GREEN ICT PRACTICES FOR ACHIEVING COST EFFECTIVENESS OF ELECTRICITY USAGE OF ICT IN SRI LANKAN APPAREL INDUSTRY

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Sri Lanka

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Thesis submitted in partial fulfillment of the requirements for the degree of Master of Business Administration in Information Technology

Department of Computer Science and Engineering

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DECLARATION

I declare that this is my own work and this dissertation does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where acknowledgement is made in the next.

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ABSTRACT

It is well known that the protection of the environment not only paves the way for a healthier life but also is required for the sustainability of our resources. Green concept has been identified as a perfect method to apply in all aspects of sustainability. Green Information Technology has occupied a leading role of Green concepts. Green ICT concept involves in reusing, reducing and recycling resources of ICT.

The objectives of this research are to identify Green ICT practices that significantly reduce electricity consumption for ICT in Apparel Industry operating in export processing sector in Sri Lanka, to describe the barriers for implementing those practices and to determine how the apparel industry can overcome those barriers. The findings of this study can be utilized for the benefit of the organizations in apparel industry and other types of organizations which are interested to implement Green ICT practices successfully. There are certain organizations in apparel industry which are already successful in implementing Green ICT practices while others are yet to implement.

Our results show that reducing datacenter power utility is the most significant practice for reducing electricity consumption of ICT while reducing electricity utilization for all equipment and printers' power utility are also important contributory factors. Further, lack of awareness of Green ICT among the staff has been identified as the main barrier for implementing those practices. However, conducting awareness program and doing cost benefit analysis can overcome the barriers for implementing Green ICT practices.

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LIST OF ABBREVIATIONS

Abbreviation	Description
AEEMA	Australian Electrical and Electronic Manufacturers' Association
AELA	Australian Environmental Labeling Association
AVE	Average Variance Extracted
CBSL	Central Bank of Sri Lanka
CD	Compact Disc
CEPIS	Council of European Public Professional Informatics Societies
CIO	Chief Information Officer
CR	Composite Reliability
CSI	Corporate Sustainability Index
DC	Datacenter
GAP	Global Action Plan
GM	General Manager
IT	Information Technology
ICT	Information and Communication Technology
ICTA	Information and Communication Technology Agency
IMS	Intelligent Manufacturing Systems
MWh	Megawatt Hour
PC	Personal Computer
PUCSL	Public Utilities Commission of Sri Lanka
PUE	Power Usage Effectiveness

RMIT	Royal Melbourne Institute of Technology
TRB	Technology Business Research
TWh	Terawatt Hour
UK	United Kingdom
USA	United States of America

1 INTRODUCTION

Information and Communication Technology (ICT) is a major part of our modern industries, workplaces and individuals as well. Technology continues to advance and grow rapidly hence the utilization of resources to ICT is also increasing day by day (Berkhout & Hertin, 2001). Therefore, it is a responsibility of the IT professionals to ensure that the utilization of energy for ICT is occurring in an efficient and sustainable manner. Especially the utilization of electricity has to be considered seriously since the electricity generation has a huge impact on Global Carbon Emission (UKParliament, 2011). In Sri Lanka, we generate electricity mainly from hydro power and in addition to that, we use diesel and coal which are very costly methods. A small percentage of electricity is generating from solar and wind which plays only a minor role in this process. Therefore, the increasing demand to the electricity in Sri Lanka has to be addressed by diesel and coal power plants which are very expensive and increasing environmental carbon footprint as well (PUCSL, 2012). It is a responsibility of the staff working in ICT sector in Sri Lanka to focus on reducing the environmental footprint of their computing infrastructure by minimizing the utilization of electricity, whilst saving costs, improving process and optimizing efficiency. Therefore the ICT has to be adapted to the concept of "Green ICT" which implies low carbon emission and energy saving.

The objectives of this research are to identify the practices followed by apparel manufacturing industry which are operating directly in export processing sector in Sri Lanka to reduce electricity utilization of ICT in their organizations and the awareness of Green ICT of their ICT staff. If such practices are not followed, then this research will identify the barriers for not following such practices and to find ways to avoid those barriers. The research questions have been listed down based on these concerns.

1.1 Current Status

The Information and Communication Technology is becoming the power of business in organizations everywhere in the world. And it is becoming a part of life of individuals as well (Kramer, Jenkins, & Kats, 2007). Therefore the utilization of energy for ICT also has significantly increased. Especially the utilization of electricity is taking a major role. Proportionally the cost of energy and environment carbon footprint increases. In recent years, environmental sustainability has become increasingly important for individuals and for organizations as well (Nidumolu, Prahalad, & Rangaswami, 2009). It has become a board priority in the aspects of managing, monitoring and improving. There is an obvious financial benefit of improving environmental efficiency and the organizations are socially responsible to support & maintain environmental friendly practices in their premises. In addition, environmental standards and rules are becoming increasingly stringent. It is becoming a global responsibility and regulations are being released and strengthened day by day and we have to adhere to those regulations strictly (Morris, 2004). Therefore it is a timely requirement to find ways to reduce energy utilization to support the sustainability of the world.

The Apparel industry in Sri Lanka plays a major role in industrial exports. As per the Economic and Social Statistics of Sri Lanka 2014 released by Central Bank of Sri Lanka, the Textiles and Garment industry take over 58% of total industrial exports in year 2012 and 2013. And this has increased significantly in last two decades. The utilization of electricity for industrial purposes is higher compared to the other sectors. Especially in Western province in Sri Lanka, 36% from the total electricity sales has been used for industrial use (CBSL, 2014). Since apparel industry occupies the majority in overall industrial operations, it has a significant impact to electricity utilization in Sri Lanka. Therefore, the utilization of electricity for ICT in apparel industry also has a significant impact compared to the utilization for manufacturing as well as the general usage.

1.2 Preliminary survey

A preliminary survey was conducted to see whether the electricity consumption for ICT in apparel industry is higher compared to non apparel industries. Three organizations were selected to collect data through personal contacts of those organizations.

- A fabric manufacturing mill
- A financial institute
- An education institution

The number of office staff employed in the fabric manufacturing mill and the financial institution were 143 and 118 respectively. The exact number of staff in the education institute could not be obtained. It was assumed that there were more than 200 office employees in the premises. The Power utilization in two non apparel industry organizations were compared with apparel manufacturing mill to see whether the power utilization for ICT in apparel manufacturing industry is higher than where it should be.

1.2.1 Preliminary data collection

A set of randomly selected questions were used to collect the initial data from the selected three organizations. For the apparel organization and financial institution, this set of questions was communicated via e-mail. The responses were also received as a reply to the same e-mail. For the academic institute, required data received via a reliable source and minor Excel calculation was done.

1.2.2 Interview

A small interview was conducted while collecting the data to know the level of awareness of Green ICT practices for reducing electricity consumption on IT personals in those organizations. As per their responses, it was realized that some of them were not implementing green ICT practices to reduce electricity consumption in the organization since their awareness of the significance of the energy utilization for ICT was not adequate. Following Table 1.1 shows the data collected while preliminary survey was conducting. Apart from reducing electricity consumption, they have implemented some other practices related to Green ICT. E.g. reduce printing, ICT equipment disposals, Servers virtualization etc.

Table 1.1: Monthly energy utilization for ICT

Organization	**Energy utilization for ICT (Monthly)**
Fabric mill	43.48 MWh
Finance institute	1.56 MWh
Academic institution	10 MWh

1.3 Problem Statement

The Information and Communication Technology is playing a major role in Apparel manufacturing industry operating in export processing sector in Sri Lanka, as per the discussion in the above sections 1.1. However the problem is that the electricity utilization for ICT in apparel industry is higher than what it should be, as per the section 1.2 and the results of the preliminary survey indicated in Table 1.1.

1.4 Research Questions

Following research questions have been defined to achieve objectives of this study.

- What are the significant Green ICT practices to reduce electricity utilization of ICT in Apparel industry operating in export processing sector in Sri Lanka?
- What are the barriers for implementing those practices?
- How can apparel industry overcome those barriers?

1.5 Research Objectives

Answers to the above three research questions will give a supporting structure to apparel manufacturing industry operating in export processing sector in Sri Lanka to implement Green Information and Communication Technology concept in their organization and reduce electricity utilization for that. Beyond this, the findings of this study will help other industries as well for implementing practices to reduce electricity consumption for ICT in their premises. Therefore, this study aims to achieve following research objectives.

- To identify the significant practices for reducing electricity utilization for ICT in apparel industry operates in export processing sector in Sri Lanka.
- To identify the barriers for implementing those Green ICT practices.
- To identify the techniques can be used to overcome the barriers.

1.6 Research Design

This section discusses about the overview of the method carried out in this research and its scope.

1.6.1 Scope of the study

This research is carried out among apparel manufacturing industry operating in export processing sector in Sri Lanka. Small, medium and large sizes of organizations in leading apparel manufacturers in Sri Lanka participated to the study. Though Green ICT has wide range of areas to discuss, this research is limited to identify significant practices to reduce electricity consumption for ICT in apparel industry and barriers for implementing those practices in their organizations in Sri Lanka. Further, the techniques to overcome such barriers were also identified as a part of this research. As the number of organizations in the selected apparel sector is limited, this research was conducted as a case study, and therefore only the executive grade ICT management staff would be interviewed.

1.7 Thesis outline

Chapter 1 (Introduction) consists the introduction about research including current status, preliminary survey, problem statement, research objectives, research questions and research methodology.

Chapter 2 (Literature review) contains literature review on Importance of Green ICT, How Organizations are implement Green ICT practices, Barriers for implementing Green ICT and How Organizations have tried to overcome barriers. In this chapter, literature was reviewed without focusing on one industry or sector.

Chapter 3 (Methodology) contains the methodology of this study with research process flow and preliminary study carried out. The data collection methods and the data sample size are also discussed.

Chapter 4 (Analysis) contains the analysis of the data collected. Analysis is performed to find significant practice for minimizing the electricity consumption for ICT, barriers for implementing Green ICT and techniques for avoiding the barriers for Apparel manufacturing industry in Sri Lanka.

Chapter 5 (Discussion and recommendation) contains the conclusion of this study. This is discussing the analysis done in Chapter 4 and recommendations for the apparel industry for Green ICT implementation.

2. LITERATURE REVIEW

In this section, we reviewed the literature for Green ICT under four sub topics. Importance of Green ICT, How organizations implement Green ICT, Barriers for Green ICT and how organizations have attempted to overcome barriers have been reviewed.

2.1 Importance of Green ICT

2% of the global carbon emissions come from the manufacture and use of Information and Communication Technology and 98% from others. Even though ICT is a part of the problem as at now it is not significantly high and ICT also can be used as a means of solution. However contribution by ICT for global carbon emissions is growing day by day causing its contribution to be significant in the future. In order to reverse these trends, the responsible ICT staffs need to consider how the ICT staff can make serious improvements in energy consumptions especially in electricity utilization (GAP, 2009).

The motivation factors for implementing Green IT among 45 Sri Lankan green awarded organizations have been identified. By using those data, how an organization can plan to Go Green in future with minimum disturbances and maximum benefits can be determined.

As per the surveys which have been conducted, the power consumption and consequent environmental impact of ICT is much greater than what is generally realized. The term "Green IT" has been defined as "The study and practice of using computing resources in ways that help reduce energy and operating costs enable sustainable business practices and reduce the environmental impact of IT practices in the larger Community". By introducing Green IT solutions, many organizations are saving lot of money by reducing the amount of power need for servers, workstations and other IT related and supportive equipment. Examples for the global trends of Green IT are, The European Commission has stipulated in its Code of Conduct on

Datacenters Energy Efficiency considering two dimensions of data centers. Firstly IT Loads which concerns the energy consumption of IT equipment itself, and secondly facility loads which concerns those elements supporting the IT equipment; such as cooling systems and air-conditioning. It aims to minimize the energy consumption of ICT by committing all parties including the data center owners and operators as well as the suppliers and service providers. Especially, USA, UK, Australian and Singapore governments' agencies are proactively working on promoting Green IT and supporting organizations by developing guidelines and policies to follow by those organizations. In Sri Lankan context, The Central Environmental Authority of Sri Lanka has commenced "National Green Awards" since 2011 to motivate organizations in Sri Lanka to go for Green practices. This study has focused on identifying the factors which drives Sri Lankan organizations to engage in eco-sustainable practices directly targeting IT (Jayathilake & Fernando, 2013).

The Chief financial officers research services report has strongly recognized the importance of Green IT. Electricity is a major requirement for IT industry. The coal and oil are a secondary source for generating electricity in Sri Lanka today. It increases environmental temperature. Green IT should be the part of the business process and it should come from the heart of the employees. Therefore Green IT focuses on change of processes, behavior and organization's culture as well. To determine the current level of Green IT managerial capability of IT organizations in Sri Lanka, following objectives have been defined.

1. Identify factors affecting IT managerial capability
2. Identify the areas that need to be improved

The challenges for IT Managers are, to reduce IT related energy use, green house gas emissions, inefficiency in equipment usage and wastes. Then they are expected to provide IT solutions to improve their environmental footprint in their businesses and supply chains. Here also the Green IT Framework is coming in to the action of Green IT. The Green IT policy and Green IT governance are the components of IT managerial capability. The energy reduction policy is coming under Green IT policy which will discuss employing energy efficient technologies, effective usage of

existing technologies and reducing the carbon footprint of the organization. Green IT implementation should not be a onetime process and should have continuous observations (Thanajeyan & Fernando, 2015).

The utilization of electricity for servers has been doubled over the period of 2000 – 2005 worldwide. This is because of the increase of the number of servers. From 2005 – 2010, the electricity used by the datacenters have been increased by about 56%. In year 2010, the electricity used by the datacenters represents 1.3% of all electricity used for the world. (Babin & Nicholson, 2012)

2.2 How Organizations implement Green ICT practices

A survey has been conducted by Carol-Ann Kogelman (2011) on behalf of the CEPIS Green ICT Task Force to find how ICT Managers in different countries implement energy efficient methods in organizations in Europe. During the survey, ICT managers were asked to determine the level of awareness of other employees within their organizations (Kogelman, 2016).

The factors affecting environmental performance through IT based processes and the areas where Green IT can be initiated in an organization with simple practices are important to be identified. This study has conducted with the help of literatures. The four paths can achieve total environmental sustainability from aspect of IT and make IT greener throughout its life cycle.

The four paths are,

- Green use
- Green disposal
- Green design
- Green manufacturing

Green use: This encourages reducing the energy consumption of IT equipments and related systems to use them in an environmental friendly manner

Green disposal: Encouraging reusing IT equipment to minimize the disposal and to dispose if unusable in a proper manner. But reusing the old IT equipment such as Servers, computers, networking equipment etc. will increase the consumption of the energy as old equipment use more energy compared to new equipment and their performance status is also low . Therefore, we should carefully select the equipment to re use in green disposal.

Green design: Encouraging designing energy efficient IT equipment. This is basically a good initiation to the IT equipment manufacturers. When designing IT systems in organizations, we should consider this path to design energy efficient IT system in the company and support to Green environment.

Green manufacturing: Manufacturing IT equipment in a green manner. This is related to the post operation of Green design.

In addition to those four, it is important to identify the ways that IT professionals should operate their Data centers in environmental friendly manner to reduce energy consumption. Some of them are, to eliminate energy leaks and use efficient cooling methods. Go for virtual servers instead of high density servers etc.
For end users, purchasing equipment only with certifications for environmental friendly standards such as ISO 14001, RoHS, etc. and practicing proper energy saving procedures and recycling methods also has discussed.
The Envirability RMIT Green ICT framework is taking an important view of Green ICT and sustainability across enterprises and then moves into the best practices of the individual technologies. Finally, the Green ICT Capability Maturity model is to measure the organization's level of capability implementing Green ICT (Fernando, Udawatta & Nanayakkara, 2011).

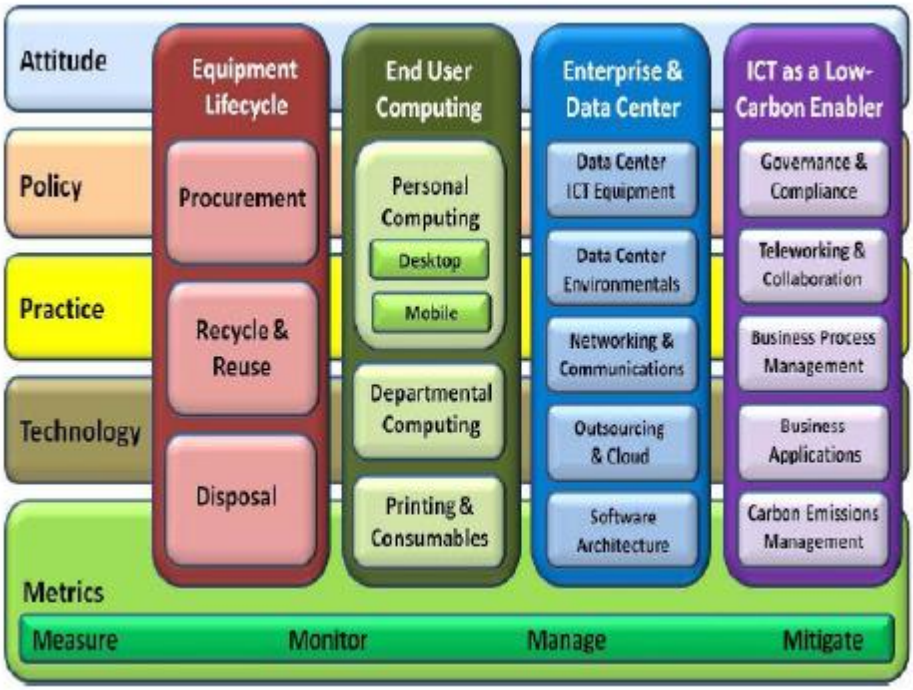

Figure 2.1: RMIT Green ICT framework

2.3 Barriers for implementing Green ICT

Kavita Suryawanshia & Sameer Narkhedeb have done a study on evolution of Green ICT and discussed the barriers in implementation of Green ICT at Higher Education institutions in India. The study found and summarized 10 barriers and the most important barrier out of the ten has been discovered for implementing Green ICT in Higher Education sector in India.

The Ten barriers are,

1. Lack of adequate funding and support from top management
2. Lack of participation from necessary Students/Staffs/Faculties
3. Environmentally unconcerned institutional culture
4. Lack of awareness of Green ICT
5. Lack of education or training from institutes
6. ICT's environmental impacts are not considered as significant

7. Lack of motivation among faculty/staff/student of institutes
8. Lack of Government strict regulation
9. Lack of good procurement practice at education institutes
10. Inadequate Research and Development activities

As per the results and analysis of the study, the most important barrier among those is lack of motivation and rationality for adopting green policies among implementers (Suryawanshia & Narkhedeb, 2015).

The Five most neglected issues in "Green IT" have been discussed by Lorenz M. Hilty and Wolfgang Lohmann for the Green ICT which has been published in Trends and Challenges in CEPIS UPGRADE which is the European Journal for the Informatics Professional in year 2011.

The Five issues are,

1. A lack in the transparency of energy costs in ICT services
2. The material demand of ICT hardware production
3. Insufficient understanding of the ICT life cycle
4. Rebound effects and the role of software
5. ICT as a critical infrastructure

Further, two authors have mentioned " A lack in the Transparency of Energy costs in ICT services" as a leading issue in those five issues. For an example, e-mail spam utilize huge energy and it caused energy consumption of 33 TWh worldwide in 2008 (Hilty & Lohmann, 2011). The ICF international has done a study on the global environmental impact of spam email. The study determined that spam accounts for 80 percent of all emails and discouraging the saving of organizations time and money and resulting greenhouse gas emissions (McAfee, 2008).

2.4 How Organizations have tried to overcome barriers

In UK, 10% of the electricity consumption is accounted to ICT equipment and has been forecasted to be 40% by 2020. In USA, 1.5% of the electricity demand is from the datacenters located in the country and it has been estimated to be doubled by 2011, by which time it will cost millions of dollars and affect to the carbon footprint as well.

However, there are several ways of cutting down electricity consumption to obtain immediate results.

- 30% of the overall energy consumed by PCs is wasted by leaving these switched on when these are not in use.
- 1,000 PCs running for 24/7 cost around £70,000 for electricity over a year.
- A third of employees in the UK forget to switch off their PCs when they leave the office at the end of the day, wasting UK £123 million a year for electricity.
- If all UK businesses shut down their computers when these are not in use, it would contribute 10% of the Government's Climate Change Levy target and 40% of the energy efficiency targets set by the Carbon Trust.

The ICT departments need plan their hardware properly and effectively. The inefficient use of ICT hardware increases the electricity consumption and waste money as well. In UK, there are also significant inefficiencies in terms of servers and data retention:

- 60% of ICT departments are using less than half of their available server storage space
- Only 1/5 have a good working policy on data retention

The smart use of ICT could contribute to a reduction in carbon emissions in other sectors which is five times greater than that of ICT sector. Some of those contributions can be used directly to reduce electricity usage.

"Dematerialization" – swapping of high carbon activities with low carbon alternatives such as e-billing instead of paper billing, teleconferencing instead of travelling to meetings and e-media instead of producing CDs or newspapers.
"Smart motors" – introducing ICT to the manufacturing sector to vary the amount of energy used by production lines, rather than motors either being on or off.

"Smart logistics" – ICT can facilitate better communication and planning, whether this is for haulage networks or customer delivery rounds. For example, many return journeys of vehicles carry no product and 80% of fleets have less than 5 vehicles. Therefore, better coordination, communication and cooperation are crucial to cutting down carbon emission.

"Smart buildings" – The way we maintain our buildings could be made far more efficient. ICT has a role to play in changing occupancy based lighting and cooling solutions to automatic systems to capture sunlight or to provide shade from unwanted warmth.

"Smart grids" – This refers to the power generation accounted to carbon footprint. Demand management and smart meters will help those supplying energy run more efficient systems, whilst interactive real-time energy displays prompt users to consider their energy consumption.

The awareness of the impact on carbon footprint by ICT activities should increase on ICT professionals. A majority of the ICT departments are not directly responsible for the cost of energy and therefore they are short of knowledge on organization's energy bills and the cost. The theoretical measurement can be used to estimate the actual energy consumption of ICT equipment. An inventory of ICT equipment should be carried out before starting the measurements (Barratt, Millar, & Bristow, 2016).

UK universities and colleges spend £147 million a year for ICT-related energy costs and making financial savings is essential which can contribute to environmental benefits as well. According to the UK Climate Change Act 2008, Education sectors are required to reduce their carbon footprint by 34% by 2020 and 80% by 2050. So the targets have been defined to achieve significant amounts of percentage and to save millions of money and long life environment. There is a scope for both cost savings and environmental improvements. For reducing energy costs the first step is determine the total expenditure on ICT and then to evaluate the cost in specific areas. This is the step that many universities or organizations and colleges find it difficult as ICT and ICT-related energy costs are not always transparent or accessible. Reduction of cost of energy is initiated by means of raising awareness in users of how much they are consuming by accurately reporting the energy costs of specific equipment and facilities. Accurate information on energy usage allows people to change their behavior and decision makers to make appropriate investment decisions (Trivedi & Deshmukh, 2013).

As the amount spent on datacenter power increases, the companies in every industry are paying much closer attention to their power bills. The positive trend is that computer companies concern on greenness. Even consumers are now well aware of green technologies and are starting to demand more environmentally friendly products in their homes and workplaces. This trend also encompasses the vehicle market. For e.g. the demand for Hybrid cars and production trend towards this demand has increased significantly.

Technology Business Research (TBR) announced that Dell took the No. 1 position in its inaugural Corporate Sustainability Index (CSI) Benchmark Report for 2009. The report measures the environmental initiatives of 40 companies in the computer hardware, software, professional services and network and telecommunications sectors. Scoring 317.9 points, Dell led the second place firm by more than 52 points in the overall index ranking. IBM recently launched a consulting service based on the Lean Six Sigma principles of efficiency. This consulting service aims at examining use of energy and water and subsequently providing the control measures to conserve

energy. According to the company sources, IBM in 1990 saved around 4.6 billion kWh of electricity and prevented almost 3 million metric tons of CO2 emissions. Therefore, essentially a reduction in wastage and recycling of the used materials is required to ensure green IT.

According to VMware Inc., they announced the opening of a new green IT datacenter in East Wenatchee, Washington. Throughout its design and build-out, VMware chose industry best practices to create an energy-efficient facility to achieve $5 million in savings per year from the facility. So green computing is a mindset that satisfies the growing demand for network computing with minimum damage to the environment. Green computing is not only about going out and designing biodegradable packaging for products. Therefore, the time has come to think about the efficient use of computers and the resources which are non renewable.

The datacenter energy consumption is difficult to measure accurately but can be done if energy supply is coming in through a single input. Power Usage Effectiveness (PUE) is used to assess datacenter efficiency. The PUE has become the industry-preferred metric for measuring infrastructure energy efficiency of datacenters.
The definition of PUE is,

$$PUE = \frac{\text{Total Facility Energy}}{\text{IT Equipment Energy}}$$

Total facility energy is defined as the energy dedicated solely to the data center (e.g., the energy measured at the utility meter of a dedicated data center facility or at the meter for a data center or data room in a mixed-use facility). The IT equipment energy is defined as the energy consumed by equipment that is used to manage, process, store, or route data within the compute space as shown in Figure 2.2.

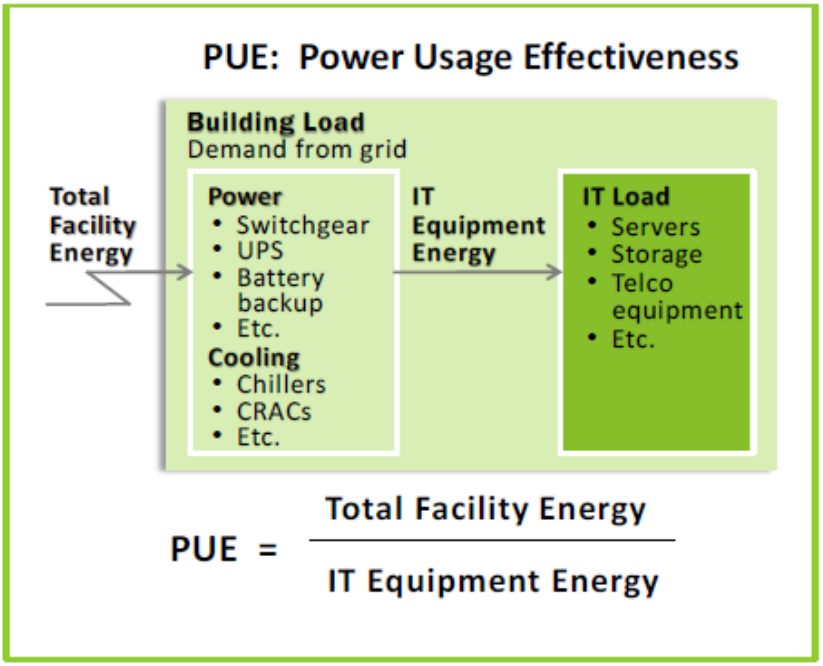

Figure 2.2: Illustration of how PUE would be calculated in a data center

A three level of approach for measuring PUE is included such as Basic, Intermediate and Advanced as indicated in below Table2.1 (Avelar, Azevedo, & French, 2016).

Table 2.1: Three level approach to PUE measurement

	Level 1 (L1) Basic	Level 2 (L2) Intermediate	Level 3 (L3) Advanced
IT Equipment Energy	UPS Outputs	PDU Outputs	IT Equipment Input
Total Facility Energy	Utility Inputs	Utility Inputs	Utility Inputs
Measurement Interval	Monthly/Weekly	Daily/Hourly	Continuous (15 minutes or less)

The Australian Environmental Labeling Association (AELA) has established a 'National Green Purchasing Network'. This network shares information and

knowledge on a wide range of products and services, including ICT. To support this environmentally friendly procurement initiative, an online database was launched by AELA in April 2005. This database provides information on the environmental performance of a wide range of consumer products, including ICT products. The New South Wales Government has established a new website to provide information about sustainable purchasing and environmentally friendly products, including ICT products. The SIMS Group Ltd and Collex Pty Ltd launched a new computer and electronics fee-for service recycling initiative on 6 March 2005 – Clean Up Australia Day. This recycling project will allow recovery of metals, circuit boards, plastics and cathode ray tube glass. Components will be processed individually, with computer tracking of brand equipment to enable recycling of components. To support improved recycling of electrical products, the Australian Electrical and Electronic Manufacturers' Association (AEEMA), Intelligent Manufacturing Systems (IMS) Australia, the Industrial Research Institute Swinburne and telecommunications waste specialist MRI Australia are collaborating in an international research and development program for recycling plastics.

The National ENERGY STAR™ Program is based on international standards for energy efficient office equipment such as computers, printers and photocopiers. It sets energy efficiency performance criteria that must be met in order for a product to qualify for the Energy Star Label. Australian Government departments and agencies are required to purchase only office equipment that complies with the US Environment Protection Agency Energy Star standard, where it is available and fit for purpose (DFAAUS, 2015).

2.5 Summary

This literature review details the findings of concepts, formulas and achievements of previous researches with regards to Green ICT. This section was organized in to four sub sections and begins with importance of Green ICT. Then the review was continued to discuss how organizations implemented Green ICT practices, barriers

for implementing Green ICT and how organizations have tried to overcome those barriers. Under importance of Green ICT, it was discussed the contribution of ICT to the global carbon emission and how it grows in future. By introducing Green IT solutions, how organizations are saving money by reducing power need for ICT equipment also were discussed. Green IT should be the part of the business process and it should come from the heart of the employees. In year 2010, the electricity used by the datacenters represents 1.3% of all electricity used for the world. Under how organizations implemented Green ICT practices, it has discussed the four paths that IT make greener. Those were Green use, Green disposal, Green design and Green manufacturing. Ten barriers for implementing Green ICT practices at Higher education institutions in India have been discussed. It has found that lack of motivation among faculty, staff and students of institutes is the leading barrier for implementing Green ICT practices. The most neglected issue in Green ICT is lack in the transparency of energy costs in ICT services. Hidden costs like energy for spam discouraging savings of organizations time and money. Finally, the ways that organizations have tried to overcome barriers were discussed. Increasing the awareness of impact on carbon footprint by ICT activities, increasing the awareness of energy cost for ICT are some of methods to overcome barriers for implementing Green ICT practice in the organizations.

3. METHODOLOGY

This research is to identify, what Green ICT practices are significantly contributing to reduce electricity utilization, to determine barriers for implementing those practices and techniques to overcome barriers, in apparel industry operating in export processing sector in Sri Lanka. Information on importance of Green ICT, Implementation of Green ICT in organizations, Barriers and how to overcome those have been gathered by doing a detailed literature review. A preliminary study was carried out by sharing an unstructured questionnaire with responsible persons in three different organizations and a small interview was conducted.

Then a questionnaire was developed to collect the data. The data collection was done using the questionnaire while conducting interview sessions over the phone. The research process flow was carried out as shown in Figure 3.1.

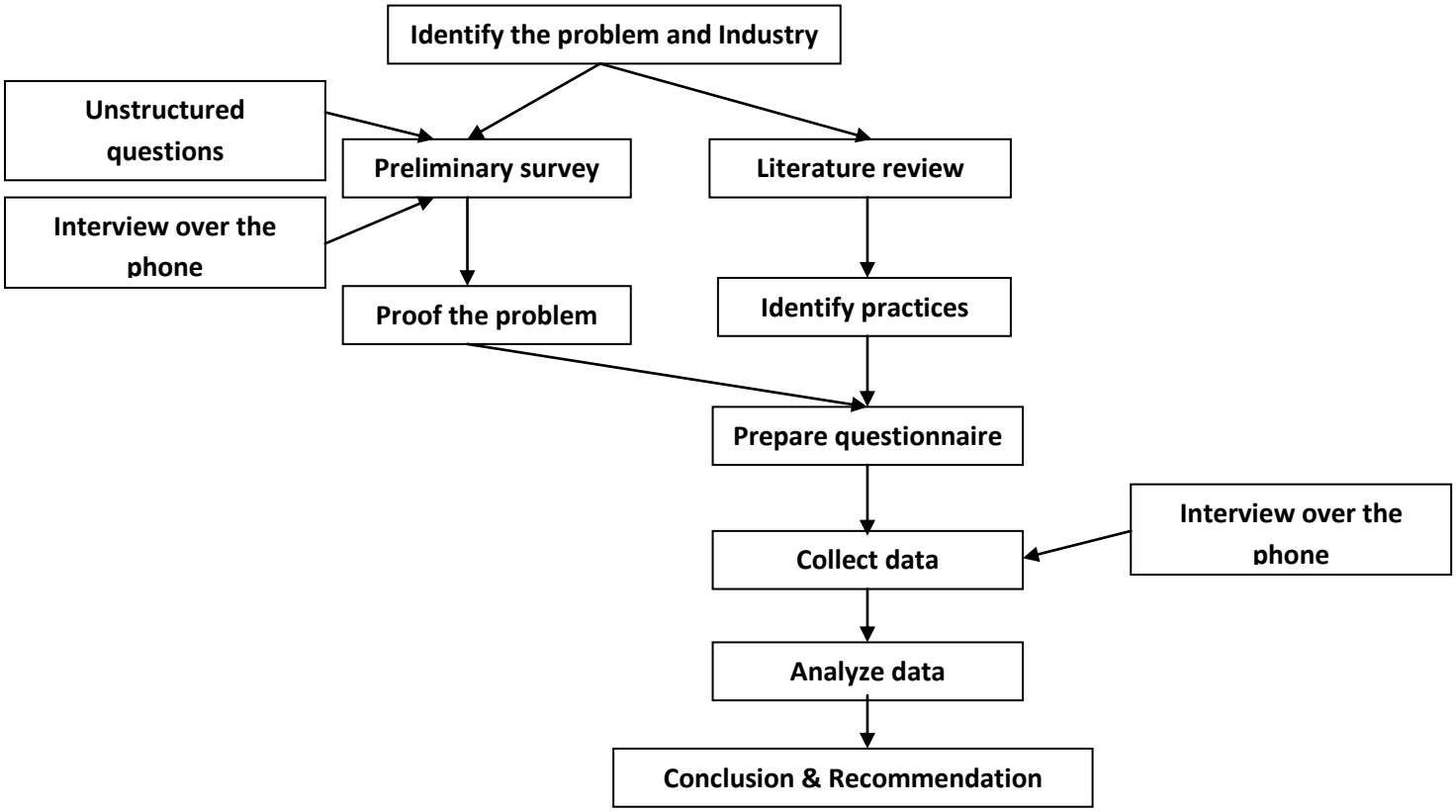

Figure 3.1: Research methodology

3.1 Preliminary study

The preliminary study was carried out for one apparel organization with two non apparel organizations. The reason for selecting non apparel organizations is to see the difference of electricity utilization and compare with the apparel organization. Three organizations were selected to collect data through personal contacts of those organizations.

- A Fabric manufacturing mills
- A Financial institute
- An Education institution

A small interview was conducted while collecting the data to determine level of the awareness of Green ICT practices for reducing electricity consumption on IT personals in those organizations. As per their responses, it was realized that they haven't thought about Green ICT practices for reducing electricity consumption in the organization since their unawareness of how significant the power utilization for ICT. Following table shows the data collected while preliminary survey was conducting. Apart from reducing electricity consumption, they have implemented some other practices related to Green ICT. E.g. reduce printing, ICT equipment disposals, Servers virtualization etc.

Table 3.1: Monthly energy utilization for ICT

Organization	**Energy utilization for ICT (Monthly)**
Apparel	43.48 MWh
Finance	1.56 MWh
Academic	10 MWh

3.2 Research Method

A detailed literature survey was done as a part of this research. To find answers to the research questions and to achieve the objectives, interview and questionnaire were used. Due to the small size of the sample, this study was carried out as a case study.

3.3 Data collection

A questionnaire and interviews were used as the main data collecting method to collect necessary data. The questionnaire was developed to answer main research questions in the study. It was circulated among executive grade IT professionals in apparel industry operating in export processing sector in Sri Lanka using personal e-mail contacts. Thereafter, few interviews were carried out over the phone to provide clarifications of the questionnaire and to make them aware of the concept of Green ICT.

3.4 Data Sample

This survey was carried out among Assistant IT Managers, IT Managers, Head of ITs, General Managers, CIOs and Director IT in apparel manufacturing industries which are operating export processing sector in Sri Lanka. Organizations were selected to cover at least one SBU of leading apparel manufacturers in Sri Lanka. Therefore the population for this research is limited. There are small, medium and large sizes of organizations. Initially the questionnaire was shared using 14 personal contacts in apparel industry. Thereafter, the questionnaire was shared with a CIO of an apparel group of company in Sri Lanka to get more responses. His responses represent entire group IT Managers responses.

3.5 Data Analysis

The collected data from the interviews and questionnaire was analyzed to find answers to the research questions. The SPSS 18 was used to analyze the validity of

the responses and to check the correlations between variables. Microsoft Excel 2007 was used to analyze the data. Pie charts and bar charts were used to present the outcomes as discussed in section 4 below.

4. ANALYSIS OF THE DATA

This chapter is presenting the analysis of the data gathered during interviews and from survey questionnaire. The sample includes only apparel manufacturing organizations operating in export processing sector in Sri Lanka. All respondents were Director-IT, CIOs, Heads of IT, IT Managers and Assistant IT Managers in apparel industry. Junior IT staff or non IT staff members were not allowed to respond to this survey since circulation done through known e-mail contacts.

Number of office staff

Number of computers are used in organizations were obtained as an important data in this study. It is indicated that the numbers of office staff in those organizations are approximately equal to the number of desktop and laptop computers are used. Figure 4.1 shows the number of desktop and laptop usage in each responded organizations.

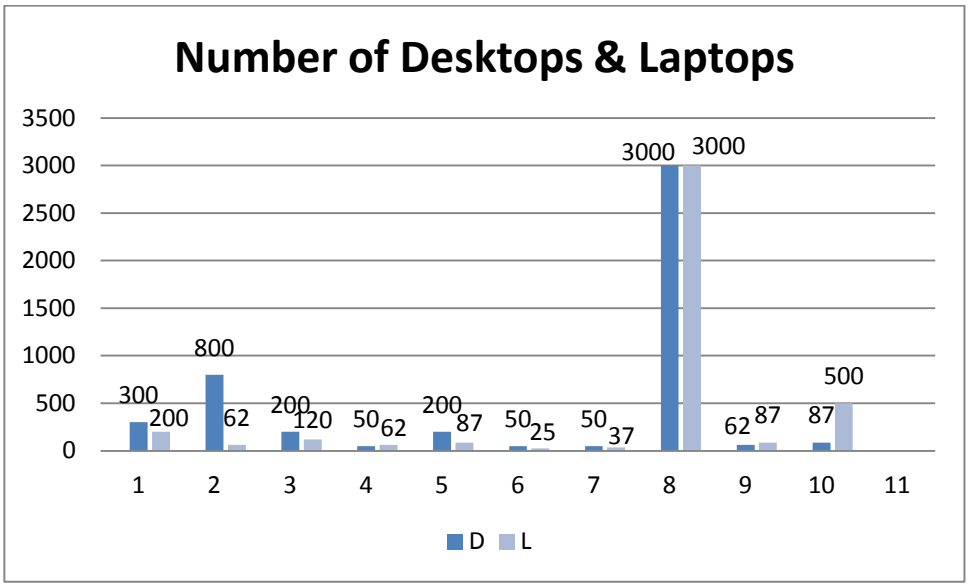

Figure 4.1: Number of Desktop & Laptop usage

The Data collection was done through online questionnaire and interviews were conducted over the phone. Only five out of the fifteen organizations have not responded to the questionnaire and to the interview.

4.1 Validity and reliability test

To measure reliability and specifically internal consistency reliability or item interrelatedness, of a scale or test, Cronbach's alpha also known as coefficient alpha can be used. Cronbach's alpha typically ranges from 0 to 1. Values closer to 1.0 indicate a greater internal consistency of the variables in the scale. Cronbach's alpha cutoff values and their level of acceptance are, >= .9 – Excellent, >= .8 – Good, >= .7 – Acceptable, >= .6 – Questionable, >= .5 – Poor, <= .5 – Unacceptable (Huward, 2015)

4.2 Responsibility level of the responded IT professionals

It was a compulsory question to answer "the responsibility level for the IT operation in the organization" of the responder. When the level of the responsibility of the responded IT professionals was analyzed, 70% were responsible for whole IT operation of the organization as shown in Figure 4.2. All respondents are responsible for 90% or above of the IT operations in the organization.

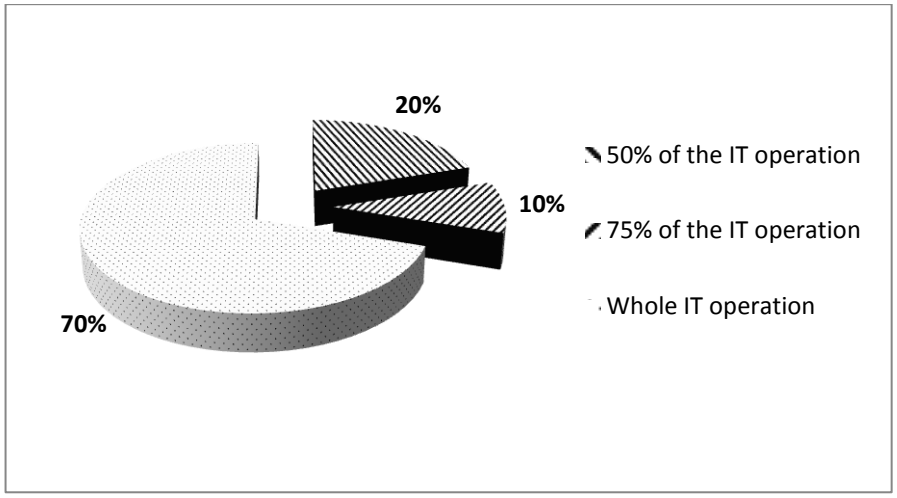

Figure 4.2: Level of IT responsibility in the organization

4.3 Other responsible designations for ICT

A question was asked to understand whether there are any other responsible ICT persons in the organization other than the responders of this study. As per Figure 4.3, there are few other responsible professionals in the organization. Especially, when a Director or GM – IT responded, another responsible person has been indicated.

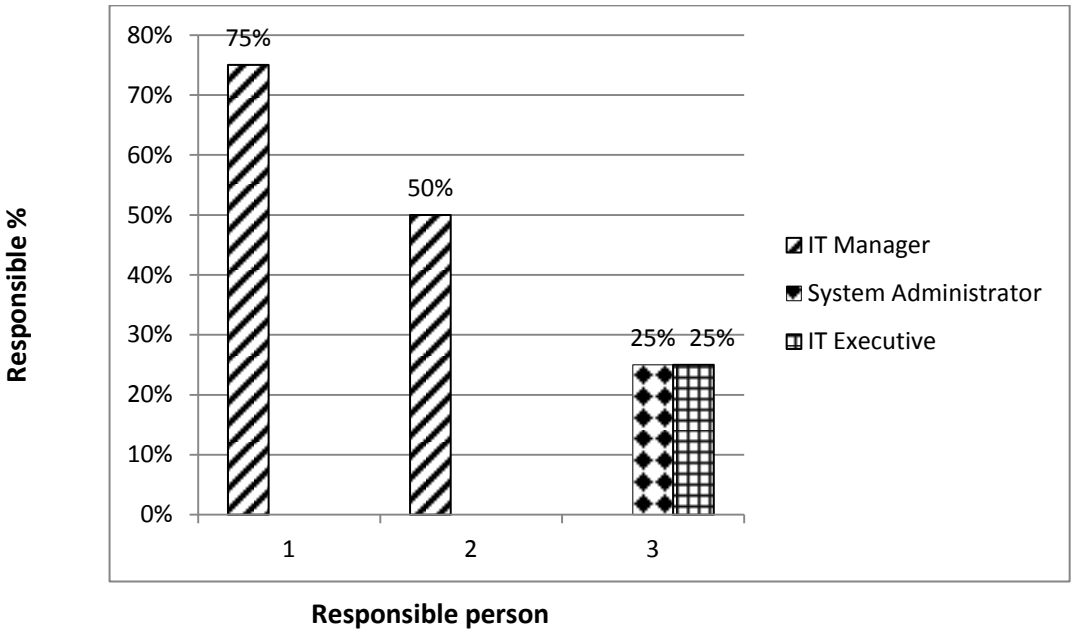

Figure 4.3: Other responsible ICT professionals

4.4 The organizations' operating hours per day

The number of hours operating per day of the organization was a key factor to analyze. Though manufacturing and back office operation operates for any number of hours per day, ICT operations is for 24 hours for almost all organizations in any industry. Three operating hour ranges have been selected by the responders as 8, 8-12 hours and 24 hours as shown in Figure 4.4. The majority of the organizations (50%) are operating from 8-12 hours while other 40% operates for 24 hours and 10% for 8 hours. Due to the demand in future for apparel products, we can assume that all factories will go for 24 hour operations in future.

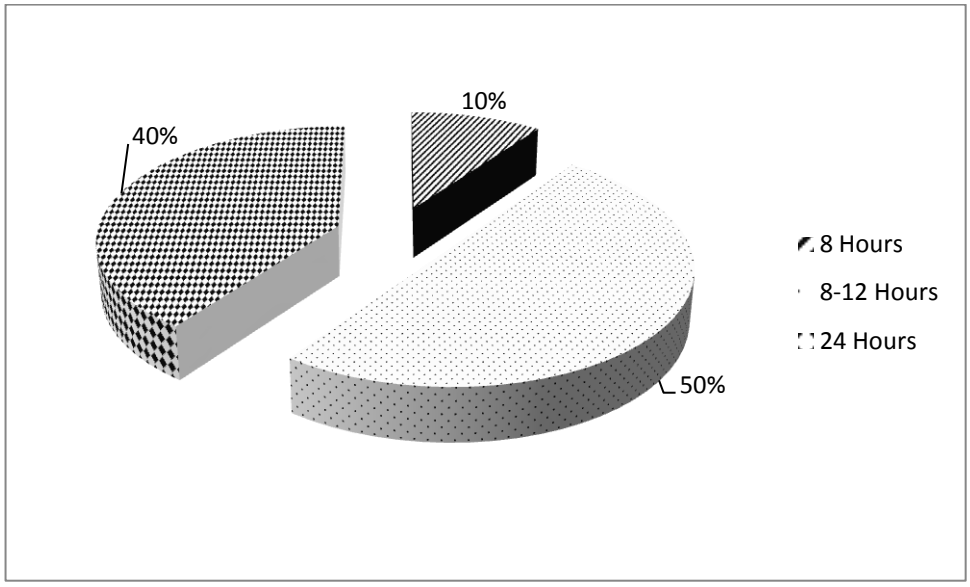

Figure 4.4: Organizations' operating hours per day

4.5 The companies which have Datacenters in the premises

An important factor to determine in this study is, where the location of the datacenter or server room of the organization. This question was asked to understand whether the datacenter or the server room is in the premises or not. As shown in Figure 4.5,

80% of responded companies are still operating their datacenters or the server rooms within the premises while others have hosted their servers on cloud or service providers' datacenters. This implies that some organizations are still not considered to avoid the datacenter's power utility by outsourcing. But 20% of the respondents have mentioned that their datacenters are not in the premises. For those companies they have mentioned that they have been hosted in service providers' datacenters as shown in Figure 4.6.

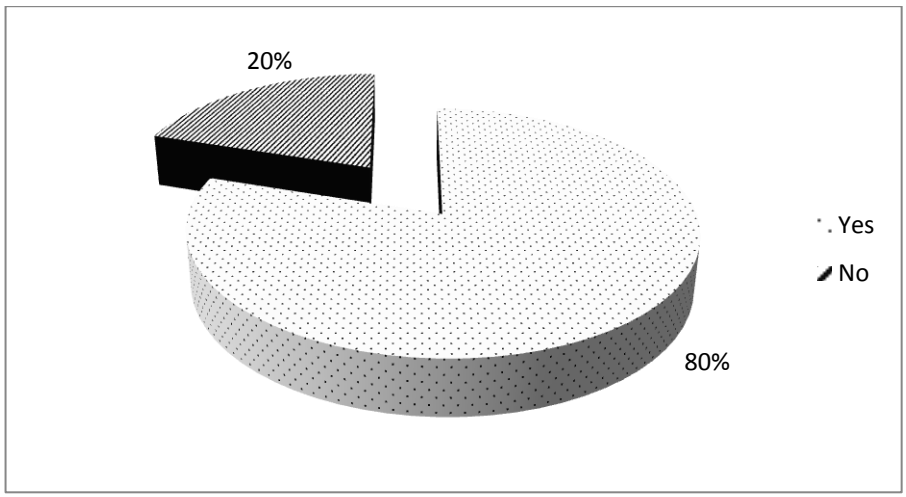

Figure 4.5: Datacenters in the premises

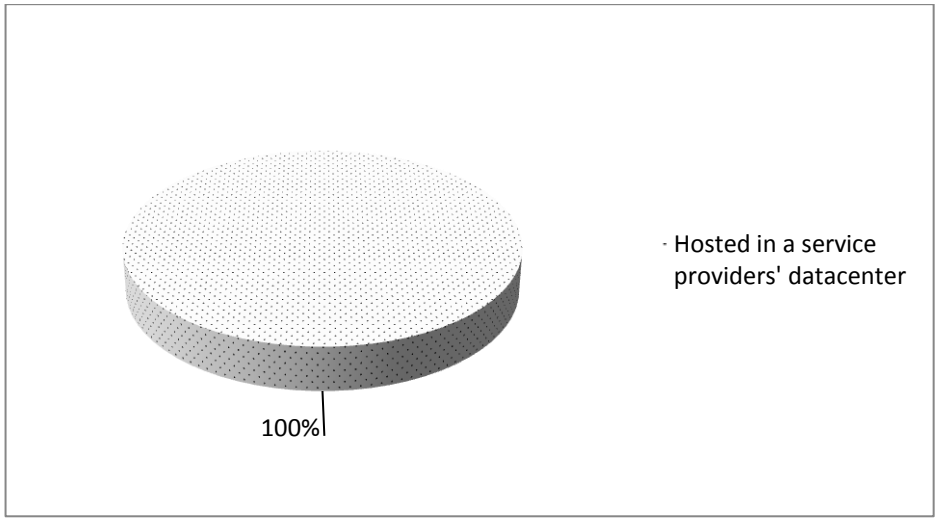

Figure 4.6: The location of the datacenters if not in the premises

4.6 Number of Servers in the Datacenter and separate power supply for DC

No. of servers in their datacenters were obtained from the companies those who have their datacenters or server rooms in their premises. The proportion of the companies with the number of servers less than 5 is equal to that with 5-10 (Figure 4.7). 50% of the companies have no separate power supply for their datacenters. Therefore, calculating the monthly cost of electricity for datacenters is quite difficult unless they measure the power utilization. But the rest of the 50% has separate power supply for their datacenters or server rooms (Figure 4.8) which makes it easier for monitoring, analyzing and saving. For some organizations, though they do not have separate power supplies, datacenter power utilization has been measured.

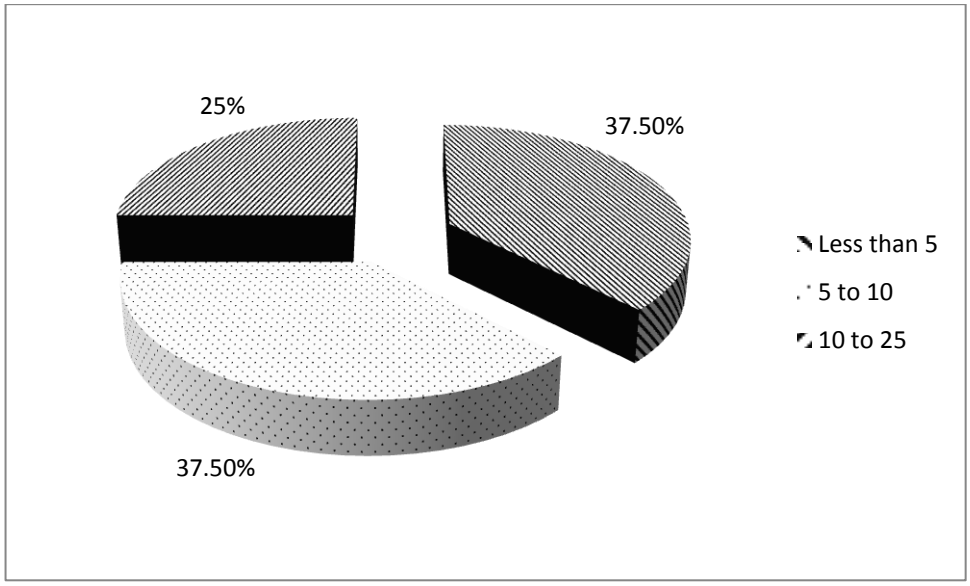

Figure 4.7: Number of servers in DC

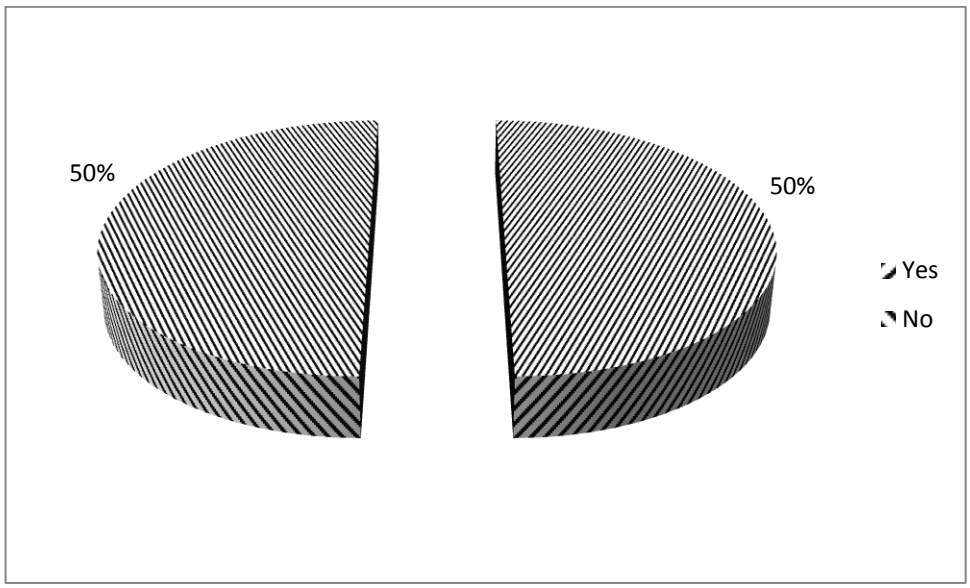

Figure 4.8: Separate power supply for DC

4.7 Monthly average cost of electricity for Datacenters

The staff of the Datacenters which have separate electricity supply from service providers knows exactly what their monthly cost of electricity for the datacenters is. According to Figure 4.8, 50% have mentioned that they have a separate power

supply while the other 50% says "No". The monthly average cost of electricity for datacenters which have separate power supplies is varying from Rs. 50,000 – to Rs. 500,000 as shown in Figure 4.9. This shows only the datacenter power cost except other IT equipment which are been used all around the organization. Especially, the cost of electricity for computers and laptops haven't been measured but calculation can be done to get approximate cost.

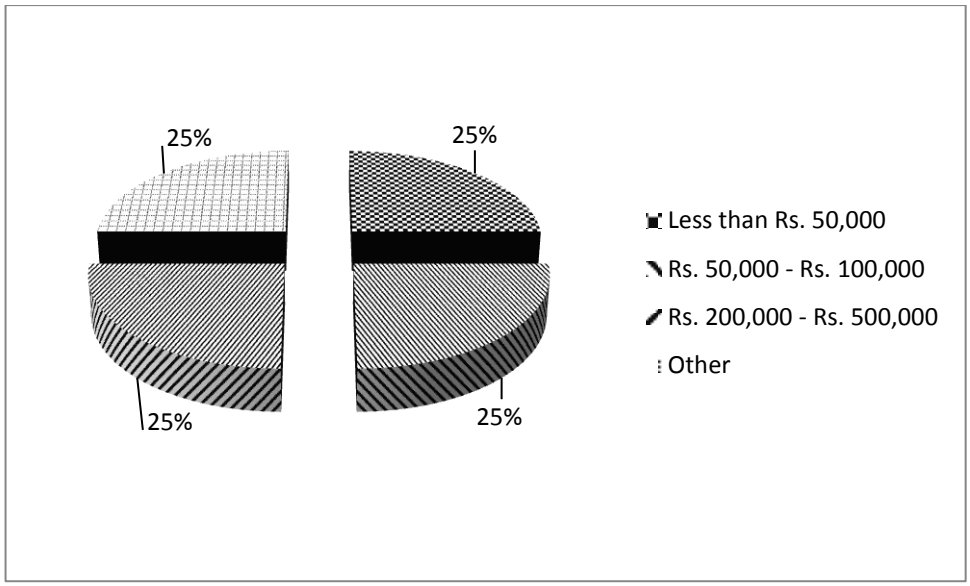

Figure 4.9: Monthly average cost of electricity for DC

4.8 Measuring Electricity utilization

Measuring electricity utilization for datacenter or server room is important to know the cost of energy if you don't get separate bills. If you are aware of the cost only, you will find ways to reduce it. From the companies which have no separate power supply to the datacenter or server room, 25% have mentioned that they measure electricity utilization in datacenters as shown in Figure 4.10. Other 75% have not measured their power utilization for DC or Server room.

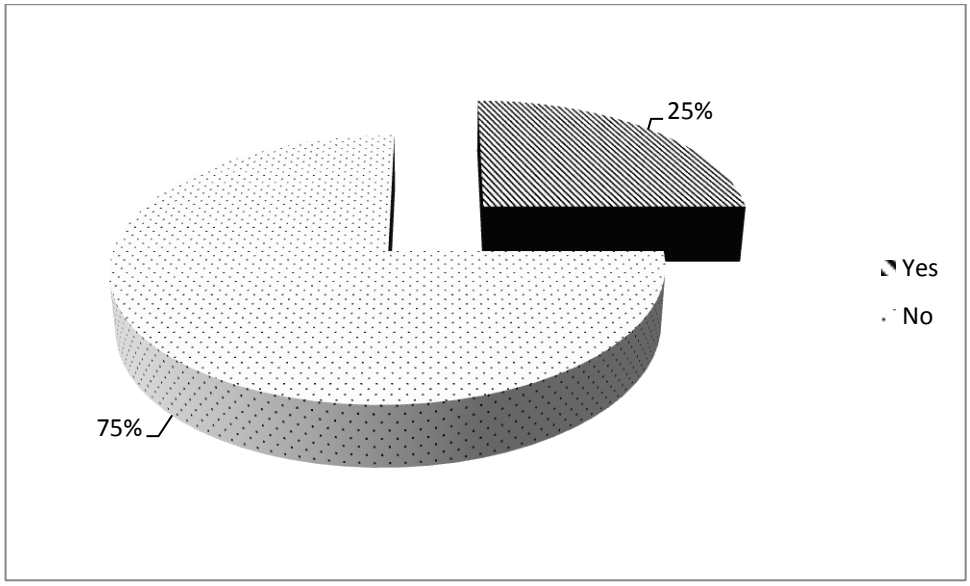

Figure 4.10: Measuring electricity utilization for DC

4.9 Desktop computers usage

As per the responses, all the companies are using desktop computers in their premises. Figure 4.11 shows the quantity of desktop computers and the percentage of companies for those quantity ranges. "Other" indicates the companies which use more than 300 computers with some companies over 3000 desktop computers.

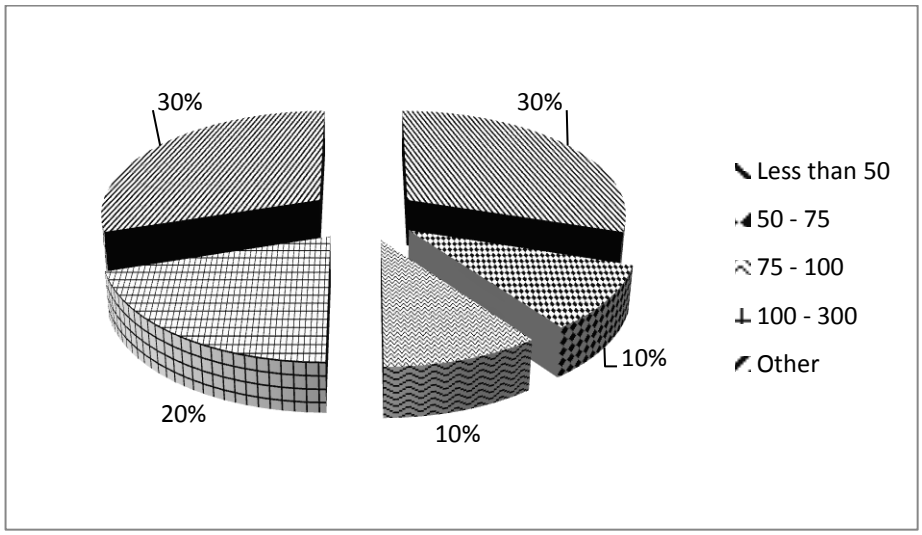

Figure 4.11 Usage of desktop computers

4.10 Energy star compliance concern for ICT equipment

Out of the above companies using desktop computers as discussed on section 4.8, 70% of the organizations have concerned on energy star compliance and certification for computers and other ICT equipment when purchasing. As shown in Figure 4.12, other 30% has no concern on energy star compliance on computers or other ICT equipment.

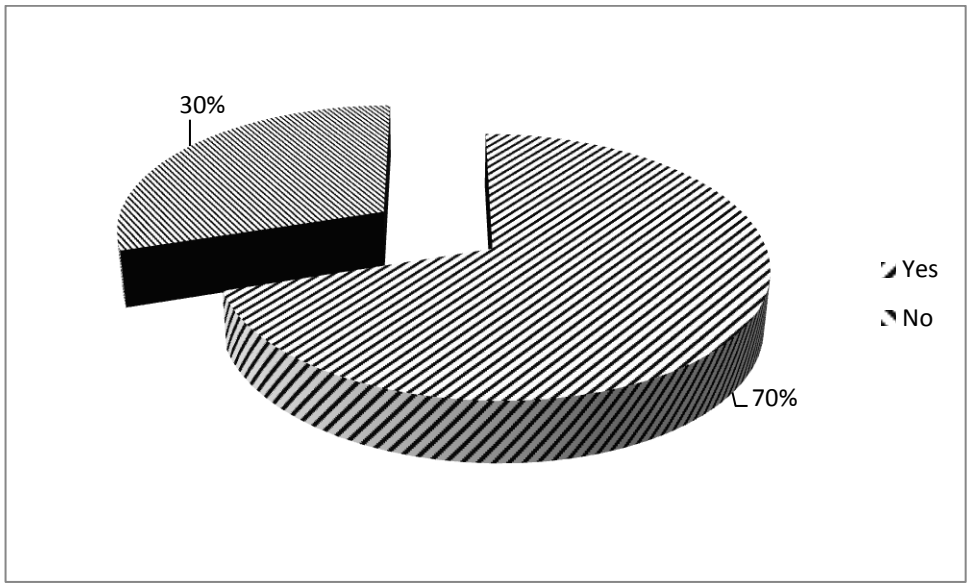

Figure 4.12: Concern on Energy star compliance

From the above companies using energy star desktop computers, 33.3% organizations use 100% energy star computers in their organization. Another 33.3% organizations are used 75% of energy star computers. Other 33.3% has 50% energy star for desktop computers. Figure 4.13 shows the percentage of energy star compliance computers in use in their companies.

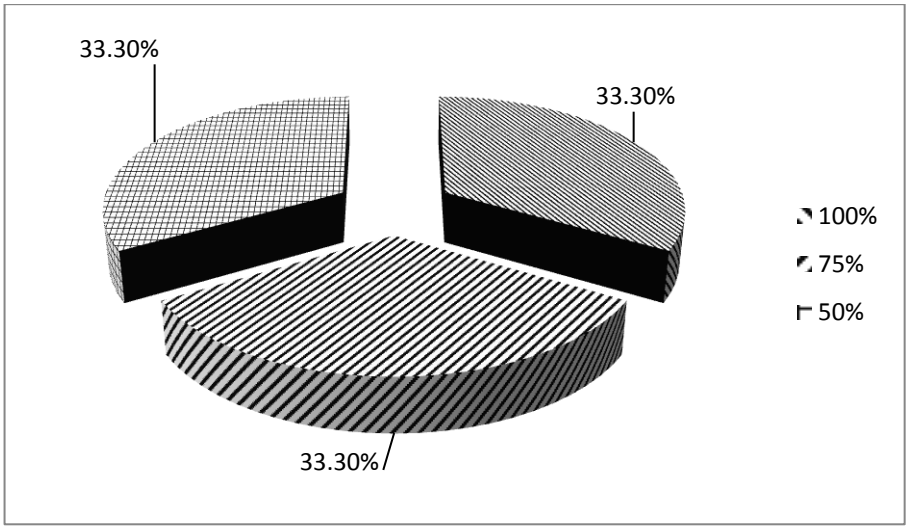

Figure 4.13: Energy star compliance computers

4.11 Computers operating for 24 hours

From the above desktop computers discussed on section 4.8, some are operating for 24 hours and some are for different period of times. 50% of the respondents have indicated that less than 25% of their computers are operating for 24hours of the day. As shown in Figure 4.14, another 30% of the respondents have mentioned that 25% - 50% of their computers are operating for 24 hours. Balance 20% has indicated as 50% to 100% of their computers are operating for 24 hours.

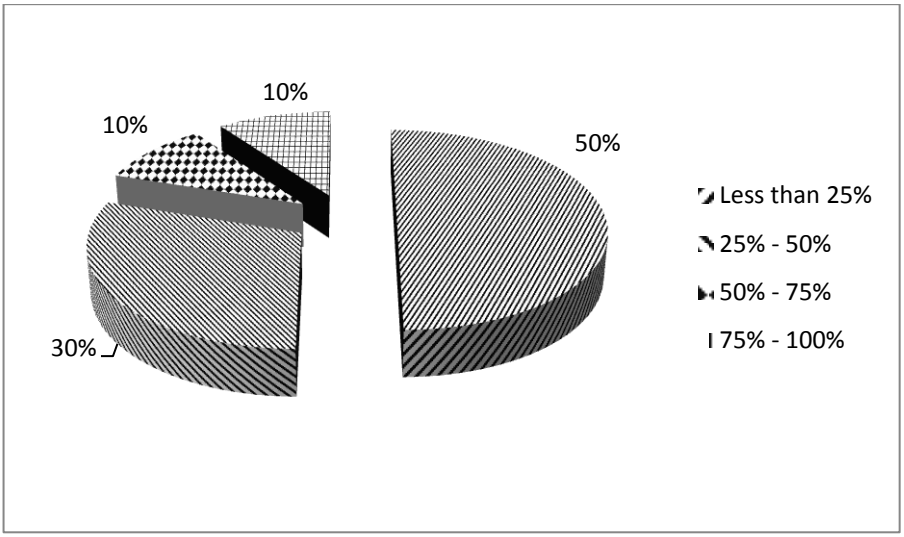

Figure 4.14: Computers operate for 24 hours

4.12 Laptop computers usage

All the companies are using laptop computers in their premises. Most of the companies are using more than 100 laptop computers and some companies over 3000. “Other” indicates the organizations that use more than 100 laptop computers in their premises. Figure 4.15 shows the laptop computer usage among the companies.

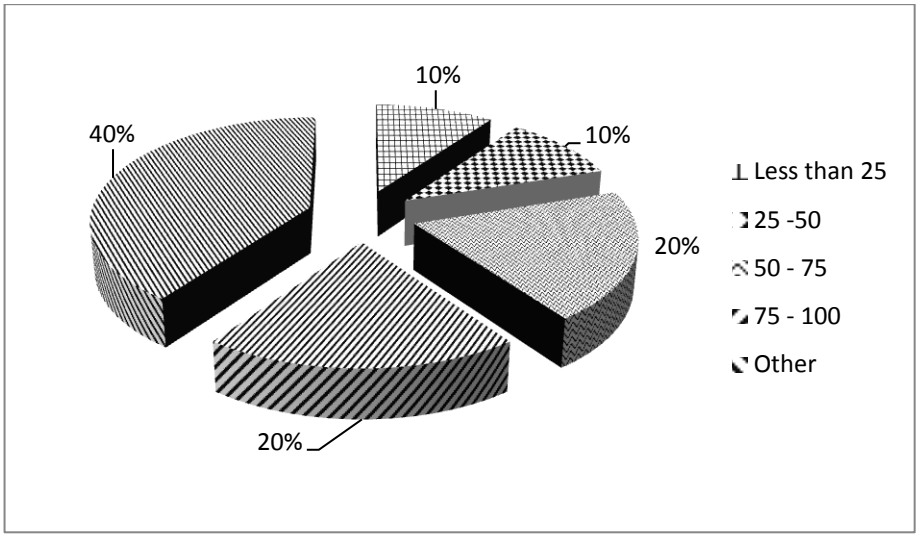

Figure 4.15: Laptop computers usage

80% of the companies are using 50 or above number of laptop computers in their premises. In terms of power utility, it is a saving compared to desktop computer usage. This research couldn't find any organization which uses only laptop computers instead of desktop computers in their premises to reduce electricity utilization and support to green ICT initiatives.

4.13 Green ICT practices implementation

50% of responded organizations have implemented Green ICT practices in their organizations while other 50% are yet to implement. From the organizations that have been implemented Green ICT practices, 100% have agreed that reduction of electricity consumption for ICT is an important practice for Green ICT. It is a strong motivation to this study.

4.14 The Practices that have been identified as significant for reducing electricity consumption for ICT

This question was covering an objective of this study. Therefore, the responses are very important for analysis and conclusion of the study. The respondents were allowed to select given practices mentioned below or indicate any other practices not given here.

1. Reduce datacenter power utility
2. Reduce computers' power utility
3. Reduce printers' power utility
4. Reduce network equipment power utility
5. Reduce all utilities
6. Other

They were allowed to select one or more practices from the above. As shown in Figure 4.16, 60% selections are for "Reduce datacenter power utility" as a significant practice for reducing electricity consumption for ICT in apparel industry. 40% selections are for "Reduce all utilities" while 20% for "Reduce printers' power utility". Therefore, the most significant practice for reducing electricity consumption for ICT in apparel industry has been identified as "Reduce datacenter power utility" by the organizations which have implemented Green ICT practices already.

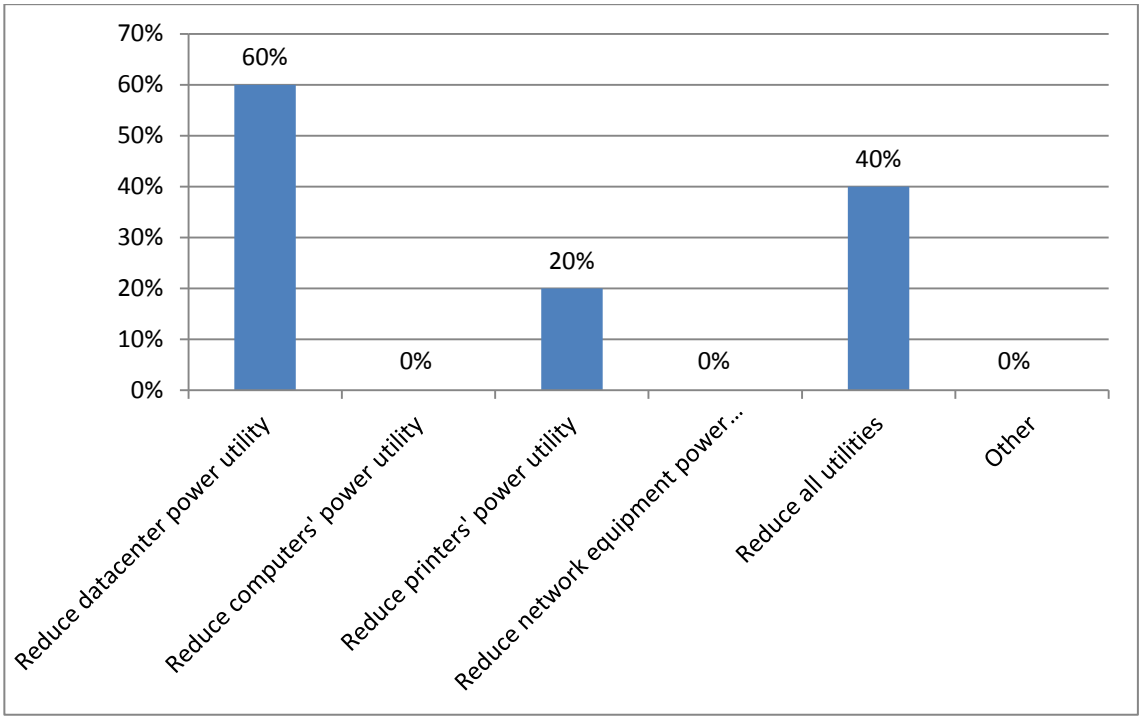

Figure 4.16: Significant practices for reducing electricity consumption for ICT

4.15 The Practices that have been implemented

This section discusses the practices that have been implemented from the practices that were discussed in section 4.13. Figure 4.17 shows practices that have been selected as implemented in their organizations as percentages. The "Reduce datacenter power utility" has been selected by 80% of the respondents as most widely implemented practice. The "Reduce computers'" power utility" has been selected by 60% which was not identified as significant in section 4.13, but still has been implemented. Since those organizations are concerned on energy star compliances and regulations, "Reduce computers'" power utility practice have been followed. 40% selections are for "Reduce printers' power utility" and 20% for "Reduce network equipment power utility". None of the responders have mentioned any other practices other than the given practices which have been implemented in their organizations which were interesting to know.

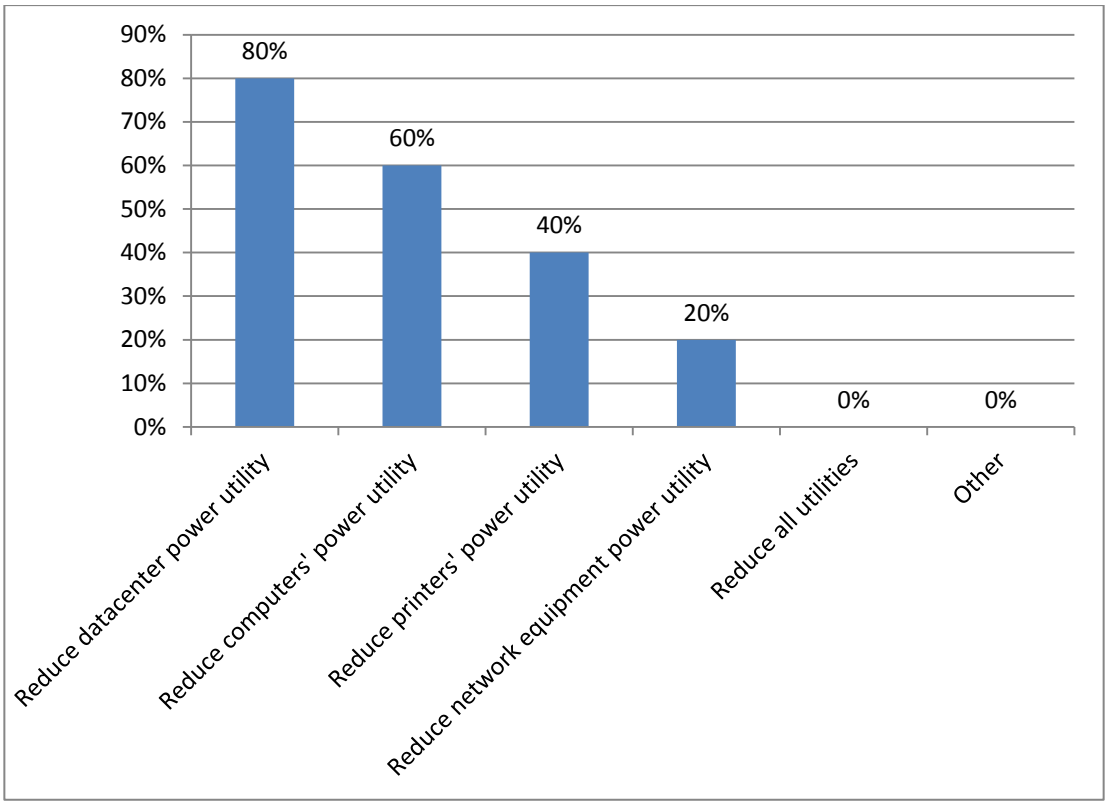

Figure 4.17: Practices which have been implemented

4.16 Barriers faced while implementing Green ICT practices

This is another question which covers an objective of this study. The six barriers which identified from the literature review were given as multiple selections to the respondents. Other than the given barriers, "Other" option was given to mention any other barriers which have been encountered while implementing the practices identified in section 4.13 and implemented in section 4.14.

1. Lack of awareness of Green ICT
2. Lack of support from top management
3. Lack of staff participation
4. Lack of training
5. Think of "No significant saving"
6. Lack of Rules & Regulations
7. Other

As shown in Figure 4.18, there are 80% selections for “Lack of awareness of Green ICT”. 40% selections are for “Lack of training” and “Think of “No significant saving”” each. There are 20% selections for “Lack of staff participation” and “Lack of rules & regulations” equally. Therefore, the leading barrier for implementing Green ICT is “Lack of awareness of Green ICT” and followed by “Lack of training” and “Think of “No significant saving””.

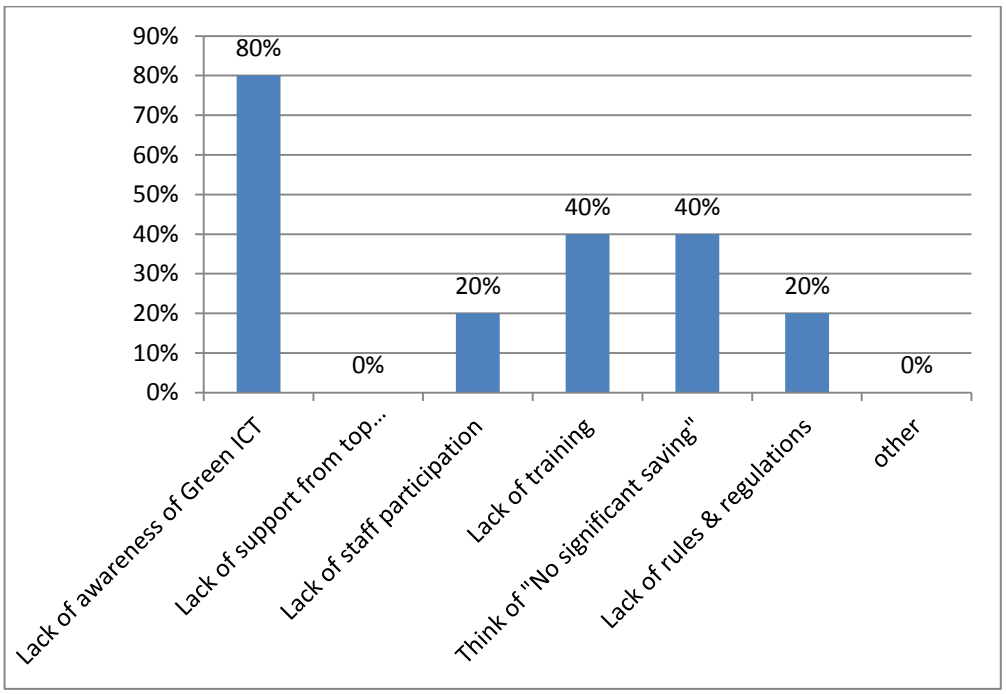

Figure 4.18: Barriers faced while implementing Green ICT practices

4.17 Techniques used to overcome barriers

This is covering the 3rd research objective of the study. This is to identify, how to overcome the barriers discussed in section 4.15 by the organizations which have implemented the Green ICT practices. The seven identified techniques were given to the responders as multiple selections. They were allowed to select one or more given techniques. The "Other" option was given to mention for any other technique which was used.

1. Awareness program conducted
2. A policy implemented
3. Train IT staff & users
4. A project implemented
5. Monitor power utility of datacenter
6. Use energy star equipment
7. Other

As shown in Figure 4.19, there are 80% (majority) selections for "Awareness program conducted". The second highest selection of 60% is for "Use energy star equipment" and all other given techniques are selected by 40% each. For this question also, no response has been received with "Other" option. Therefore, the leading technique for overcoming barriers is "Awareness program conducted" and followed by "Use energy star equipment".

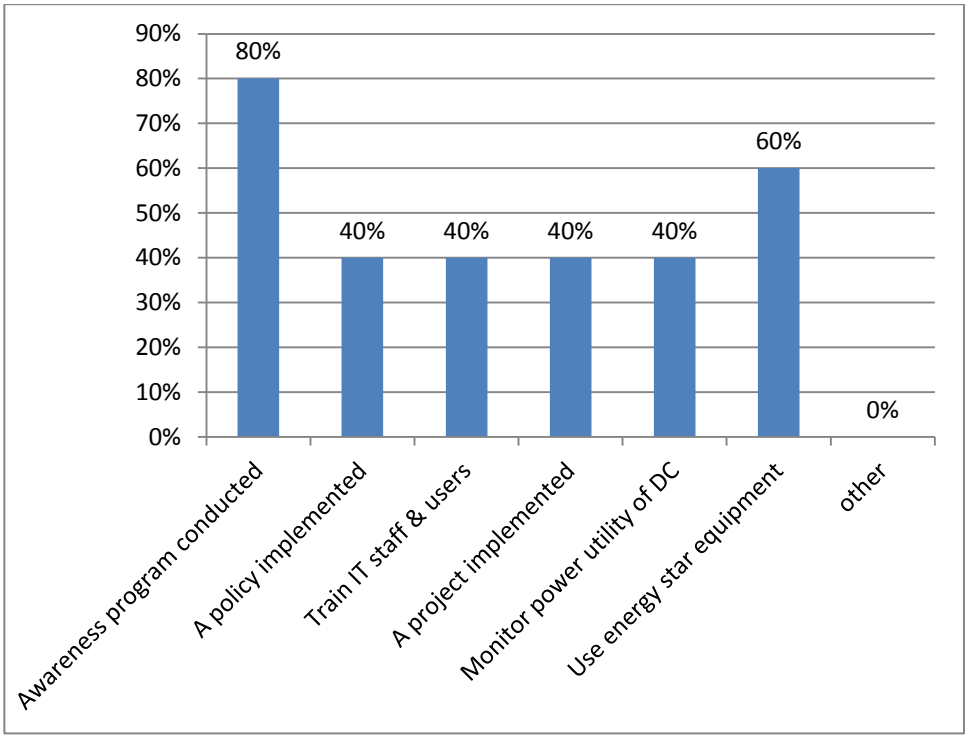

Figure 4.19: Techniques used to overcome barriers

4.18 Electricity saving by implementing Green ICT

The electricity saving is a cost saving to the organization. And it is appreciating the sustainability of the resources. As this study is conducting to achieve the cost effectiveness through green ICT, it is important to know how much of electricity saved by reducing electricity utilization. As shown in Figure 4.20, maximum monthly energy saving of 10MWh has been done by 20% of the organizations and the next higher saving of 5MWh by other 20%. Another 20% of respondents have saved 1MWh of energy monthly. The "Other" option has been selected by the organizations to mention that "Haven't calculated".

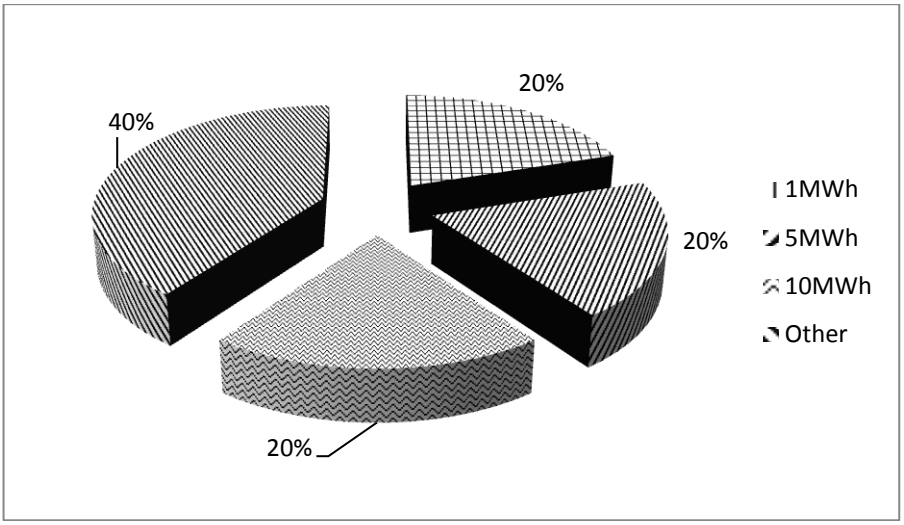

Figure 4.20: Monthly electricity saving

4.19 Other Green ICT practices which have been implemented

For further awareness of Green ICT implementation of the organizations which have implemented practices for reducing electricity utilization, one question was asked for other Green ICT practices. As shown in Figure 4.21, "Recycling ICT equipment" and "Reduce printing cost" each has obtained 80% selections and followed by "Reuse ICT equipment" with 60% selections. No "Other" practices have been mentioned. Reuse ICT equipment will increase power utilization hence unsupportive to Green ICT and to the objectives of this study as well.

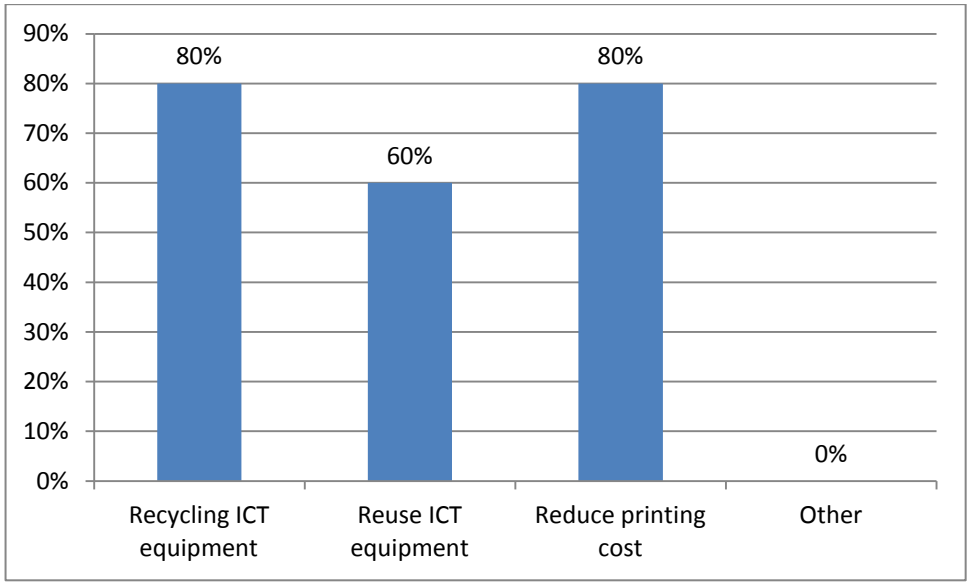

Figure 4.21: Other Green ICT practices implemented

4.20 Barriers identified by Green ICT unimplemented organizations

This is to understand the barriers for the organizations those who haven't implemented any of the Green ICT practices. Here, five multiple selection options were given to the respondents to select. The "Other" option was allowed to organizations which have faced barriers other than what is mentioned in the selection list. As shown in Figure 4.22, the highest selection percentage of 40% is for the barriers "Not aware about those practices" and "No enough resources for implementing Green ICT practices" each. The second highest of 20% is for "Management not interest" and "Other" each. The "Other" option has been selected by the organizations which has relocated their datacenters recently and some other reasons. There are 10% selections for "No significant saving" and "Implementing cost is higher than saving" equally. However, some of those organizations have tried to overcome barriers for implementing Green ICT practices. Among those organizations, 60% have tried to avoid those barriers while other 40% have not. Therefore, the leading barriers identified by the organizations which were failed to implement Green ICT practices are "Not aware about those practices" and "No enough resources for implementing Green ICT practices".

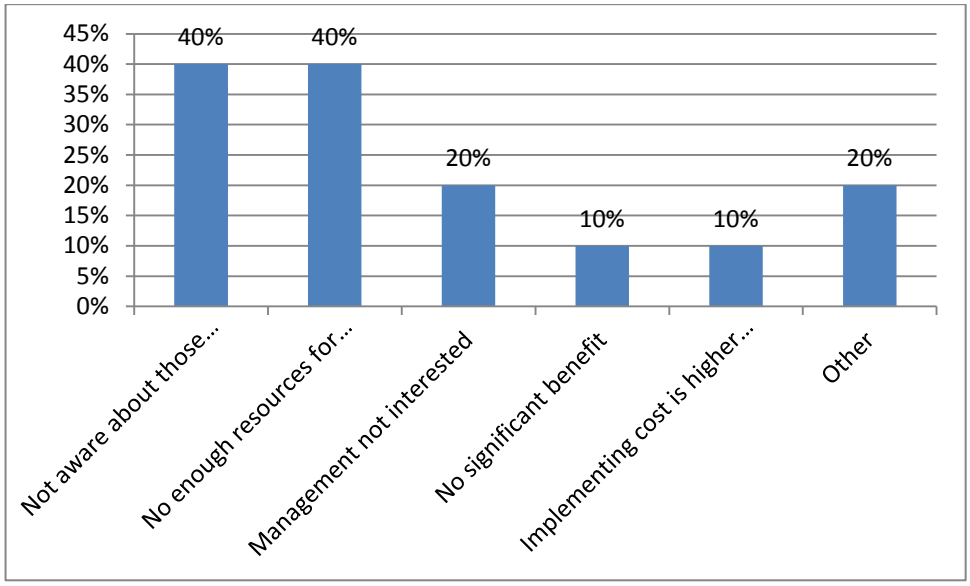

Figure 4.22: Barriers identified by Green ICT unimplemented organizations

4.21 Techniques identified by Green ICT unimplemented organizations

In this section, the techniques identified by the organizations which could not implement Green ICT practices are discussed. As shown in Figure 4.23, all the organizations have tried by doing “Cost benefit analysis” as the leading technique. There are 50% selections for “Awareness program” and 33.3% for “Third party involvement”. “Form a team” has been selected by 16.7%.

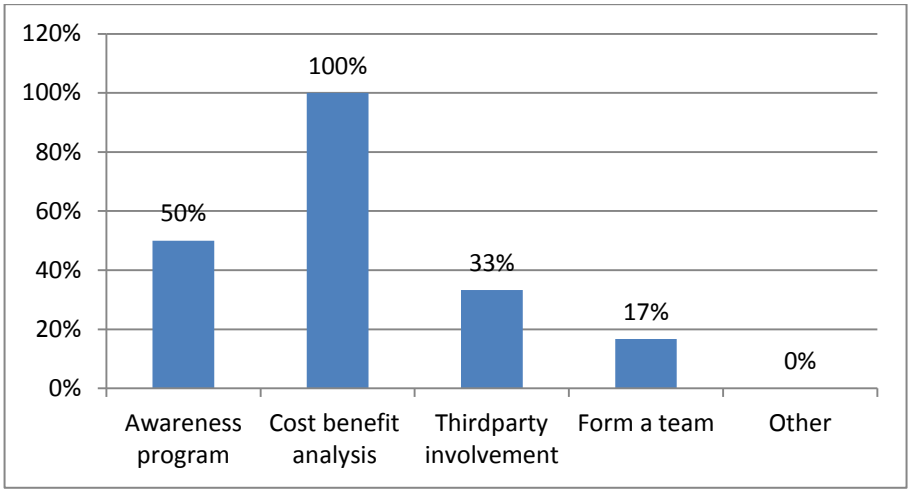

Figure 4.23: Techniques identified by Green ICT unimplemented organizations

4.22 Relationship test between Green ICT unimplemented organizations against the organization size

The organization size was obtained using the number of desktop and laptop computers usage of the organizations. As per the Pearson correlation coefficient test, there is a small negative correlation between Green ICT implementation and organization size.

5. CONCLUSION AND RECOMMENDATIONS

This chapter uses the findings of the research and come up with recommendations. As mentioned in the introduction, the purpose of this research was to identify the practices followed by apparel manufacturing industry operating in export processing sector in Sri Lanka to reduce electricity utilization of ICT and awareness of Green ICT of their ICT staff. This research was identified the barriers for implementing Green ICT practices. Finally, the techniques used by those organizations to overcome those barriers were also identified.

5.1 Discussion

How Organizations are implementing Green ICT practices were identified in section 2.2 in the literature review. It was not only for apparel industry but generally for any type of organization. In that section, we identified how ICT Managers and IT professionals implement energy efficient methods in their organizations in Europe. Green use encourages reducing the energy consumption of IT equipments and related systems to use them in environmental friendly manner. Operating datacenters in environmental friendly manner to reduce energy consumption was discussed. After conducting this research, we identified the practices significant for reducing electricity consumption for ICT, barriers for implementing those practices and techniques to overcome those barriers which are discussing in separate sections below.

5.1.1 Practices identified as significant for reducing electricity consumption for ICT

Based on the discussion of Section 4.13, 50% of responded organizations have implemented Green ICT practices in their organizations while the balance 50% is yet

to implement. Based on the Section 4.14, the significant practices have been identified for reducing electricity consumption for ICT in apparel industry. As per the analysis in the section 4.14 and as shown in Figure 4.16, 60% of the Green ICT implemented respondents have selected "Reduce datacenter power utility" as the most significant practice for reducing electricity consumption for ICT in apparel industry. There are 40% selections for "Reduce all utilities" while 20% selections are for "Reduce printers' power utility". This proves that effort to reduce all equipment power utilities is less effective than reducing datacenter power utility. Therefore, it is recommended to achieve the cost effectiveness of electricity usage of ICT in the organizations of apparel industry operating in export processing sector in Sri Lanka by reducing datacenter power utility.

5.1.2 The Green ICT Practices that have been implemented

Based on the analysis in Section 4.15, some practices have been implemented though they haven't been identified as significant in Section 4.14 as discussed in Section 5.1.1. "Reduce datacenter power utility" has selected by 80% of the respondents as an implemented practice and "Reduce computers' power utility" has been selected by 60% which was not identified as significant practice in Section 4.14. "Reduce printers' power utility" and "Reduce network equipment power utility" were selected by 40% and 20% respectively. Therefore, it has been proven again that reduce datacenter power utility is the most significant practice and therefore it has been implemented in the organizations of apparel industry in Sri Lanka.

5.1.3 Barriers for implementing Green ICT practices

There were organizations that have implemented Green ICT practices after overcoming the barriers. And some other organizations have not been able to implement Green ICT practices but they have identified the barriers. In this section, we discuss the both barriers and identify barriers as one set for implementing Green ICT practices in apparel industry in Sri Lanka.

Based on the analysis of Section 4.16, 80% of the Green ICT implemented organizations selected “Lack of awareness of Green ICT” as the leading barrier for implementing Green ICT practices. There are 40% equal selections for “Lack of training” and “Think of “No significant saving”” each. The “Lack of staff participation” and “Lack of rules & regulations” were selected equally by 20%.

Based on the analysis of Section 4.20, there were 40% selections for the barriers of “Not aware about those practices” and “No enough resources for implementing Green ICT practices” as barriers for not implementing Green ICT practices in their organizations. Another 20% selections are for “Management not interest” and “Other” each. Another 10% is for “No significant saving” and “Implementing cost is higher than saving” each.

Therefore, we can take all those barriers as one set and list down as follows.

Lack of awareness of Green ICT
Lack of training
Think of “No significant saving
Lack of staff participation
Lack of rules & regulations
No enough resources for implementing Green ICT practices
Management not interested
No significant saving
Implementing cost is higher than saving

5.1.4 Techniques used to overcome barriers

As discussed in Section 5.1.3, there are organizations that have implemented Green ICT practices after overcoming barriers and other organizations have not been able to implement but barriers have been identified. Both of those organization types have used and identified techniques to overcome barriers. Therefore as a conclusion in this

section, those techniques will be considered and listed down as one set of techniques to overcome barriers for implementing Green ICT practices in apparel industry which are operating in export processing sector in Sri Lanka.

Based on the analysis of Section 4.17, the techniques have been identified for overcoming barriers against implementing Green ICT practices by the organizations that have implemented Green ICT practices in their organizations. As per the analysis of Section 4.17, the most effective technique is "Awareness program conducted". The second highest selection is for "Use energy star equipment". Other techniques, "A policy implemented", "Train IT staff & users", "A project implemented" and "Monitoring power utility of DC" are all in the third position.

Based on the analysis in Section 4.21, The "Cost benefit analysis" is the best technique that can be used to overcome the barriers for implementing Green ICT practices by the organizations which have failed to start so far. Conducting Awareness program for the staff about Green ICT concept, forming a team as Green ICT and involving a third party for implementation also can be used as effective techniques to avoid barriers.

Therefore, we can take all those techniques as one set and list down as follows.

Awareness program conducted

Cost benefit analysis

Use energy star equipment

A policy implemented

Train IT staff & users

A project implemented

Form a team for Green ICT

Monitoring power utility of DC

Third party involvement

5.1.5 Monthly electricity saving by Green ICT

As per the analysis in section 4.18, the maximum monthly saving of 10MWh is done by 20% of the organizations that have implemented Green ICT practices. Therefore, the annual average saving of electricity will be 120MWh for an organization which is equal to 120,000KWh. Assume, if a Sri Lankan domestic electricity consumer utilize maximum monthly electricity usage of 100KWh. Then the annual electricity usage for this consumer will be 1200KWh. This shows that the annual electricity saving of 120,000KWh by implementing Green ICT practices in apparel manufacturing industry in export processing sector in Sri Lanka can provide electricity for another 100 domestic consumers annually. This is a significant saving of electricity and effective solution for future demand of electricity and to minimize the carbon footprint of electricity generation.

5.1.6 Validity and Reliability of the results

According to factor analysis, Composite Reliability (CR) and Average Variance Extracted (AVE) were obtained. For evaluating internal consistency, the Cronbach's alpha was assessed. Following table shows the values of above for each variable.

Table 5.1: Validity and Reliability

Variable	CR	AVE	Cronbach's Alpha
Significant practices for reducing electricity consumption for ICT	0.762	0.468	0.795
Barriers for implementing Green ICT practice	0.794	0.422	0.852
Techniques used to overcome barriers	0.850	0.591	0.892

5.2 Recommendations

Based on the observations in Section 5.1.1 and the analysis in Section 4.14, it has been identified that the reduction of datacenter power utility is the most significant practice for reducing electricity consumption in apparel industry operating in export processing sector in Sri Lanka. But based on the analysis in Section 4.5, only 20% of the responded organizations have hosted their servers in service providers' datacenters or in a cloud service. Other 80% is still maintaining their servers in the premises. It has been proved that increase of numbers of servers in the world has results the increase of electricity consumption in the world (Babin & Nicholson, 2012). Therefore it is recommended that the apparel manufacturing organizations in Sri Lanka to focus on reducing electricity usage of datacenters to achieve the maximum cost effectiveness of electricity usage of ICT.

The policies and regulations should come out from the authorities to optimize the use of electricity for datacenters Sri Lanka. Therefore, we recommend Sri Lankan government to buildup centralized data centers in export processing zones which have been situated all around Sri Lanka and provide the facilities for apparel organizations to outsource their server infrastructure in those centralized datacenters.

We also recommend to optimize the use of electricity in other ICT infrastructures such as Computers, Computer Networks, Voice Networks, Document printing and copying etc. which are also important practices for Green ICT.

As per the observations in Section 5.1.3 and the analysis in Section 4.16 and 4.20, it has been identified that the Lack of awareness of Green ICT is the main barrier for implementing Green ICT practices. Therefore we recommend to the top management of the apparel manufacturing organizations to focus more on Green and sustainability concepts especially in ICT and improve the awareness of Green ICT in staff. That will cut down the cost of energy in your organizations as well.

There are two best techniques which can be recommended to the ICT management in apparel manufacturing industry Sri Lanka to avoid the barriers and start Green ICT concepts in your organizations. As per the observations in Section 5.1.4 and analysis

in Section 4.17 and 4.21, conducting awareness program and doing a cost benefit analysis are the most efficient techniques that can be used to avoid barriers for implementing Green ICT practices. Therefore the management should focus on this and give broad priority to conduct awareness program or get their ICT staff participated at the public programs conducting for Green ICT. While improving the awareness of Green ICT, it is recommended to conduct cost benefit analysis to see the real benefits that organization can gain through Green ICT. The benefits cannot be measured only by means of the rupee value. They should concern on direct and indirect benefits that environment can obtain to the sustainability while considering the cost savings.

The section 5.1.5 has shown that the monthly maximum saving (10MWh) of electricity usage of ICT is significant. This saving can be benefited to average 100 domestic consumers of electricity monthly. Therefore, it is highly recommended to the Sri Lankan authorities to promote the concept of Green ICT as a solution to the future electricity demand and sustainability.

5.3 Limitations of the Research

We acknowledge the limitations of this study that limit the applicability of the findings and open paths to future researches. The selected study population of 15 organizations is small as discussed in section 3.4 which limits the validity of the interpreted findings and conclusions.

This study was carried out considering the apparel manufacturing industry which is operating in export processing sector in Sri Lanka. The study population which consists of known and selected apparel manufacturing organizations that do not represents the entire apparel industry in Sri Lanka. For this reason, these findings cannot be generalized to the broader community based on this study alone.

5.4 Future Research

Information and Communication Technology (ICT) is a major part of our modern industries, workplaces and individuals as discussed in Section 1. Adapting to the Green concepts by the organizations is being considered as a competitive advantage in modern business decision making process. Since ICT is playing a major role there, Green ICT is an important factor for organizations. Therefore, conducting more Green ICT surveys in the other industries will help to find problems against Green ICT practices and recommend solutions for particular barriers in other industries as well.

Further, this research can be extended to the next level to see what the best practices are that organizations can implement to reduce electricity consumption for ICT other than hosting or outsourcing datacenters.

5.5 Conclusion

This study shows that some of the organizations in apparel manufacturing industry operating in export processing sector in Sri Lanka are following Green ICT concepts and some practices have been already implemented while others are yet to implement. Generally, the organizations are experiencing common barriers. Techniques to avoid barriers have been identified. The countries such as Australia, United Kingdom and USA which can be identified as our main buyers for apparel products, which have already been taken necessary actions by imposing rules and regulations to develop the concept of Green ICT. It is not far away that the compliance of Green ICT will be considered compulsory to win businesses with those countries. Therefore, organizational management in apparel industry has a responsibility to encourage their employees towards Green ICT concepts by facilitating the requirements. The responsible authorities in Sri Lanka have to define new rules and regulations for Green ICT while providing the necessary knowledge and ICT infrastructure to those organizations.

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7. List of Appendices

Green ICT Project – Questionnaire

My name is Tharanga Amarasinghe, a MBA IT student at University of Moratuwa. I am conducting a research under the title of ACCELERATION OF COST EFFECTIVENESS THROUGH GREEN ICT – REDUCING ELECTRICITY UTILIZATION FOR ICT IN APPAREL INDUSTRY, SRI LANKA. Below questionnaire is to gather survey responses from the responsible IT professionals in apparel industry in Sri Lanka. I greatly appreciate your valuable time taking for completing this survey and your responses will be highly confidential and I assure that these information will be used only for this academic purpose. This survey consists 32 questions and no. of questions for you will be based on your responses and your answers for all those questions will be very helpful to conduct my survey accurately.

I kindly request you to read each question to the end and give the answer to best of your knowledge.

Thanking you,

Tharanga Amarasinghe

E-mail: tharanga.15@cse.mrt.ac.lk

Mobile: 0717707625

1. What is your company name? If your organization is a group, please mention the group name and location you are working. E.g. ABC group – Gampaha (If you do not wish to reveal your company name, please mention a name such as "Company A" or similar) *

2. Your Name and Designation (At least designation in case you do not wish to reveal your name) *

3. What is your level of responsibility for IT operations in the company? *

Mark only one oval.

- Whole IT operation Skip to question 5.
- 75% of the IT operation Skip to question 4.
- 50% of the IT operation Skip to question 4.
- 25% of the IT operation Skip to question 4.
- No responsibility Skip to question 4.

4. What are the other designations responsible for the IT operations in your company? Please select percentage for each designation (preferably total of Q3 answer and this answer to be 100%)

Mark only one oval per row.

	100%	75%	50%	25%	0%
IT Manager					
System Administrator					
Network Administrator					
IT Executive					

5. For how many hours your company operates per day? *

Mark only one oval.

- 8 Hours
- 8-12 Hours
- 24 Hours
- Other:

6. Do you have a Data center/ Server room in the premises? *
Mark only one oval.

- Yes Skip to question 8.
- No Skip to question 7.

7. If you answered "No" to the above Q6, where are your Servers located? *

Mark only one oval.

- At Head Office Skip to question 13.
- In another city/ branch Skip to question 13.
- Hosted in a service providers' Datacenter Skip to question 13.
- Use cloud services Skip to question 13.
- Other: Skip to question 13.

8. If "Yes" to the above Q6, how many servers are in your Datacenter/Server room? *

Mark only one oval.

- Less than 5
- 5-10
- 10-25
- 25-50
- Other:

9. Do you have a separate electricity power supply from service provider (CEB,LECO etc.) to your datacenter/server room , for which you receive the electricity bill monthly? *

Mark only one oval.

- Yes Skip to question 10.
- No Skip to question 11.
- Other:

10. If "Yes" to above Q9, what is monthly average cost of electricity of the Datacenter/Server room? *

Mark only one oval.

- Less than Rs. 50,000 Skip to question 13.
- Rs. 50,000 – Rs. 100,000 Skip to question 13.
- Rs. 100,000 – Rs. 200,000 Skip to question 13.
- Rs. 200,000 – Rs. 500,000 Skip to question 13.
- Other: Skip to question 13.

11. If "No" to the above Q9, have you measured the electricity utilization for the datacenter/server room? *

Mark only one oval.

- Yes Skip to question 12.
- No Skip to question 13.
- Other:

12. If "Yes" to above Q11, what is the monthly average electricity utilization for the datacenter/server room? If you do not know the electricity usage, please mention at least the cost in Rupee value using "Other" option. *

Mark only one oval.

- Less than 2MWh
- 2MWh – 5MWh
- 5MWh – 10MWh
- 10MWh – 20MWh
- Other:

13. Has your organization allocated Desktop computers for individual users? *

Mark only one oval.

- Yes Skip to question 14.
- No Skip to question 18.

14. If "Yes" for above Q13, how many desktop computers are in the premises? *

Mark only one oval.

- Less than 50
- 50-75
- 75-100
- 100-300
- Other:

15. Are you concerned on energy star compliance/certification for desktop computers/ICT equipment when purchasing?
Mark only one oval.

- Yes Skip to question 16.
- No Skip to question 17.

16. If "Yes" for above Q15, what percentage of desktop computers are with energy star in your organization? *

Mark only one oval.

- 100%
- 75%
- 50%
- 25%
- Other:

17. From above desktop computers (selected on Q14), what percentage of computers are operating for 24 hours? *

Mark only one oval.

- Less Than 25%
- 25% - 50%
- 50% - 75%
- 75% - 100%
- Other:

18. Has your organization allocated Laptop computers for users? *

Mark only one oval.

- Yes Skip to question 19.
- No Skip to question 20.

19. If "Yes" for above Q18, how many laptop computers are in the premises? *

Mark only one oval.

- Less Than 25
- 25 - 50
- 50 - 75
- 75 - 100
- Other:

20. Has your organization implemented Green ICT practices? *

Mark only one oval.

- Yes Skip to question 21.
- No Skip to question 29.

21. If "Yes" to above Q20, Reduce electricity consumption for ICT is an important practice for Green ICT. Do you agree that reduction of electricity consumption for ICT is an important practice for Green ICT.? *

Mark only one oval.

- Yes Skip to question 22.
- No Skip to question 27.

22. If "Yes" for above Q21, what practices have you identified as significant for reducing electricity consumption for ICT? Please select one or more practices. *

Tick all that apply.

- Reduce datacenter power utility
- Reduce computers' power utility
- Reduce printers' power utility
- Reduce network equipment power utility
- Reduce all above utilities
- Other:

23. What are the practices that you have implemented as indicated in above Q22? Please select one or more *
Tick all that apply.

- Reduce datacenter power utility
- Reduce computers' power utility
- Reduce printers' power utility
- Reduce network equipment power utility
- Reduce all above utilities
- Other:

24. What barrier/barriers have you faced while implementing above practices? Please select one or more *
Tick all that apply.

- Lack of awareness of Green ICT
- Lack of support from Top management
- Lack of staff participation
- Lack of Training
- Think of "No significant saving"
- Lack of Rules & Regulations
- Other:

25. What technique/s did you use to overcome above barriers? *
Tick all that apply.

- Awareness program conducted
- A policy implemented
- Train IT staff & users
- A project implemented
- Monitor power utility of DC
- Use energy star equipment
- Other:

26. By implementing Green ICT practices, how much of electricity could you save monthly? Please mention if saving is in Rupee value using "Other" option. *
Mark only one oval.

- 1MWh Skip to question 28.
- 5MWh Skip to question 28.
- 10MWh Skip to question 28.
- 15MWh Skip to question 28.
- Other: Skip to question 28.

27. What are the Green ICT practices that have been implemented in your organization? *

Tick all that apply.

- Recycling ICT equipment
- Reuse ICT equipment
- Reduce printing costs
- Other:

28. What are other Green ICT practices that have been implemented in your organization? *

Tick all that apply.

- Recycling ICT equipment
- Reuse ICT equipment
- Reduce printing costs
- Other:

29. If you haven't implemented any of Green ICT practices in your organization, what were the barriers to not to implement any of above practices? Please select one or more *

Tick all that apply.

- Not aware about those practices
- No enough resources for implementing those practices
- Management not interested
- No significant benefit
- Implemention cost is higher than the saving
- Other:

30. Have you tried to overcome above barriers and implement Green ICT in your organization?
Mark only one oval.

- Yes Skip to question 31.
- No Skip to question 32.

31. If Yes for above Q28, what technique did you use to overcome barriers? Please select one or more *

Tick all that apply.

- Awareness program
- Cost benefits analysis
- Third party involvement
- Form a team
- Other:

32. Are you interested to further improve those practices?

Mark only one oval.

- Yes
- No
- Other:

An interview was carried out based on the above questionnaire