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SUSTAINABLE MANAGEMENT OF IT RESOURCES – THE PROBLEM OF E-WASTE

Abstract. The paper presents the most important issues connected with development of a sustainable approach in the IT area. It includes the historical background of sustainable principles application, which ultimate goal has been to reduce the negative impact caused by widespread use of computer infrastructure on the environment. The literature review has been the basis for determining the roots of "green" standards for computer equipment commonly used by all types of organizations. A particular focus of the paper is on the problem of electronic waste disposal, which most of contemporary organizations contribute to, if they use IT infrastructure in their operations. Generally, the goal of the paper is to present the range of the problem causes by e-waste and increase the awareness of organizations in the scope of its collecting, recycling and first of all limiting its amount.

Keywords: green computing, sustainable IT, e-waste

ZRÓWNOWAŻONE ZARZĄDZANIE ZASOBAMI IT – PROBLEM ODPADÓW ELEKTRONICZNYCH

Streszczenie. W artykule przedstawiono najważniejsze kwestie związane z rozwojem idei zrównoważonego rozwoju w obszarze IT. Zawarto w nim tło historyczne zastosowania zasad zrównoważonego rozwoju, którego ostatecznym celem jest redukcja negatywnego wpływu powodowanego przez rozpowszechnione wykorzystywanie infrastruktury komputerowej, również w organizacjach, na środowisko naturalne. Bazę do określenia korzeni „zielonych” standardów w dziedzinie sprzętu komputerowego powszechnie wykorzystywanego w organizacjach stanowiła krytyczna analiza literatury. W artykule szczególnie zaakcentowano problem utylizacji odpadów elektronicznych, do powstawania których przyczynia się większość współczesnych organizacji, jeśli tylko wykorzystują one w swoim działaniu infrastrukturę informatyczną. Ogólnie celem artykułu jest przedstawienie skali problemu powodowanego przez odpady elektroniczne oraz podniesienie stopnia świadomości organizacji w zakresie ich zbierania, przetwarzania, a przede wszystkim ograniczenia jego ilości.

Słowa kluczowe: green computing, zrównoważone zasoby IT, odpady elektroniczne

Introduction

The primary goal of the discipline of IT sustainability is to enable firms to use computing resources more efficiently while maintaining or increasing overall performance[1]. The sustainable approach to the organizational IT resources has been gaining in popularity in recent years and it is presently treated as a key factor in shaping the policy in relation to organizational IT resources use. The current trend in applying the sustainable development principles in the IT domain concentrates particularly on the issue of minimizing the negative impact of organizations on the environment and assuming a long-term relationship of organizational IT resources, their clients and the society, the ultimate goal of which for enterprises is winning a strong market position – this approach is frequently defined as sustainable IT services. This effort is meant to reduce environmental problems that are caused by widespread application of IT technology and create a sustainable environment. In the course of past two decades of the previous century until presently the application of IT solutions in various areas of work, education and life has caused that we have grown used to the benefits it offers, improvement and convenience to our lives and professional duties. This explosion of technological advances in the IT domain has resulted in widespread adoption of IT solutions in global dimension, yet it has also brought new types of threats to the natural environment. Unfortunately, its rapidly growing power demand and consumption, as well as the problems arising both during its production and disposal stage, have created severe environmental problems. Therefore, the necessity to take more interest in the issues of environmental protection and creating good practices and policies of dealing with its negative impact on natural environment have become vital in all organizations that use IT resources in their operations.

The goal of the present paper is to present a brief history of sustainable principles application in the IT area, which confirms that this domain, being aware of its negative impact on the natural environment, has been implementing them under various terms for many years. Additionally, as one of the aspects of sustainable management with reference to organizational IT departments operations is the disposal stage of electronic waste, the cognitive focus of the second chapter of the paper is the analysis of the applied ways of processing it. In the third chapter the attention has been paid to reducing its (and at the same time organizational) harmful influence on the environment through recovering valuable

[1] Harmon R., Demirkan H., Auseklis N., Reinoso M.: From Green Computing to Sustainable IT: Developing a Sustainable Service Orientation. 43rd Hawaii International Conference on System Sciences (HICSS), 2010.

elements it contains. The extensive literature studies provide evidence that apart from being a problem to organizations e-waste can also constitute a valuable resource, which if used effectively can lead to significant savings of rare metals resources and energy consumed in the process of their extraction.

1. Sustainability – genesis of the term and standards in the IT area

The literature on the subject includes numerous definitions of the term sustainable development, however the most frequently quoted one comes from Our Common Future, also known as the Brundtland Report according to which: "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs"[2]. Two key concepts can be distinguished within it. The first one concerns the basic needs of the less advantaged parts of the world's population, which deserve particular interest and attention from the side of well developed world's economies. The latter one refers to the notion of the current stage of technological development and social organization with reference to the environment's ability to satisfy the present and future needs. When attempting to apply these principles to the IT area the term sustainable development can be defined as "the knowledge and practice of developing, producing, using and utilizing computers, servers and all the related sub-systems such as monitors, printers, data storage devices as well as network and communication systems in an efficient way, so its negative impact on the natural environment is minimized or even entirely avoided"[3]. Thus, it can be also stated that sustainability in the IT area consists in more efficient use of organizational computer infrastructure, simultaneously maintaining or even increasing its previous capacity and decreasing its negative influence on the environment, with particular attention paid to the problem of electronic waste disposal, collection and recycling.

On the basis of the literature review it can be stated that the goals and principles of sustainable development in the IT area have been the concern of this domain since computers started to be used on a larger scale. And so, the sources of sustainable principles implementation, at least with reference to informatic resources, date back to the 1960s of the previous century. It was in 1968 that Stewart Brand and his team published the first Whole Earth Catalogue, which at that time constituted a commonly accepted compendium of knowledge on environmentally friendly technologies as well as advice on their implementation. In 1972 the number of copies sold exceeded one million, which won it the

[2] http://www.iisd.org/topic/sustainable-development, 14 03 2017.

[3] Murugesan S.: Harnessing Green IT: Principles and Practices. IEEE IT Professional. January-February 2008, p. 24-33.

National Book Award, for the first time in history awarded to a catalogue. Many years later in one of his famous speeches Steve Jobs compared the Whole Earth Catalogue to Google[4].

However, a truly serious attempt to implement sustainable development principles in the IT domain actually occurred in the 1990s of the 20th century. This was largely the result of a very fast development in the IT area, followed by extensive computerization of institutions and businesses. It started in 1991when the US Environmental Protection Agency – EPA introduced its programme "Green Lights", which aimed at promoting energy-saving lighting. Then in 1992, the same agency introduced the Energy Star programme, which established energy-saving specifications for computers and monitors. Despite its initial purely voluntary nature, it has become an international standard for energy efficiency with reference to consumer products. Its first achievement was introducing the sleep mode in consumer products. The term "Green Computing", which was at that time equivalent to sustainable IT is believed to have its origins in the Energy Star programme implementation. Green computing was defined as one of many environmental initiatives to reduce our impact on the Earth, which is accomplished by taking actions that alleviate global warming and sustain Earth's limited resources. Maximizing the use of computing resources while reducing the "carbon footprint" of an organization's IT infrastructure is the goal of green computing[5].

Yet, the real interest in the sustainability in the IT domain falls on the last decade, which is directly connected with the cost of energy which is necessary to power the organization's IT infrastructure as well as a rapid development of technologies by means of which business services are provided through the Internet – such as Cloud Computing. Another important factor that lies at the basis of sustainable approach to organizational IT resources use is growing social awareness as to the negative climate changes and fears connected with energy security. Therefore, the growing demand for energy, growing all the time cost of maintaining and utilizing informatic infrastructure in organizations and the threat of more serious effects of global warming caused that a number of organizations, institutions and government agencies made attempts to find measures which would diminish the negative impact of computer resources on natural environment. These efforts resulted in introducing, both in the United States and the European Union, standards and procedures aimed at providing an incentive for computer industry, organizations and individual users to save energy and reduce the amount of waste from used computer equipment. They include the following regulations[6]:

– WEEE – European Directive on Electric and Electronic Waste which came into effect on 2013. This directive imposes the responsibility for electronic and electric waste on equipment producers. It is their responsibility of producers to collect used electric and electronic equipment on the free-of-charge basis. The goal of the directive is to reduce the amount of electric and electronic waste and constitute an incentive for electronic

[4] http://www.teamquest.com/import/pdfs/whitepaper/shades-of-green.pdf, 12.03.2017.
[5] Ibidem.
[6] Hanselman S.E., Pegali M.: The Wild Wild Waste: e-Waste. SIGUCCS '07, October 7-10, 2007, p. 157-162.

equipment manufacturers to design their products in such a way that in its life-cycle it is more environmentally friendly. The producers had to join the compliance programmes and were registered in each member state of the European Union.

- RoHS – the European Directive that concerns a reduced use of certain dangerous substances in the course of electronic equipment manufacturing. This directive is closely related to the WEEE Directive. The substances included into the limits are: lead, mercury, cadmium, hexavalent chromium, polybrominated diphenyl and polibrominated phenyle ether.
- EPEAT – the Green Electronics Council created Electronic Product Environmental Assessment Tool - EPEAT), which is supposed the help the customers evaluate, compare and choose desktop computers, laptops and monitors according to the 23 required and 34 additional criteria of being environmentally friendly. According to the EPEAT classification products are defined as bronze, silver and gold ones. The bronze ones comply only with the required criteria, the silver ones comply with the basic criteria and at least 14 additional ones while the gold ones comply with the basic criteria and at least 21 of the additional ones. Since the year 2007 the federal agencies in the USA have been obliged to buy only the products registered with EPEAT.
- Energy Star 4.0 Standard – desktop computers, notebooks and workstations manufactured after 20 July 2007 and bearing the Energy Star labels comply with very rigorous requirements of the 4.0 standard. This standard regulated energy efficiency for external and internal energy supplies and work modes: sleep, idle and stand-by.
- Computers have to comply with these requirements save energy in all modes of their operations.

Table 1 includes and aggregated summary of environmentally-friendly regulations in the scope of electric and electronic equipment. As one can conclude on the basis of Table 1, European regulations concern mainly electronic waste and application of dangerous materials in the manufacturing processes. The focus of American standards in turn is primarily on energy efficiency.

The positive effects of introducing these environmentally-friendly standards concerned first of all turning the public attention to the fact that although generally computerization resulted in making human work easier, at the same time it started to constitute a serious threat to the natural environment. The established standards caused that organizations as well as individual users took more interest in the issue of computer equipment being less destructive to the environment. The provisions of these guidelines have been followed worldwide for years now, which can be perceived as an evidence that sustainability with reference to the use of organizational IT resources is not a new phenomenon, but rather an evolving and developing one.

Table 1

Regulations and standards in the scope of electronic equipment

Regulation or standard	Sponsor	Concerns	Compliance
WEEE: Waste Electrical and Electronic Equipment Directive	EU	Electric and electronic waste	Producers have to collect used electric and electronic equipment free of charge. Designing new products must take into consideration their eco-friendly features. Producers have to belong to compliance schemes in order to sell their products.
RoHS: Restriction of Hazardous Substances	EU	Dangerous materials in electric and electronic equipment production	It defines lead, mercury, cadmium and three other substances as dangerous ones. Their use is limited and is subject to special regulations and restrictions. It is connected with the WEEE Directive.
EPEAT: Electronic Product Environmental Assessment Tool	U.S. The Green Electronics Council	Energy efficiency for desktop computers, laptops and monitors, basic 23 and additional 34 criteria of being environmentally friendly	Generally, compliance in this case is voluntary except for sales to government agencies – in this case it is required.
Energy Star 4.0	U.S. EPA U.S. Department of Energy	Energy efficiency for desktop computers, notebooks and workstations.	Defines standards for external and internal energy supplies and defines modes :sleep, idle and stand-by for computers.

Source: Own elaboration on the basis of http://www.pitt.edu/~dtipper/3350/GreenICT1.pdf.

2. The need for sustainable development application in the IT area – world electronic waste concern

While analyzing the basic goals of applying sustainable IT principles in organizations, the three main areas can be distinguished in this scope, which consist mainly in:

- reduced use of dangerous materials,
- maximizing the energy efficiency in the whole period of product's life-cycle,
- promoting recycling and bio-degradation of used products and industrial waste.

With this reference the problem of electronic waste (e-waste) disposal is one of main environmental problems that contemporary organizations have to face and which needs to be addresses if the goal of making organizational IT resources more environmentally friendly is ever going to be achieved. Electronic waste (e-waste), is a generic term used to describe all types of old, end-of-life or discarded electrical and electronic equipment, such as household appliances; office information and communications equipment; entertainment and consumer electronic equipment; lighting equipment; electric and electronic tools; toys; and leisure, sports and recreational equipment that are powered by electricity. E-waste contains both valuable and hazardous materials that require special handling and recycling methods[7]. According to Gartner estimation over 133,000 PCs are discarded by U.S. homes and businesses each day, and only less than 10 percent of all electronics are being recycled[8]. In the European Union, according to the reports by Interpol and the United Nations in 2012 in all the member countries only 35% (approximately 3,25 million of tonnes) of e-waste was recycled. The rest of it, which is roughly about 6,05 million tonnes was recycled improperly, exported or dumped into rubbish[9].

Within the territory of the European Union the management of electronic waste is regulated by Directive 2012/19/EU of the European Parliament and of the Council of 4 July 2012 on waste electrical and electronic equipment (WEEE). There are 10 categories of electronic equipment which are covered by the abovementioned Directive (Annex I to Directive 2012/19/EU) and include[10]:

1. Large household appliances.
2. Small household appliances.
3. IT and telecommunications equipment.
4. Consumer equipment and photovoltaic panels.
5. Lighting equipment.
6. Electrical and electronic tools (with the exception of large-scale stationary industrial tools).
7. Toys, leisure and sports equipment.
8. Medical devices (with the exception of all implanted and infected products).
9. Monitoring and control instruments.
10. Automatic dispensers.

Data concerning electronic waste disposal is provided by all the European Union's member states according to the provisions of the Commission Decision 2005/396/EC specifying the rules for monitoring compliance of Member States and establishing data formats for the purposes of Directive 2012/19/EU of the European Parliament and of the Council on waste electrical and electronic equipment. All the Member States have the obligation to report to the Commission on the achievement of the targets for WEEE collection, re-use, recycling and/or recovery on the basis of Commission Decision 2005/369/EC. Despite the existing legislation in force, various member states demonstrate different levels of performance in this scope. Figure 1 presents the data by Eurostat concerning the amount of WEEE collected by country in kg/inhabitant for the years 2007 and 2013.

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[7] http://www.gartner.com/it-glossary/electronic-e-waste/, 18.03.2017.
[8] Hanselman S. E., Pegah M., *The wild wild waste: e-Waste*, Conference Paper, January 2007
[9] http://technowinki.onet.pl/biznes-i-finanse/europa-ma-problem-z-elektrosmieciami/8kqjkp, 18.03.2017.
[10] http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32012L0019, 17.03.2017.

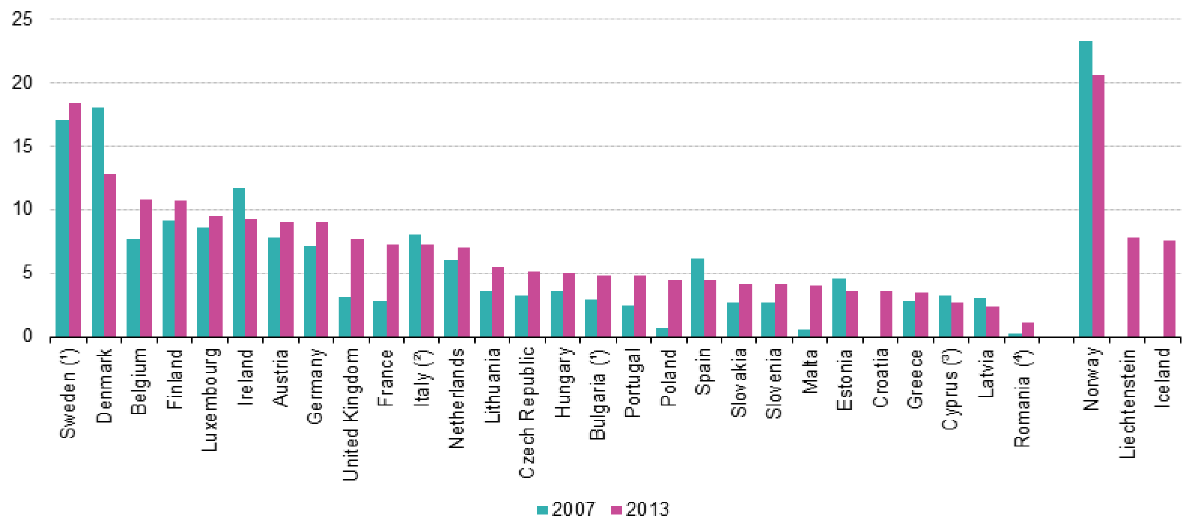

Fig. 1. Amount of WEEE collected by country in kg/inhabitant for the years 2007 and 2013
Source: Eurostat.

Figure 1 shows the amount of WEEE collected by country in kg/inhabitant for the years 2007 and 2013. The sum of all electronic waste collected from various sources is presented in it. As one can notice the amount of electronic waste was different in particular EU countries in 2013. In Romania it reached merely 1.2 kg/inhabitant while Sweden recorded an impressive 18.4 kg/inhabitant in Sweden and was outperformed in this scope by Norway with the result 20.7 kg/inhabitant. The observed disparities in the amounts of collected waste result mainly from the different consumption levels of electronic equipment as well as different efficiency of waste collection schemes in particular countries. Another observable in Figure 1 fact is an improved significance in separate waste collection in majority of the countries. Only seven countries recorded a decrease in WEEE collection, however the level of separate e-waste collection in these countries was already relatively high already in 2007.

A comparison of WEEE collection in 2007 and 2013 shows that separate collection has improved significantly in most of the countries. Decreasing amounts for WEEE collection were reported by only seven EU Member States including Denmark and Ireland where the level of separate collection was already high in 2007. With reference to the category of collected e-waste in 2013 it can be observed that it was not IT and telecommunication equipment that constituted the largest share of this waste, it actually came in the second place with 575 000 tonnes. The largest amount of collected e-waste constituted in 2013 large household appliances – 1,6 million tones and 46% of total WEEE collected in the EU member states, and consumer equipment came third in this category with 553 000 tonnes[11]. Thus, it can be concluded that although used IT equipment does not occupy the first position on the list of electronic waste being a serious burden to the natural environment, its position on this

[11] http://ec.europa.eu/eurostat/statistics-explained/index.php/Waste_statistics_-_electrical_and_electronic_equipment, 18.03.2017.

list is still relatively high, which justifies the efforts of the organizations to reduce this negative influence.

3. E-waste and rare metals recycling

Another problem with discarded electronic products is that they contain a number of toxic metals and chemicals such as lead, mercury, cadmium, chromium, and PCBs. However, this problem can also be solved in favour of natural environment. Used electronic equipment includes scarce elements the resources of which are constantly decreasing. According to the data in this respect we are already facing problems with some metals shortages, and it is expected that within the next ten years there will be serious problems with fast mining of metals such as: gold, silver, tin, zinc, zircon, cadmium, wolfram, cooper, manganese, nickel and molybdenum. Some of these metals have already been included into the group of so called critical metals, which means that they do not have proper primary and secondary sources and a possibility to start the production at various stages[12]. Presently it is estimated that if the human race maintains the currently valid consumption model, we can expect fewer than 50 years of relatively cheap access to metals[13]. The detailed data on supply of metals used in high technology products has been aggregated in Table 2.

Table 2

World supplies of metals used in electronic products – prognosis for the future

Element	Metal production (mg)	Metal world resources (mg)	Statical sufficiency
Manganese	16 000	630 000	about 39 years
Nickel	2 100 000	75 000 000	about 36 years
Zinc	13 000 000	250 000 000	about 19 years
Cooper	17 000 000	680 000 000	about 40 years
Silver	24 000	540 000	about 23 years
Gold	2700	52 000	about 19 years
Cobalt	110 000	7 500 000	about 68 years
Wolfram	73 000	3 200 000	about 44 years

Source: http://www.sitg.pl/przegladgorniczy/pokaz/art-1097a13-pdf.html.

On the basis of data included in Table 1, it can be concluded that organizations may expect more dependence in this area in favour of the countries that possess larger resources of these metals. Not only will these countries be able to gain an advantageous position on the market but they will also have the ability to influence their supplies and prices. This in turn can be reflected in a threat to the further development of economies dependent on importing these resources and organizations which either use these resources in their processes or use products manufactured with the use of these metals. This situation can be particularly

[12] http://www.sitg.pl/przegladgorniczy/pokaz/art-1097a13-pdf.html, 21.03.2017.
[13] Ibidem.

dangerous for the USA and Europe. Presently the country with a monopoly position with reference to rare metals resources is China. It possesses 23% of world's rare metals reserves and produces 97% of rare elements. However, their intensive mining, which has been taking place for over 50 years, means that the Chinese reserves are constantly decreasing. Comparing the data for 2010 when China exported 39 000 tonnes of rare metals and data from 2014 when the export amounted 30 258 tonnes[14], one can state that the world's supply decreased in this period by a quarter, which was reflected in prices of these metals on the world markets and indirectly in production cost of electronic goods manufactured with the use of these elements. The fact that China has appealed to other countries to increase the mining of these rare metals by them can also be considered to be an evidence of a too extensive use of them, especially in fast developing economies, which is directly reflected in rapidly shrinking world resources of these metals. Interestingly, in this respect e-waste can be treated as valuable source of rare metals, which if processed properly can produce significant amounts of metals that are of particular value due to their common use in products of new technology, being products of civilization progress of global societies An additional benefit, which needs to be stressed here, is the fact that recycling rare metals from electronic e-waste means that they do not have to be mined so intensively and this will allow their resources last longer than it is currently expected, which is accordant with the sustainable development principle of not compromising the needs of future generations to meet their own needs. The summary of data on amounts of rare metals in scrapped electronic waste has been presented in Table 3.

Table 3

Scrapped rare metal resources in 2010

E-waste receivers	Scrapped	No. of pieces	Gold (kg)	Silver (kg)	Palladium (kg)	Cooper (kg)
China	computers	10 700 000	2400	10 700	850	5 350 000
	mobiles	70 000 000	1600	17 500	630	630 000
India	computers	2 000 000	440	2000	160	1 000 000
	mobiles	17 000 000	400	4000	150	150 000
RPA	computers	690 000	151,8	690	55,2	345 000
	mobiles	8 500 000	200	2100	75	75 000
Senegal	computers	32 000	7	32	2,5	16 000
	mobiles	1 000 000	24	250	9	9000

Source: Umicore.

As it can be observed on the basis of Table 1 electronic scrapped waste contains large amounts of valuable rare metals. Yet, these rare metals are frequently wasted as the countries in possession of them lack proper infrastructure or knowledge to recycle them. In 2010 China itself scrapped 4 tonnes of gold, 850 kg of palladium and 5 350 000 tonnes of cooper in e-waste. According to the estimates by UN, the values will grow four times by 2020[15]. Thus, these are figures that have to be taken into consideration especially as the content of primary metals in e-waste is much higher than in the primary ores from which they are obtained.

[14] http://www.sitg.pl/przegladgorniczy/pokaz/art-1097a13-pdf.html, 21.03.2017.

[15] http://technowinki.onet.pl/artykuly/elektrozlom-kto-produkuje-go-najwiecej-i-gdzie-trafia/e5qtv, 23.03.2017.

Recycling circuit boards can be more valuable than mining for ore. One ton of circuit boards is estimated to contain 40-800 times more gold than one metric ton of ore. There is 30-40 times more copper in a ton of circuit boards that can be mined from one metric ton of ore[16]. The amount of gold recovered from one ton of e-waste from personal computers is more than that recovered from 17 ton of gold ore. The processes for recovering primary metals from electronic scrap, in limited cases are easier than their primary ores[17]. And finally another important reason in favour of e-waste recycling in order to recover rare metals it includes is saving energy. According to the US Environmental Protection Agency there are seven main benefits for using recycled iron and steel over their virgin materials, one of them being a significant energy saving in case recycled materials are uses instead of virgin materials[18]. Equally important is the fact that processing of e-waste will significantly reduce the demand for mining ores to obtain primary metals. Therefore, not only can mining of metals the resources of which are endangered be reduced, but also considerable amounts of energy that is required in the process of their extraction can be saved. The energy savings for common metals and materials have been aggregated in Table 4.

Table 4

Recycled materials energy savings compared to virgin materials

No.	Materials	Energy savings (%)
1	Aluminum	95
2	Cooper	85
3	Iron/steel	74
5	Zinc	60
6	Paper	64
7	Plastics	>80

Source: http://wealthfromwaste.net/wp-content/uploads/2014/11/Metal-Extraction-Processes-for-Electronic-Waste-and-Existing-Industrial-Routes.pdf.

However, in some cases many of the EU member states try to address the issue of e-waste disposal (particularly containing hazardous substances) by exporting the used equipment outside their borders, violating in this way the EU directive on reducing the amount of e-waste. For example Germany itself exports about 155 tonnes of e-waste. This situation is to a large extent the result of the valid legislation imposed by the European Union, which causes that proper utilization of used organizational IT equipment is expensive. A proper utilization of a computer screen costs twice as much in Europe than in Asia or Africa. However, what organizations that aim at being environmentally-friendly have to understand is that recycling of used equipment means for them long-term gain. Even if collecting and utilizing old computer equipment is not directly reflected in the organization's profit and loss balance sheet, it definitely contributes to reduced exploitation of new resources, which in turn prolongs their availability and inhibits growth in their prices, despite the energy consumption

[16] http://earth911.com/eco-tech/20-e-waste-facts/, 19.03.2017.

[17] http://wealthfromwaste.net/wp-content/uploads/2014/11/Metal-Extraction-Processes-for-Electronic-Waste-and-Existing-Industrial-Routes.pdf, 23.03.2017.

[18] Ibidem.

involved in the recycling process. It has to be stressed here that one of the goals of sustainable development is also looking after the less advantaged part of the global society. Organizations which try to cut the cost of old IT equipment disposal contribute directly to the export of e-waste to less advantaged countries of Africa and Asia. The exported e-waste is then recycled there, but the process violates all the principles of sustainability in this respect, involves child labour, causes harm to lives and health of local residents and causes growing contamination of local environment. One of such places is Guiyu in China, which is a major dumping ground for e-waste from the United States. After the e-waste is transported over to China, the electronics are dumped in the town where it litters the streets and poisons the residents. Hydrochloric acid is thrown on the items to reveal the steel and copper to be reused. High levels of lead have been reported among residents[19].

Therefore, the solutions that have to be considered by all organizations making use of IT resources may actually go into two directions. The first of them is introducing and following such organizational policies of IT resources use which will reduce the amount of e-waste produced by organizations. This may mean reducing the amount of possessed IT equipment through virtualization of their operations – server virtualization, application virtualization, etc., and moving their resources to the cloud. The second solution is improving energy efficiency, which may involve introducing changes to the computer infrastructure, cooling systems, data centres efficiency or use of cloud computing services. Therefore, it can be stated that in total sustainable IT services require the integration of green computing practices such as power management, virtualization, improving cooling technology, recycling, electronic waste disposal, and optimization of the IT infrastructure to meet sustainability requirements[20]. These issues are to be discussed in more detail in the Author's next paper.

Summary

Application of sustainable development principles in managing organizational IT resources becomes a key factor in the operations of contemporary organizations. One of the major advantages resulting from sustainable IT resources management is efficient use of energy at the time when the demand for it is constantly growing. Additionally, which is equally important, sustainability in the IT domain makes it possible to use the computer infrastructure in a more efficient way, preserving or even increasing its previous capacity and decreasing its negative impact on natural environment. The costs connected with of maintaining and utilizing informatic infrastructure in organizations, global warming effect and

[19] http://earth911.com/eco-tech/20-e-waste-facts/.

[20] Harmon R., Auseklis N.: Sustainable IT services: Assessing the impact of green computing practices. International Conference on Management of Engineering & Technology, PICMET 2009, Portland 2009.

large amounts of electronic waste caused the search for principles, standards and procedures aimed at reducing the negative effect of organizations and individual users on the natural environment. This led to formulation and establishment of international standards in this scope which are still valid. Additionally, the growing amount of e-waste has become a serious threat to the environment and forced the organizations to address this problem as one of basic sustainable management goals in their operations. However, e-waste can also be treated as a valuable source of rare metals, which are of particular value as they are commonly used in products of new technology. Organizations that contribute to recycling rare metals from electronic e-waste simultaneously contribute to less intensive mining of these metals which will allow their resources last longer than it is currently expected. By applying these strategies organizations create their positive image, which confirms their pro-ecological awareness and is positively identified by the consumers who consciously choose products and services offered by environmentally-friendly organizations. However, to constitute a comprehensive solution sustainable IT services require overall integration of green computing practices such as power management, virtualization, improving cooling technology, recycling, electronic waste disposal, and optimization of the IT infrastructure.

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