Journal of Health Care Communications
ISSN: 2472-1654

Open Access Review Article

Green Information and Communication Technologies (Green ICT): A Review of the Requirements

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ABSTRACT

Introduction: Developing ICT-related standards and setting requirements are crucial for protecting the environment form detrimental effects of ICT.

Objective: This literature review aims to provide an overview of green ICT requirements in selected counties.

Method: This study reviewed the environmental requirements in United States, UK and Australia. The websites of environmental protection agencies of the selected countries and a number of data bases including Scopus and Science Direct were used to obtain relevant information. The articles and documents were evaluated in terms of their relevance to the aim of study.

Findings: The requirements for green design and manufacturing of ICT equipment were set in countries under study. Requirements for energy management of ICT equipment and behavior changes regarding appropriate use of ICT equipment were set in relation to ICT use in the countries, while there was no evidence about applying Green ICT scorecard in the United States regarding green disposal of ICT equipment, the Produce Compliance Scheme (PCS) was only in place in UK.

Conclusion: Setting the environmental requirements for ICT and addressing these in practice, can help to minimize the environmental problems through designing energy efficient products, behaving environmentally and disposing the electronic waste with minimal or no impact on the environment.

Keywords: Environmental requirements; Green ICT; Environmental problems

INTRODUCTION

Nowadays, human civilization is facing with environmental problems that threaten the life of inhabitants of the earth. This issue is of critical importance and cannot be easily ignored [1]. Environmental pollution, as a global environmental problem, is influenced by multiple factors, such as industrialization, population growth and urbanization [2]. Environmental pollution has been accompanied with serious ecological problems in the past half century, such as global warming, damage to the ozone layer, loss of biodiversity and natural resources, air pollution and acid rain

Received:	20-August-2022	**Manuscript No:**	IPJHCC-22-14099
Editor assigned:	23-August-2022	**PreQC No:**	IPJHCC-22-14099 (PQ)
Reviewed:	07-September-2022	**QC No:**	IPJHCC-22-14099
Revised:	22-March-2023	**Manuscript No:**	IPJHCC-22-14099 (R)
Published:	29-March-2023	**DOI:**	10.36846/2472-1654-8.2.8012

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Citation: Moghaddasi H, Rabiei R, Naemee R (2023) Green Information and Communication Technologies (Green ICT): A Review of the Requirements. J Healthc Commun. 8.8012

in the past half century [3]. Information and Communication Technology (ICT) is considered as an important tool to reduce environmental problems; however, the evidence indicates some negative influences of ICT on the environment [4-8]. Based on estimations, ICT is responsible for production and dissemination of about 2% of carbon dioxide which is equivalent to 860 million tons. In addition, the chemical components of unusable ICT equipment cause serious damage to water, air and soil. Furthermore, the excessive increase in the number of radio masts and permanent propagation of electromagnetic waves pollute the environment and can have negative impacts on humans, animals and plants [9-11]. With the development of infrastructures and facilities of ICT and increasing public awareness about environmental protection and sustainable development, green ICT has received increasing attention [12,13]. Green ICT, by definition, is the science of designing, manufacturing, utilizing and efficient recycling of computers, printers, databases, fixed and mobile communication devices and their associated systems, in order to have minimal adverse effects on the environment [14]. In other words, green ICT is the capability of implementing policies to apply and execute environmental regulations regarding design, production, use and disposal of ICT products to reduce detrimental effects on the environment [15]. The main concepts related to green ICT are green design and manufacturing, green use and green disposal [16]. Green ICT could bring positive environmental and economic effects through improving the use of energy, reducing greenhouse gas emissions, minimizing the use of harmful substances as well as encouraging reuse and recycling of electronic waste [17]. Many governments are trying to improve their environmental performance through setting explicit policies and efficient programs regarding ICT and the environment. However, despite the common aspects of these policies and programs, different countries have various performances in this regard. Governments and environmental protection agencies can reduce the negative environmental effects of ICT through developing of environmental requirements, including managerial policies (using environmental assessment tool for manufacturers of ICT products, energy management of electronic products, producing environmentally friendly equipment and management of surplus electronic equipment); incentive policies (granting green ICT Scorecard to evaluate performance of organizations); behavior change policies for the employees (educational programs, Tele-conferences and shutting down the computers after working hours) [18]. Since green ICT is a relatively new direction and countries have different experiences in this area, learning from the experiences of leading countries can have a fundamental role in determining the direction and success for other counties. This study aimed to review the environmental requirements of selected countries in three domains of green ICT (green design and manufacturing; green use and green disposal).

LITERATURE REVIEW

The focus of the literature review was on locating documents regarding environmental requirements of ICT and green ICT in United States, UK and Australia. The countries were selected according to their status in international green ICT rankings [19]. In addition, relevant academic published articles were searched. The preliminary search was on the websites of environmental protection agencies of the selected countries to obtain relevant documents. For academic publications, a number of databases were used including Scopus, Science Direct, Pubmed and Proquest. The search terms included, but not restricted to, green ICT, environmental problems, ICT and environment. The preliminary search results were reviewed on the basis of the relevance of the documents and contributions to the aim of the study. In the final step, a total of 39 documents and articles were reviewed. This study excluded non-english language publications.

Findings

The Environmental Protection Agency (EPA) in United States set its electronic policy in 2009 for managing energy, purchasing environmentally friendly products and recycling electronic products. In 2011, the UK government introduced the green ICT strategy for producing cost effective ICT products, consuming energy efficiently and eliminating negative environmental impacts. Similarly, the Australian government launched sustainable ICT plan to improve environmental performance and reduce carbon dioxide emissions from ICT industry. The findings related to green ICT requirements *i.e.*, green design and manufacturing, green use and green disposal in selected countries are presented as below [20].

The Requirements for Green Design and Manufacturing

In three countries under study, the manufacturers were required to designate and produce energy efficient ICT equipment. However, the requirement that the ICT suppliers should have an environmental management system aligned to ISO14001" was only set and mandated in Australia. In addition, the application of Electronic Product Environmental Assessment Tool (EPEAT) was a requirement in United States and Australia. Exploiting the ICT to organizations' operation and the delivery of online services to citizens and enterprises had been passed into law in the selected countries. In addition, the standard for electromagnetic field exposure was in place in the three countries studied. In line with sustainable procurement, the government was made responsible to prepare standards for electrical products procurement in the countries under study. The requirements for green design and manufacturing are presented in **Table 1**.

Table 1: Requirements for green design and manufacturing in selected countries.

	United States	UK	Australian

Designate and procure energy-efficient products	✓	✓	✓
Applying an environmental management system by ICT suppliers aligned to the ISO 14001 standard.	-	-	✓
Developing an Electronic Product Environmental Assessment Tool (EPEAT) for green procurement of ICT products	✓	-	✓
Exploiting ICT to government operations and public services	✓	✓	✓
Developing Electromagnetic Field (EMF) exposure standards	✓	✓	✓
Government buying standards for ICT equipment (sustainable procurement)	✓	✓	✓

The Requirements for Green Use

The policy of energy management of data centers equipment according to environmental standards has been developed in US, UK and Australia. The requirement pertaining to behavior change in employees regarding appropriate use of equipment was seen in these countries. However, the policy of granting green ICT scorecard in order to measure organizational performance and the law for reporting the preparation and use of ICT equipment was only seen in Australia. The requirements of green use in countries under study are summarized in **Table 2**.

Table 2: Requirements for green use in selected countries.

	United States	UK	Australian
Implementing an ICT Energy Management Plan (EMP)	✓	✓	✓
Implementing of best management practices for energy efficient management of servers and data centers.	✓	✓	✓
Reporting operational ICT energy consumption	-	✓	✓
Efficiency savings on existing ICT equipment by encouraging behaviour changes and encourage the right behaviour	✓	✓	✓
Replacing and/or waiving equipment that does not meet green compliance requirements	✓	✓	-
Internal governance arrangements and integrating ICT sustainability into internal documentation by agencies	✓	✓	✓
Applying green ICT scorecard	-	✓	✓
Applying strategies to manage demand and unnecessary consumption of ICT equipment	✓	✓	✓
Keeping records for the use of ICT equipment	-	-	✓

The Requirements for Green Disposal

The requirements related to re-use or reconstruction of ICT equipment to avoid unnecessary buying new equipment, recycling of ICT equipment through an environmentally friendly approaches, developing standards for safe disposal of ICT equipment were seen in selected countries. **Table 3** requirements with regard to the use of green can be seen.

Table 3: Requirements for green disposal in selected countries.

	United States	UK	Australian
Reusing or refurbishing surplus equipment	✓	✓	✓
Donating surplus equipment in the society or overseas, subject to security	✓	✓	-
Recycling and reusing components of ICT equipment	✓	✓	✓
Mandatory standards for disposal of ICT equipment	✓	✓	✓
Updating policies for disposition of all agencies excess or surplus electronic products	✓	✓	-
Maintaining records of the type and method of disposal of ICT equipment	-	-	✓
Producer Compliance Scheme (PCS)	-	✓	-

Developing policies and environmental standards along with considering the relevant requirements play a pivotal role in reducing the environmental effects. The comparison of ICT environmental requirements in selected countries in the domains of green design and production showed that energy efficiency of ICT products is considered as a key factor for purchasing ICT products in US and Australia. In the UK, factors such as energy consumption and disposal method were considered at the time of buying ICT products. In many countries, governments are one of the largest buyers of ICT products and services that not only can reduce negative environmental impacts, but can increase competition and innovation among the manufacturers of ICT products through developing environmental requirements. With respect to green design and manufacturing, the requirement for ICT manufacturers to have an environmental management system aligned with ISO14001 was only set and mandated in Australia. The compliance of ICT manufacturers with environmental standards could help to ensure that the manufacturers are committed to environmental impacts of their products. Manufacturers can help to reduce the negative impacts of ICT through choosing appropriate raw materials, limiting the use of hazardous materials, using recyclable and biodegradable materials for recovering resources from the electronic waste. Implementing environmental management systems in other countries, therefore, can be considered a promising approach to protect the environment from harmful effects of ICT products. Comparing ICT environmental requirements in selected countries revealed that ICT producers in US and Australia were required to use Electronic Product Environmental Assessment Tool (EPEAT). In the UK, Government Buying Standards (GBS) set by the European Union were put in place. Compliance of manufactures with EPEAT criteria has a significant influence on producing environmentally friendly ICT equipment through reducing or eliminating hazardous materials, producing durable products, saving energy along with waste management and using of degradable materials. This tool requires manufacturers to produce eco-friendly products through the whole life cycle of the products. Furthermore, it allows consumers to choose the best product through evaluating and comparing products based on environmental criteria. Gupta states that the concept of green IT means that all processes related to ICT equipment from the manufacturing to the recycling and disposal must be fully compatible with the environment. In other words, manufacturers are required to build ICT equipment that have the least impact on the environment through reduction of energy consumption, proper disposal and using recyclable and biodegradable materials. Similarly, Prasad noted stated that for proper use of energy resources, reduction of e-waste and greenhouse gas emissions associated with the ICT, all the environmentally related issues should be taken into consideration from the beginning (when deciding to design). Therefore, it is necessary for environmental protection agencies of other countries to implement environmental assessment tools, such as EPEAT, in their electronic policies. Regarding the green use, the act of energy management of data centers' equipment was issued in US, UK and Australia through reducing the number of centers, increasing virtual activity and using efficient technologies for

measurement and evaluation of energy consumption. Borah suggested that in order to adapt data centers' equipment with the environment different approaches must be implemented to reduce power consumption and reduce negative environmental impacts. The first priority must be energy consumption management of data centers, because managers often are concerned about the performance of data centers' equipment rather than the energy consumption. Therefore, attention should be paid to energy consumption of data centers in terms of environmental and economic aspects. Due to the growing impact of ICT and increasing equipment of data centers, setting plans for managing energy of data centers' equipment, training managers and employees and establishing standards for manufacturing and use of ICT equipment is crucial. Regarding green use of ICT, the policy of promoting green culture and behavior in business and establishing behavioral changes in government employees about the appropriate use of ICT equipment, such as turning off unnecessary equipment, use of electronic documents archive and teleconferencing had been made in all the countries under study. Vereecken suggested that the related policies must be made in order to limit the negative environmental impacts of ICT. It is notable that ICT has a great potential to reduce energy consumption, but it depends on adopting necessary policies, financing and training along with behavioral changes, though addressing these aspects in practice seems to be difficult. The use of ICT equipment requires an understanding of the environmental consequences of improper personal behavior as well as awareness and training of the right behavior. Green ICT strategies, as one of the key strategies, have the potential to reduce the negative impacts of ICT through increasing the awareness of individuals, about the proper use of ICT and the adverse effects of ICT on the environment. Green ICT principles were established in internal policy of the organizations in United States, Australia and UK. In their study, Lakshmi suggest that practical approaches, such as developing environmental assessment tools and making the organizational policies, can help to protect the environment from negative impacts of ICT. Similarly, Suri indicates some solutions for saving energy and protecting the environment, including turning off computers when not in use; applying energy management system; as well as using environmentally friendly equipment.

In Australia, , policies have been made regarding assessing the awareness level of organizations' personnel of green ICT and the effectives of green ICT training programs for more effective management of activities related to green ICT. Therefore, an organization with greater coordination and cooperation in implementing these programs is eligible to receive Green ICT Scorecard. Making incentive policies for green ICT has a fundamental role in creating competition among manufacturers producing ICT equipment and thereby protecting the environment. Thus, these kind of policies could be recommended for other countries.

DISCUSSION

In relation to the green disposal, laws pertaining to eco-friendly recycling of electronic waste and reuse of surplus IT equipment to avoid increasing electronic waste were in place in all the selected countries. Lukose notes that improper management of electronic waste during recycling may lead to significant irreversible risks for human health and the environment. However, by proper management electronic waste is a valuable resource called "urban mine". Disposal of electronic waste performed by informal sectors is causing environmental hazards that can be avoided by the official management of this kind of waste. For this reason, mandatory standards have been in place in Australia for returning ICT equipment to manufacturers for repair, reuse and recycling without adverse environmental effects. Similarly, in the UK, the ICT manufacturers are required to Producer Compliance Scheme (PCS) collect, recycle and properly dispose of electronic waste including ICT equipment. There are some approaches that could help to have an effective waste management for ICT equipment, including:

- Producing and importing of high quality computers;
- Monitoring the importing ICT equipment and preventing illegal entry of these equipment into the country;
- Allocating special places for the delivery of computer waste by the people;
- Training for optimal use of ICT equipment and proper disposal of electronic waste;
- Legislating for delivery of computer waste to a special place and setting regulations for importers of computer equipment;
- Investing in knowledge and technologies for recycling ICT equipment and using the experience of leading countries.

CONCLUSION

The rapid development of ICT has brought with it environmental problems such as increasing ICT waste. Establishing mandatory standards and enforcing the requirements to manage ICT waste are important approaches in reducing the adverse effects of this type of waste. Making regulatory policies for protecting the environment has a key role to play. Considering the environmental policies in the three domains of green ICT, *i.e.*, green design and manufacturing, green use and green disposal. In addition, learning from the experiences of leading countries can determine the direction and success of developing countries to achieve effective environmental sustainability.

AUTHOR CONTRIBUTION

HM contributed to the conception and design of the study and preparation of the manuscript. RR contributed to the conception, design of the study and preparation of the manuscript. All authors participated in the sessions held regarding the literature retrieved. All authors went through and approved, the final manuscript.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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