percent of the energy used by office equipment. Their energy consumption is second only to office lighting (Bray, 2006). A survey by IBM (IBM, 2007) found that one in four firms were unaware of the percentage of energy costs consumed by IT.

Considering the large amount of energy consumed by IT, it is important for small businesses to assess their IT energy usage and take steps to maximize efficiency.

1. Server room upgrades and new builds

This section focuses on ways small businesses can improve the efficiency of server rooms. Many small businesses have a room, or closet, dedicated to housing the company servers and databases. For most small businesses, the server room is the largest contributor to IT energy costs, and holds the most ROI for capital invested in green initiatives (Mines, Brown, & Lee, 2007). Increasing power consumption and escalating demand for information storage and distribution are creating unsustainable stresses on data center equipment, applications, power and cooling capacity.

In addition to reducing energy consumption, there are other benefits to improving server rooms. A study by InfoTech Research Group (IBM Corporation, 2009) found the main reasons businesses invest in server room/datacenter upgrades are as follows:

- Decrease costs and increase effectiveness of cooling and ventilation systems
- Increase server and computing capacity
- Improve reliability of servers
- Reduce maintenance and management costs
- Reduce server room space requirements

According to the Uptime Institute, the three-year cost of powering and cooling typical servers is one-and-a-half times the cost of purchasing server hardware (Brill, 2007). Further, Accenture (Nunn, 2007) found data centers use approximately one-hundred times the electricity per square foot of a typical office building. Most energy consumption in a data center falls into four areas:

- Critical computational systems (servers, networks, storage)
- Cooling systems
- Power conversion such as power distribution units (PDU)
- Hoteling (everything else: lighting, and so on). (Curtis, 2008)

The consistent increase in the cost of electricity and the proliferation of data centers also warrant server room modernization and optimization. From an environmental standpoint, the biggest benefit comes from more efficient use of each watt that enters the server room.

Upgrading server rooms can reduce, or at least hold energy costs steady, while computing capacity increases.

The main ways to optimize a datacenter are: floor layout (to optimize airflow), server configuration, consolidating (or virtualizing) servers and using efficient power supplies (Velte, Velte, & Elsenpeter, Green IT: Reduce Your Information System's Environmental Impact While Adding to the Bottom Line, 2008). Companies should also evaluate the cooling and airflow of the server room. Considering that "up to 50 percent of the energy used in a server room goes to power and cool equipment, rather than computations and processing," it would be wise to look for ways to optimize cooling of server rooms (IBM, 2007).

San Murugesan (Murugesan, 2008) recommends that the first steps small businesses should consider to be are:

- Implement blade servers
- Work to optimize the air flow in the data center/server room
- Consider liquid cooling vs. air cooling
- Virtualization

Blanking panels are another simple method to improve server room airflow efficiency. These work by filling in the empty slots in server racks, thereby preventing hot air from moving to the front of the servers. Ideally, a server room should have a hot isle/cold isle airflow system, where the hot air is pushed out the back of the servers. If there are too many empty slots, the hot air can mix with the cold air at the front of the servers, putting extra load on the cooling system (Schultz, 2010).

Figure 5

To demonstrate how much a small business can save by optimizing server rooms, consider a case study by Google (Google Inc., 2011) on a retrofit of one of their network POPs (Points of presence: a smaller networking room similar to a small-business server room). With a capital investment of $25,000, Google was able to save $67,000 in yearly energy expenses, and expects to save hundreds of thousands over the lifetime of the equipment. The retrofit was completed without any operational downtime.

Google recommends three best practices for retrofitting a server room:

1. Continuously measure energy usage
2. Optimizing air flow
3. Turning up the thermostat

Specifically, the retrofit was accomplished by:

1. Adding temperature monitoring
2. Optimizing air vent tiles
3. Increasing temperature and relative humidity settings on CRACs (computer room air conditioners)
4. Blocking off the ends of cold aisles with curtains
5. Installing blanking plates and side panels to prevent cold air passing through empty rack spaces
6. Adding extensions to all CRAC air returns
7. Adding a new CRAC controller

A creative new way to help cut down on datacenter cooling costs was explored by researchers at Microsoft and the University of Virginia. This method, called "Data Furnaces," helps people save on their individual heating costs by placing servers into peoples' homes. It works by routing the excess heat from the servers into the ductwork or water pipes to heat the residential building. (Liu, Goraczko, James, Belady, Lu, & Whitehouse, 2011). While placing servers in residences poses obvious security and maintenance risks, the concept is a creative way to help reduce carbon emissions.

As an example of server room success, accounting and advisory firm KPMG was able to achieve a 5 percent improvement in efficiency in one of their data centers. This was accomplished by raising the ambient temperature in the server room, raising the temperature of the water in the cooling tower and migrating to blade servers (Violino, 2011). By raising the air temperature, the cooling system does not have to work as hard.

2. PC Power Management and Optimization

While not as popular as virtualization or cloud computing, workstation optimization and power management can be an effective way for small businesses to reduce their energy consumption. Many of these techniques are common sense, such as powering off unused machines or enabling sleep or hibernation modes when PCs are not in use.

There are approximately 108 million desktop and laptop computers in use in commercial buildings in the US; the majority of these PCs are powered "On" at nearly equal levels day and night (Barr, Harty, & Nero). The Lawrence Berkley National Laboratory (LBNL) conducted a study to measure energy usage by office equipment in after-hours power status (Barr, Harty, & Nero). The study revealed significant energy savings could be achieved by putting inactive PCs to sleep at night. In addition, the study showed that most PCs are "On" more than 90 percent of the time (Barr, Harty, & Nero).

According to Gartner, PCs and monitors represent 31 percent of all energy consumed by IT equipment (Barr, Harty, & Nero). Therefore, if companies have the ability to deploy a centralized, automated method of turning on PC operating system power management features, they save energy during evenings and weekends, but also saved energy during the workday. Data center power-consumption alone was expected to cost businesses $7.4 billion in 2011, versus $4.5 billion in 2006, according to the United States Environmental Protection Agency (Dlana, 2012). Despite this large expense, the EPA found that 55 percent of businesses do not measure their power usage—and 85 percent of organizations do not use power efficiency metrics such as power usage effectiveness (PUE) (Dlana, 2012). This lack of awareness exposes the significant cost-saving benefit IT equipment power optimization offers companies; the below sections discuss policies, software and hardware changes that can significantly lower energy cost and carbon footprints for businesses.

New operating systems and computer hardware have the capability to lower power use. Also, network based software allows IT managers to implement PC power policies across the organization. It is difficult for companies to implement a pre-set automatic turn-off for computers and printers. This is largely due to the variability of employees' work schedules – managers do not want to discourage employees who want to work early or late to finish projects. Also, many companies leave workstations on overnight so they can download software updates. However, keeping all computers, printers, and displays powered on overnight and weekends wastes energy and money.

Specifically, the costs of not powering down PCs when they're not in use can range from $25 to $75 for a computer and monitor (Samson, 2008). New software tools collect information about network and PC device usage states by observing network traffic, to determine inefficiencies and wastage of power, and simplifying centralized control of PC power policy (Barr, Harty, & Nero).

For example, Autonomic Software offers its ANSA suites. ANSA suites use an intelligent agent for tasks, such as vulnerability management, asset management and PC power management. Autonomic's Software costs approximately $33 per license for the first year, then $10 per license for each sequential year. (Samson, 2008)

Despite the overhead cost of licenses, companies can benefit long-term. For example, if a company with 500 computers invests in power management software at $33 per license, this would be an upfront cost of $16,500 for the software. Based on the range of money to be saved by powering off PCs when not in use, the company can expect to make back $25 to $75 per computer through energy savings. After year one, the company would expect to have, at minimum, paid for 75 percent of the licensing fees of year one. After two years, the license price would decrease to $10. Therefore, at the end of year two total license costs would be $21,500, but the company could expect a range of savings between $25,000 and $37,500.

Companies can also use power strips for non-essential devices; shutting the power strip off at the end of the day eliminates unnecessary power usage from plugged-in, yet turned-off, devices. In addition, companies can transition from old cathode-ray tube (CRT) monitors to flat-screen liquid crystal displays (LCD). LCDs save both energy and space. A German report found that over a 5-year usage period, LCD monitors produce about half the emissions of a CRT monitor, and reduce the emissions of a complete desktop system by 15 percent (IGEL Technology GmbH, 2008).

3. Printer Consolidation

Printer consolidation is a process that will optimize the printer fleet to decrease the cost of hardware, consumables (paper, ink, and toner), electricity, and maintenance. Organizations can save as much as 65 percent of total printing costs through printer consolidation efforts, making this a compelling savings initiative (Info-Tech Research Group, 2010).

For most small businesses, printing costs, including ink, toner and paper, are a necessary expense. Excess printing is harmful to the environment and a company's bottom line. Fortunately, however, there are techniques that reduce printing costs, energy and carbon footprint. This section will outline ways that printing costs can be reduced and an example of a company successfully utilizing printer consolidation.

Printer consolidation offers companies with an opportunity to become greener. Below are ways consolidating and eliminating devices in the printer fleet can organizations to reduce their carbon footprint and save costs in the following ways:

- Reduced electricity consumption
- Reduced use of consumables (paper, ink, toner)
- Reduced hazardous waste from consumables and devices

An example of the substantial amount of savings to be realized from printer consolidation is Procter & Gamble. Caroline Basyn, P&G's director of global business services proposed outsourcing printing at all 200 P&G sites to a managed print service (MPS) provider. Prior to the MPS, offices were free to buy their own devices and supplies, a practice that "was absolutely not efficient," says Basyn.

In 2008, P&G chose Xerox Office Services, with the goal of reducing its printing and copying fleet from 45,000 devices to fewer than 10,000. This MPS increase the average number of users per printer from 4 to 15 employees. Small businesses who can adopt these practices on a smaller scale can benefit from increased productivity by their IT staff.

Although only approximately 30 percent of sites have converted to MPS, P&G has reduced printing costs by 27 percent, paper costs by 30 percent and energy costs by 40 percent, according to Xerox figures (Collett, 2010).

Though Basyn originally chose to go the MPS route to improve efficiencies and help digitize the company, the cost savings can't be ignored. Document printing and processing costs are typically equivalent to 3 percent to 5 percent of a company's revenue, according to Gartner. For P&G, that would put such costs as high as $3.8 billion in 2008 (Collett, 2010).

Utilizing a managed print services (MPS) provider allows companies the ability to consolidate, centralize and outsource management of its printing and copying functions. In return for paying a monthly fee to an MPS provider, you can cut printing and copying costs by 25 percent (Collett, 2010). Further, companies can leverage economies of scale and concise the number of printers needed. "MPS vendors such as Xerox, HP, and others have taken efficiency to the next level: Not only can they streamline printing and copying operations to help customers save money, but they claim that they can maximize worker productivity by monitoring what employees are printing, and where and when they're doing it, and then suggesting workflow and process improvements (Collett, 2010)." Thus, it evident that printer consolidation can offer companies the ability to:

- Reduce energy consumption - consolidation of printing stations
- Decrease IT carbon footprint - utilization of more efficient printing/copying equipment
- Increase IT productivity – reduction in IT support needed for maintenance and trouble shooting
- Increase employee productivity – Reduces unnecessary printing – through MPS monitoring services

C. Disposal and Recycling

"Electronics are the fastest-growing part of the world's trash problem, with an estimated 50 million computers becoming obsolete annually (Recycling, 2011)." Computer electronics contain hazardous and toxic materials that pose significant environmental risks. For example, CRT monitors contain toxic lead oxide that can pollute ground water; PC-related components & batteries are comprised of chromium, nickel, zinc, mercury and other heavy metals and plastic equipment housings can release dangerous gases if incinerated. (Recycling, 2011)

The above containments and their effects make responsible disposal crucial to ensuring a healthy environment. According to the Green Grid, responsible disposal is defined as “effected to standards that ensure the lowest possible environment impact and the highest possible recovery of embedded materials, in line with the notion of “resource”.

In addition, there are more than 550 state and federal e-waste laws in existence today; these laws specify procedures and reporting requirements for a US organization that recycles at least 220 pounds of e-waste per month. The penalties for improper recycling or inadequate reporting can be as much as $32, 500 per day (Recycling, 2011). Even alternatives like donation or employee purchase carry a risk, because the liability for environmental hazards can fall back on the originating party with penalties applied against all involved parties. Companies can avoid penalties and sending unnecessary waste to landfills by responsibly disposing old equipment by donating or selling old equipment to repurchase or buyback services. Sometimes old IT equipment can even earn credit toward future IT purchases. Additionally, services can securely erase sensitive information from old servers and hard drives (IBM, 2007).

For example, companies can partner with an authorized electronics recycler, such as EPC Asset Recovery Solutions to protect themselves from state and EPA penalties and to utilize, when possible, the most environmentally-friendly form of recycling: re-use (Recycling, 2011). EPC Asset Recovery Solutions audits all received equipment through by technicians to discern remaining value for refurbishment or remarketing. If re-marketable value exists, EPC will purchase the equipment at Fair Market Value pricing.

In addition, non-profit think tanks are beginning to provide companies with tools that allow them to take a more active role in the recycling/disposal of IT waste. An example can be seen in the recent Electronics Disposal Efficiency metric proposed by the Green Grid. The Green Grid is a non-profit, open industry consortium of end users, policy makers, technology providers, facility architects, and utility companies that work to improve the resource efficiency of information technology and data centers throughout the world (Verge, 2013)." This year the Green Grid continued to broaden its scope, expanding from data center energy to resource metrics. The industry group's new metric, the Electronics Disposal Efficiency (EDE) metric is an electronics disposal metric for commercial end-users of IT equipment (About The Green Grid, 2013). The Green Grid believes the EDE metric will boost recycling and offer organizations a way to measure themselves and improve over time, rather than as a score to be compared against other entities. This metric is designed to help minimize electronic waste, specifically servers and other enterprise hardware. The goal is to provide a way for organizations to measure the responsible management of IT EEE (Electronics and Electrical Equipment) that reaches EOCU (end of current use) or EOL (end of life and reuse, recycling, and disposal), through providing guidance and maintaining standards.

V. Project Milestones

The deliverables for this project include:

- Background research from academic and industry sources as described in the literature review
- Interviews from industry professionals implementing green initiatives
- Evaluation of green initiatives of a local small businesses
- Recommendations to a local small business

1. Summary of Interviews

Interviews were conducted with IT professionals in the technology field. Interviews were conducted by email and in-person and lasted approximately 45 minutes each. Questions were general in nature and focused on areas related to green IT. Interviews were conducted with the following professionals:

- Joe Norris: Chief Technology Officer, New Hanover Regional Medical Center (NHRMC)
- Michael Wade: Senior Account Executive, EMC Corporation
- Todd Hawthorne: Partner Business Manager, VMware
- Steve Perry: IT Director, University of North Carolina Wilmington

All interviews were transcribed and then read several times to identify key issues. The complete interviews, including questions may be found in Appendix A. Green IT opportunities and current practices were identified. The remainder of this section will discuss these findings and present a current portrait of green IT in Wilmington, NC.

Consistent with the findings previously presented in the paper, interviews with local professionals revealed financial benefits to be the driving force behind choosing to adopt green IT practices. Joe Norris, NHRMC discussed how green IT has become almost an expectation. Norris sees the implementation of green IT practices as an avenue for cost savings, and, therefore, an obvious consideration for future plans. For example, NHRMC currently uses louvered vents to remove heat from its datacenter and utilizes software to power down servers when CPUs are not needed. Norris noted the value of outsourcing; running applications in-house can be costly, requiring extensive upkeep and high energy costs. Outsourcing allows small businesses to utilize the economies of scale and efficiencies typically available only to larger companies.

The importance of infrastructure and data center design and was discussed in all interviews. Michael Wade discussed the value of effective data center design, using the example of EMC's Durham NC Center of Excellence; specifically describing the power usage effectiveness and cooling savings.

It is important to note the significance of defining a goal and vision for IT green practices. All interviews stressed the importance of defining the purpose of going green. Todd Hawthorne gave the example of Coca-Cola, a huge proponent of global sustainability. Coca-Cola needed to find a source of clean water for markets, such as India. Therefore, creating a plan to implement green practices to improve the water supply, not only allowed the company to reap environmental benefits from improving the water supply, but also financial benefits from creating a water source able to service markets with limited clean water.

Finally, all interviews suggested change in data centers and company practices can be expected. Hawthorne expressed the importance of respecting company culture and creating ways to engage employees in adhering to new green practices. As consistent with the finding of the paper, a change-agent was suggested to implement such cultural changes.

VI. Summary of Best Practices

Even given that every small business has different priorities and budgets, most small businesses should benefit from implementing at least some of the following best practices, outlined below.

1. Measure Current Energy Use And Establish A Baseline

Data centers should be monitored to create a baseline to determine their current efficiency and to compare against future changes in energy use. “It is important that companies continue to measure energy usage, even after software has been put in place. Metering specific racks or types of equipment, such as servers, can provide valuable insight into which consolidation, virtualization and optimization projects will yield the best ROI going forward” (Lamb, 2009). Energy monitoring and management software programs, such as IBM’s Active Energy Manager (AEM) and HP’s Insight Control allow companies to measure and monitor usage and virtually implement power management.

2. Diagnose Problems and Identify Opportunities

Once a baseline has been established, companies should consider bringing in an energy assessment company or co-op to identify opportunities to reduce energy usage. The company will conduct an assessment of the company’s energy consumption habits and recommend practices to reduce energy consumption.

3. Communicate Green IT Plans and Appoint Change Agent

Communication of plans and goals to save energy via green IT is an important step. Implementing green IT requires a change in culture, as adopting green practices demands modification to the way business is done for every employee. To aid in changing employee mindsets, companies should look to implement “green IT certification” programs or initiatives.

Also, it is recommended that companies designate a “change agent” to be a source of information and training on new processes. The action plan should deliver a consistent message and should be adopted by all levels of the company. In addition, companies should target quick-win activities that can work to modify employee’s mindset about green IT, as well as offer cost and energy saving benefits, for example, turning off unused IT equipment and enabling power management on printers and other peripherals.

4. Optimize Server Room

The next step is to optimize the server room or datacenter. Small businesses should design server rooms so that air flow is optimized to reduce stress on air conditioners. This can include installing blanking panels and curtains. If feasible, programmable thermostats should be installed and companies should not keep the server room too cold. Businesses should also inspect Computer Room Air Conditioners (CRACs) for inefficient air flow and leaks that can dramatically reduce their efficiency. Second, companies should consider installing new CRAC controllers. Third, IT staff should inspect the placement of tiles. Over time, the movement of aisles and other equipment can result in the relocation of the perforated tiles to non-optimal locations

5. Consolidate, Outsource and Virtualize

Consolidation of IT operations and using virtualization and thin clients to reduce server footprint and energy use are the most well-recognized and most-often-implemented efficiency strategies of the past few years. Reducing the number of power drawing components in the data center to a minimum directly reduces the amount of energy consumed as well as decreases cooling requirements. Businesses should also consider hosting as many applications as possible in the cloud, since they will run and manage them better than a company can internally.

6. Buy Green and take Advantage of Rebates

When purchasing new equipment, companies should opt for the most energy efficient products they can afford. The government Energy Star program is a good resource for which to determine how environmentally friendly products are. Lastly, companies should take advantage of government rebates and/or consult their electric company for ways to reduce power consumption.

7. Properly Recycle Unused IT Equipment

This should be obvious, but small businesses should properly dispose of unwanted equipment. Many services will pick up your old equipment and recycle it, free of charge. When in doubt, never throw IT equipment into the garbage. Contaminants like mercury do not belong in landfills.

8. Turn Off, Print Smart and Work Smart

Turn on power saving settings like hibernate and/or turn off equipment when not used. Also, only print what is absolutely necessary and use efficient print settings, such as draft mode and double-sided printing to save paper and ink. Lastly, take advantage of telecommunication technology to reduce vehicle travel.

VII. Recommendations

Recommendations for green IT for a small business will depend on the practices of the particular small business. The project included an assessment of Regional Telecommunications

Company. During my internship at Regional Telecommunications Company, I was able to observe IT practices, including one of the larger server rooms. Based on my observations, talks with IT managers and previously defined best practices, I propose the following recommendations for Regional Telecommunications Company to become "greener," and to reduce costs.

1) Install power meters to set baselines. This will allow for the calculation of ROI of future improvements.
2) Continue to virtualize as many servers as possible.
3) Consider outsourcing as many applications as possible. For example, consider using Microsoft Office 365 and hosted email and other "cloud" services where feasible.
4) Optimize server rooms. Specifically, raise the ambient temperature from 67 degrees to at least 75, or even 80 degrees, to reduce cooling costs. Also, optimize air flow by creating hot aisles and cold aisles and by installing blanking panels and curtains.
5) Power down workstation computers as often as possible.
6) Phase out inefficient "fat-client" desktops with "thin-clients."
7) Get top management to set a green policy and appoint "change agents" to promote energy efficiency. Also, consider a reward/incentive system for green ideas and practices.

A cost/benefit analysis was completed and presented to Regional Telecommunications Company management.

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Appendix A. -- Interviews

(Interviews removed).

Appendix B. – Green IT Evaluation Form

(Evaluation form removed).