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Security requirements for personal computers

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Abstract. The relevance of the study lies in guaranteeing the safety of personal computers for consumers (users) and complying with the requirements of technical regulations in this part. The purpose of the study was to determine and analyse the factors of personal computer assortment formation under the conditions of the uncertainty of economic and social features of modern times, with a focus on aspects of safety and environmental responsibility of computer equipment, as a priority mechanism for consumers. Emphasis is placed on cyber security, the importance of protecting a personal computer from cyber attacks. Methods of systematic analysis of statistical databases were used in the study. The high rates of development of Ukraine in the field of computerisation of many areas of industry and economy during the years 1993-2023 were noted. It has been proven that as of the year 2024 there is one personal computer, a tablet, a laptop or a netbook in every household. Changes in the economy, politics, technological aspects and other external factors that can affect the personal computer market are shown. The ability of companies to adapt to changes and requirements is noted as a key source of their success. The ergonomic, anthropological, psychophysiological requirements for screen devices that guarantee the safety of consumers (users) are given. The conditions of compliance of personal computers with the requirements of technological regulations in terms of ecodesign, aimed at improving the environmental safety component in accordance with consumer requirements, are defined. It is shown that the modern market of personal computers has several key trends in the formation of assortment policy which includes: flexible configurations and individualisation; increased attention to the gaming segment; development of artificial intelligence technologies; increasing the amount of memory and speed; environmental responsibility; development of wireless technologies; high mobility; focus on high-performance workstations. It has been determined that compliance with environmental safety requirements is important for business, because companies that pay attention to environmentally responsible may have a competitive advantage. It is shown that the most common are the standards and certification systems for personal computers, which are a series of certification standards that determine the requirements for the environmental and ergonomic quality of computer equipment, in particular, monitors. The practical significance of the results lies in increasing of the competitiveness of personal computers, taking into account the safety recommendations for consumers (users) of the relevant equipment to strengthen the role of environmental aspects and cyber security requirements

Keywords: computer engineering; regulations; security; cyber security; consumer; environmental responsibility

Introduction

The relevance of the chosen research topic lies in the fact that Ukraine, being in a state of war from February 24, 2022, is confidently gaining a leading position in the IT-services market, taking a leading position among other countries in terms of access to the Internet. The

market of IT-goods and services being a segment of the economy is rapidly developing in accordance with the strategic course of the Ministry of Digital Information of Ukraine. According to the Ukrainian Institute of the Future (2018), digitalisation is the main mechanism for

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achieving Ukraine's strategic goal of increasing GDP eightfold (up to USD 1 trillion) by 2030. The priority programs determined by the Government of Ukraine (Official website of the Government Portal, 2024) are the digitisation of all basic public services for citizens and businesses. Therefore, it is impossible to achieve success without having the tools to implement the strategy: equipment, technologies, personnel. Events during the period of 2019-2023 (COVID-19, distance education and work, a full-scale invasion of the aggressor country into Ukraine) gave the computer equipment market new challenges related to the need to solve new tasks (Decree of the President of Ukraine No. 64, 2022). The importance of a clear system of requirements for the personal computers (PC) safety and its compliance by manufacturers with the provision of a guarantee for users make the chosen topic of research important and indicates its feasibility in the future.

With the development of computer technologies, user requirements for the personal computers safety are changing, so it is relevant to identify and analyse these changes. During 2020-2021, a revival of trade of this type of product was observed in connection with the need of remote work. Years 2022 and the first half of 2023 were marked by a decrease in sales, and at the end of 2023 an increase was observed, what indicates the balancing of supply and demand.

The authors L.O. Chernyshova & L.V. Novikova (2021) in their work researched information and communication technologies regarding methods of data collection, processing and transmission in order to obtain the latest data on the state of the object, process, phenomenon in order to create qualitatively new information. According to H. Cabezas (2022), a professor at the Research Institute of Applied Earth Sciences of the University of Miskolc in Hungary, the amount of electronic waste (computers, monitors, computer peripherals) in the United States counts 205 million units of computer products every year. The amount of e-waste is growing rapidly in India and China due to the high demand for computers. An increasing number of Ukrainian consumers have access to the Internet and they use personal computer in their professional activities, which requires compliance with consumer safety and cyber security requirements for computer systems.

According to O. Dovgan (2023), the global market for cyber security, as a component of the development of the ecosystem, is aimed at protecting personal computers (PCs), networks and databases from criminals and will reach 484.97 billion US dollars by 2030. In her work the author also emphasises that the issue of information security is extremely relevant in difficult conditions of uncertainty, economic crisis during military operations. In the works of I. Makarchuk & I. Fedulova (2023), issues of cyber security of computer devices, methods of protection against unauthorised

disclosure of confidential information of consumers are considered. In the article of the authors R. Odarchenko *et al.* (2023) the connection between the development of communication networks and the implementation of internationally accepted 5G standards is shown. It is shown that the transition to the 5G network requires compliance with cyber hygiene to prevent cyber threats. S. Fedushko (2023) points out the possibility of cyberattacks to cause damage to both PC consumers, companies, and the state, and considers the importance to develop new methods of protecting the information database and training users. According to the author, cyber security and cyber hygiene are critically important components of ensuring the security of computer systems. The priority is the issue of consumer (user) safety which is regulated by regulatory and legal documents. Research in this area will allow to find out the consequences of the impact of electronic devices on the health of consumers (PC users) and the environment and determine factors to minimise this impact.

In many countries of the world, working at a computer belongs to the category of dangerous activity due to the influence of various factors on the health of the consumer (user), therefore it is important to determine the methods of informing consumers about the personal computer safety requirements, which affect conscious choice during geopolitical, economic and social instability.

In the conditions of military operations in Ukraine, it is relevant not only to comply with the requirements of safety standards and energy efficiency of PCs and other electronic devices, but also to ensure the fulfillment of other tasks related to energy supply and energy saving (Decree of the President of Ukraine No. 722, 2019). According to occupational health researchers O.E. Kruzhilko *et al.* (2021), users of computer equipment may be exposed to various hazards: electrical, energy, fire, thermal, chemical, mechanical, radiation. For electronic devices, one of the best safety systems, recognised at the world level, is considered to meet the requirements of European directives, which declare the absence of a negative impact on the health of the consumer and on the environment. And therefore do not cause a threat to the user's life, economic development, trade relations and the reputation of the state on the international arena (Directive 2014/30/EU, 2014).

The purpose of the article was to determine the specifics of changes in the personal computer market in terms of increasing consumer attention to the environmental requirements of certifications in accordance with safety requirements. The task was also set to show the importance of informing consumers (users) about the safety of products for changes in the formation of companies strategy of selling personal computers.

Materials and methods

The object of the study was the system of compliance with PC security regulations, which was developed and

implemented by the countries of the European Union, its goals and competitive advantages for both enterprises and consumers (users), possible threats due to non-compliance with security requirements for the human user. Security requirements for PC users are covered in Technical Regulations and EU directives (Council Directive 90/270/EEC, 1990; Directive 2009/125/EU of the European Parliament and of the Council..., 2009; Directive 2014/30/EU of the European Parliament and of the Council..., 2014). The importance of cyber security under the conditions of a hybrid war has been studied. The requirements for convincing compliance with the environmental responsibility of manufacturers and the formation of an assortment policy of trade enterprises were also studied.

The theoretical and methodological basis of the study was the change and growth of the importance of consumers in the formation of modern requirements for the safety of computer equipment. Scientific publications from 2019 to 2024 in professional journals were monitored while conducting this research. Articles for analysis were selected in the following areas: commodity science; practice of modern materials science and commodity science; entrepreneurship and trade; safety of goods and products; ecology and technology of environmental protection; environmental engineering; medical sciences and public health. The search for scientific publications was carried out based on such keywords as “personal computer”, “computer equipment market”, “electronic devices”, “monitor consumer safety”, “security systems”, “technical parameters of security”, “safety”, “electronic waste”, “computer technology”, “cyber security”, “cyber hygiene”, etc. Data from the information sites of the State Statistics Service of Ukraine (State Statistics Service of Ukraine. Statistical Collection, n.d.), the Government Portal (Official website of the Government Portal, 2024) were also used. While working on the article, the content of the Laws of Ukraine was analysed: “On the Main Principles (Strategy) of the State Environmental Policy of Ukraine for the Period until 2030” (Law of Ukraine No. 2697-VIII, 2019), “On the Public Health System” (Law of Ukraine No. 2573-IX, 2022), “On General Safety of Non-Food Products” (Law of Ukraine No. 2736-VI, 2010), “On Electronic Communications” (Law of Ukraine No. 1089-IX, 2022); Decrees of the President of Ukraine “On the Goals of Sustainable Development of Ukraine for the Period up to 2030 (Decree of the President of Ukraine No. 722, 2019), Resolutions of the Cabinet of Ministers of Ukraine: “On Approval of the List of Types of Products for which State Market Surveillance Bodies Carry Out State Market Surveillance” (Resolution of the Cabinet of Ministers of Ukraine No. 1069, 2016), “On Approval of the Technical Regulation on the Establishment of a System for Determining Requirements for Ecodesign of Energy-Consuming Products” (Resolution of the Cabinet of

Ministers of Ukraine No. 804, 2018), “On Approval Technical Regulations on Ecodesign Requirements for Computers and Computer Servers” (Resolution of the Cabinet of Ministers of Ukraine No. 737, 2019). The European legal framework for safety requirements was analysed (Council Directive 90/270/EEC, 1990; Council Directive 89/391/EEC, 2008). The content and requirements of these documents were examined using the method of analytical analysis.

While conducting an research for the article, both general scientific and special methods were used: economic and statistical: a method of comparative analysis to determine the level of consumer access to the Internet in Ukraine and other countries of the world, an analytical comparison of various aspects of the computer market situation and generalisation of official data of foreign marketing structures, the State Statistics Service of Ukraine, system analysis of statistical and informational databases. The observation method was used to study the consequences of non-compliance with safety requirements when working with PCs of consumers of different gender and age. Methods of logical analysis and generalisation of scientific literature were used to make conclusions. The abstract-logical method was used to understand the relationship between such parameters as the degree of PC provision of consumers, the degree of accessibility to the Internet, the indicator of screen time and the possibility of potential dangers for the health of users. This method is also used to identify patterns and formulate assumptions regarding the impact of user safety on achieving the goals of the strategy of environmental policy of sustainable development. Methods of analysis and synthesis were used to generalise problematic issues and determine development trends in the outlined field. The method of forecasting was used to determine the prospects for the development of the PC market with the maximum possible indicators of safety and environmental responsibility of both manufacturers and consumers of electronic devices regarding the management of computer device wastes. With the help of this method, a conclusion was made about the expediency of further research in this field. Analytical method was used to determine the topic for further research.

Results and discussion

The modern market of computer equipment is quite saturated, dynamic and import-dependent. In the era of information technologies, such indicator of activity as efficiency, which can be achieved thanks to the use of a personal computer, is gaining more and more importance. PC belongs to high-tech products, the component base of which has individual technical characteristics and purpose, and this fact determines the choice of the consumer depending on his needs (Technical characteristics and purpose of the main components

of a personal computer, 2024). Many jobs, as of 2024, require the use of computers the business could not function without.

Operational assessment of the development of information and communication technologies is the basis of a balanced policy at the regional level for managing sustainable development and is a determining criterion for progress in a digital, economic and social society (Korepanov, 2018). The development of computer technologies is related to cyber security. An increase in cyber attacks is recorded in all countries of the world, mostly in the fields of education, health care, scientific research, government and military structures. According to O. Dovgan (2023), the number of encrypted attacks increased by 22% in 2022, which caused a significant increase in cyber threats in Asia (287%), Europe (119%) and Latin America (2851%).

According to statistics from the Official website of CERT-U (2024), in the period from 23:00 January 21, 2024 to 10:30 January 22, 2024, malicious files were downloaded more than 3000 times, and they successfully "infected" several dozen computer devices. A computer functioning in an affected state for about a week can have from 80 to 120 or more malicious (infected) files, not counting those that will be created on removable storage media that will be connected to electronic devices during this period.

Requirements for the safety of consumers (users) of personal computer equipment with screen devices were developed according to the European Council Directive 90/270/EEC dated 05/29/1990 (Council Directive 90/270/EEC, 1990). The minimum requirements for safety and health were taken into account by technical coordination with the provisions of the fifth framework Directive in the interpretation of Article 16, part 1 of the European Community Directive 89/391/EEC (Directive 2014/30/EU of the European Parliament and of the Council, 2014). The authors L.V. Pelyk & Y.A. Peleh (2018) investigated the requirements for the safety of non-food products, which are planned by the manufacturer during the design, production, and use of the product by the consumer during the service life, and which form the regulatory and legal framework.

Safety in Ukraine is regulated by state medical and sanitary rules (sanitary regulations), which are mandatory for the implementation of measures and requirements necessary to ensure state medical and sanitary standards, non-compliance with which poses a threat to the health and life of consumers, as it is specified in the Law of Ukraine No. 2573-IX (2022). The importance of guaranteeing product safety is emphasised by the integration of European and Ukrainian requirements in terms of consumer health protection. All dangerous factors available among PC consumers, must comply with scientifically based safety standards, hygienic and ergonomic requirements, approved by the resolution of the Chief State Sanitary Doctor of

Ukraine dated December 10, 1998 No. 7 (State Sanitary Rules and Regulations for Working with Visual Display Terminals of Electronic Computing Machines 3.3.2.007-98, 1998). This regulatory document defines the permissible parameters of electromagnetic non-ionising radiation and electrostatic field. Problems of determining the safety requirements of consumers when using goods of a technically complex group and regulating standards in order to provide them with the necessary information and favourable working conditions are discussed in works of such scientists as L. Andriievska *et al.* (2021), Y. Mineshita *et al.* (2021), D.O. Badea *et al.* (2022).

To assess the level of compliance of computers with environmental requirements, the operational characteristics of those available on the international market, and reference indicators established by the legislation of other countries are taken into account (Directive 2009/125/EU, 2009). Computers belong to the list of products (Resolution of the Cabinet of Ministers of Ukraine No. 1069, 2016), on which the State Production and Consumer Service carries out state market supervision in accordance with the current legislation (Law of Ukraine No. 2736-VI, No. 2735-VI, 2010). According to the requirements of the Technical Regulation (Resolution of the Cabinet of Ministers of Ukraine No. 737, 2019), manufacturers of stationary computers, monoblocks and laptops must provide information about their safety in technical documentation and post it on websites. The assessment of compliance of computers with the requirements of the Technical Regulations is carried out in accordance with the internal control procedure.

Changes in the economy, politics, technology and other external factors affect the personal computer market, and companies' quick adaptation to change is an instrument resulting in their success. It is important to develop a marketing product policy for such high-tech products as PCs. The author K.L. Lukach (2018) notes that the PC market is developing along with the development of the computer technology market, and the prospects of their development are connected with the improvement of the state of modern international trade. The main task of commodity policy, as noted by the authors E.V. Lisenyi & Yu.I. Dyachenko (2021), is the creation of a product that has competitive advantages and simultaneously gives maximum satisfaction to consumer and market needs and the company's profit. The number of users with access to the Internet worldwide is constantly increasing (Fig. 1). According to Digital 2023 research October global statistics report (2023) as of October 2023, the number of Internet users in the world was 5.3 billion, which was 65.7% of the total population. And as of January 2024, according to Global Digital 2024 (2024), the total number of users worldwide is 5.35 billion, or 66.2% of the world's population.

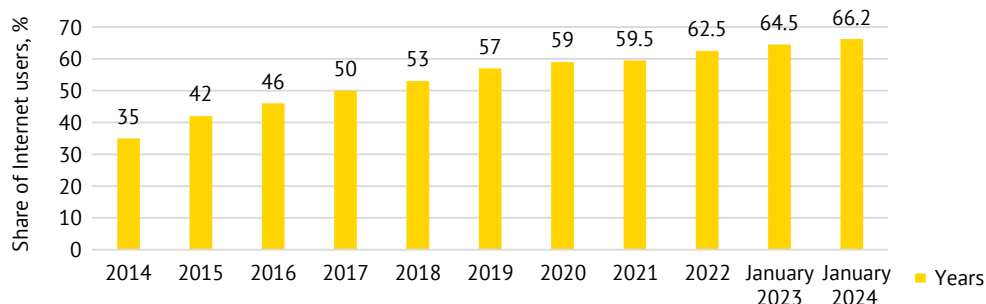


Figure 1. Share of users worldwide with access to the Internet for the period from 2014 to January 2024

Source: developed by the author based on the Official website of Statista (2024)

According to the mentioned data, within one year, from January 2023 to January 2024, the number of Internet users increased by 1.7%, and in 10 years (from 2014 to 2024), it has almost doubled. Laptops account for 57% of the time spent by consumers (Internet users) on a PC. It is established that the use of PCs and laptops has increased, similarly, the rate of access to the Internet network has increased by 3.9% relative to 2022 (State Statistics Service of Ukraine. Statistical Collection 2022, n.d.).

Analysing the standard of living in Ukraine during the years 1993-2023, despite the deep economic crisis of the past years, the coronavirus pandemic, military actions in Ukraine, and the low standard of living of the average citizen, it is worth noting Ukraine's achievements in the field of computer technologies and their implementation in various household segments (Table 1).

Data in Table 1 shows that as of 2020, each household already had one personal computer, tablet, laptop, or netbook. But there are households that have a personal computer for each family member. The indicator of access of personal computer users to the "Internet" network of the global electronic communication system, which operates according to international Internet protocols (Law of Ukraine No. 1089-IX, 2022), is important. Authors I.O. Pyshnograiev & I.O. Tkachenko (2022) believe that access to the Internet is one of the many indicators of human life, which are used for modelling the level of sustainable development. Statistics have shown a fairly significant difference in access to the Internet between users living in urban and rural areas (Solop, 2022). Data as of 2022 regarding the access of Ukrainian households to the Internet in 2021 are shown in Table 2.

Table 1. Number of PCs per 100 households

Years	2000	2005	2010	2014	2016	2018	2020
Personal computers, tablets, laptops, netbooks, pcs	1	9	31	63	80	90	98

Source: developed by the author based on Statistical Yearbook of Ukraine for 2021 (2022)

Table 2. Data on the share of households in Ukraine with access to the Internet at home (as a percentage of the total number)

No.	All households	Those who live	
		in cities	in the countryside
1			
2	82.7	87.4	72.8

Source: developed by the author based on the State Statistics Service of Ukraine Statistical Collection 2022 (n.d.)

The data in Table 2 indicate the insufficient level of access to the electronic communication network, especially in rural areas. The same opinion is shared by the authors I. Makarchuk & I. Fedulova (2023), who defined a high, but still insufficient, level of household access to the Internet. These authors believe that for the further development of the digital economy, at least 95% of the population should have access to the Internet at home. Despite a slight slowdown in access in 2022 (only 2%), 2023 trends indicated that by the end of 2023, almost 2/3 of the world's population had no Internet connection (Computer review, 2022). This is confirmed by the data presented by the analytical company in the annual report (Global Digital 2023, 2024).

According to the analytical report (Digital 2024: Ukraine, 2024), there were 29.64 million Internet users in Ukraine in January 2024, and the Internet access rate at the beginning of 2024 was 79.2% of the total population. From January 2023 to January 2024, the number of Internet users in Ukraine increased by 1.1 million (+3.7%).

The United Nations (UN), recognising access to the Internet as a "fundamental human right", declared universal connection of the population to the Internet as its goal by 2030. According to the chief analyst of Data Reportal and CEO of Kepios Simon Kemp (Digital 2023. October global statistics report, 2023), as of October 2023, the level of Internet access is below 20% in 9 countries of the world and less than 50% of the

population uses the Internet in 61 countries of the world. 2.85 billion of the world's population out of 8.06 billion, as of October 2023, remain without access

to the Internet. However, among the countries of the European Union, the largest share of Internet users is in Northern European countries (Fig. 2).

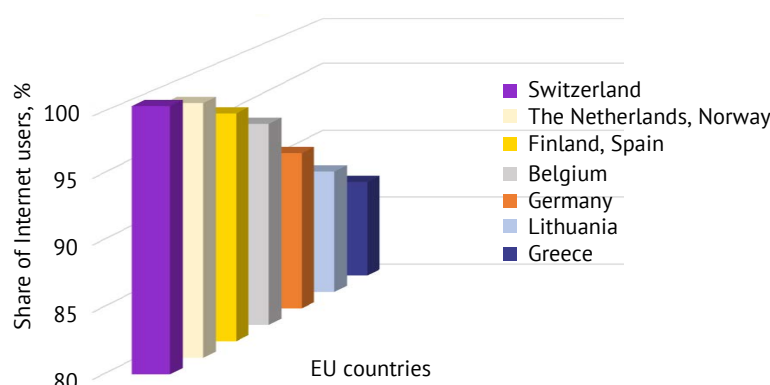


Figure 2. Share of Internet users in EU countries

Source: developed by the author based on the Official website of Eurostat Statistics Explained (2023)

According to the Official website of Eurostat Statistics Explained (2023), the first places in terms of access to the Internet in 2023 belongs to Switzerland (100%), the Netherlands (99.2%), Luxembourg and Norway (99%), and the average the indicator for the European Union was 91.5%. World analysts claim that

despite Ukraine lagging behind developed countries in terms of the number of computerised professional processes, in terms of the introduction of computer technologies, Ukraine belongs to the countries with high rates of computerisation, which is confirmed by the data in Table 3.

Table 3. Differentiation of households by the level of access to the Internet by computer users of different gender and age (data as of 2022)

No.	Persons in households	Households with people of certain age (in %)					
		all households	children up to 18 years	18 years and older	from 18 to 35 years	from 36 to 59 years	59 years and older
1							
2	Women	82.7	99.0	83.8	99.2	95.5	65.8
3	Men			87.9	99.2	93.8	69.3

Source: developed by the author based on Global Digital 2023 (2024)

According to the data of statistical observations (Statistical Yearbook of Ukraine, 2022), in 2019-2021, the retail turnover of enterprises retailing computers, peripheral equipment, and software grew dynamically and amounted (in millions UAH): in 2019 – 7530.5; 2020 – 9903.7; 2021 – 13527.2. At the same time, there was a decline in sales of personal computers due to the growing popularity of portable devices such as tablets and smartphones. Thus, according to the research data of L. Andriievska *et al.* (2021), the smartphone market was actively developing. However, there are certain segments of the market that remain stable or even grow in terms of sales, such as gaming computers and personal computers for professional use. The gaming segment remains one of the most dynamic in development.

The Ukrainian market still remains quite profitable for well-known computer systems manufacturers despite the fluctuations associated with the pandemic and the war. According to the analytical research company International Data Corporation (2023), the personal computer market saw its most significant decline in 2023, caused by the result of the COVID-19 pandemic, which affected the growth of demand for PCs and other computing tools for remote work and distant learning in 2021-2022. The company's analysts believe that the market and the supply of personal computers in 2024 will grow by 3.7%, to 261.4 million units compared to the previous year. This level will exceed the indicators of 2018, but will be lower than the similar indicator in 2019, when the pandemic had not yet affected the personal computer market (Table 4).

Table 4. Volumes of supply of personal computers and netbooks on the world market

Years	2018	2019	2020	2021	2022	2023	2024*	2027*
million units	259.6	266.1	302.6	341.04	285.1	248.5	261.4	287.9

Note: *calculated based on forecasts of the analytical company International Data Corporation

Source: developed by the author based on International Data Corporation (2023)

In the modern market of personal computers, several key trends in the formation of assortment policy are observed, namely: flexible configurations and individualisation; increased demand for gaming devices; development of artificial intelligence and wireless technologies; increasing the amount of memory and speed; environmental responsibility; high mobility; focus on high-performance workstations. All this prompts the release of new products and components, such as high-performance graphics cards, processors and other components aimed at gamers.

High-speed SSD storage, new processor architectures, improved screens and other technological innovations affect the formation of competitive advantages of users and the competitiveness of companies. But the most important consumer advantage for the user when purchasing a personal computer is safety indicators. The goals of sustainable development of Ukraine for the period up to 2030 identified as a priority vector the safety of life and health of consumers, which is impossible without access to safe and high-quality industrial goods (Decree of the President of Ukraine No. 722, 2019).

Authors D.V. Diachkov *et al.* (2020) consider the increase of the competitive position of companies and ensuring competitive advantages with the help of assortment to be one of the important goals of the product policy of enterprises. The transition to resource-saving technologies in the field of computer technologies, the full implementation of environmental impact assessment is provided for by Law 2697-VIII, which adopted the Strategy of the State Environmental

Policy of Ukraine for the period until 2030 (Law of Ukraine No. 2697-VIII, 2019) in 2019. Consumers and companies are increasingly paying attention to the environmental aspects of their products and compliance with safety standards. As noted by the authors V.D. Khurdey *et al.* (2021) the purchasing behavior of consumers regarding the priority in the crisis is changing towards product safety. This is a key issue for business, as companies that pay attention to environmental responsibility can have a competitive advantage. It is worth noting that the COVID-19 pandemic has had a significant impact on the PC market due to the increased demand for workstations for remote work and distant learning. Existing standards and certification programs help consumers and manufacturers in the evaluation and selection of computer monitors that meet ergonomics, safety and environmental indicators. According to the authors V. Vishnevsky *et al.* (2021), environmental requirements for computer monitors are becoming increasingly important in the world, in conditions of growing attention to sustainable development and environmental responsibility.

Standards and certification programs establish requirements for ergonomics, energy efficiency, use of environmentally-friendly materials and reduction of environmental impact. Safety certification for computer monitors may include indicators of electromagnetic compatibility, safety in compliance with electrotechnical standards, migration of harmful substances and other important parameters. The most frequently used standards and certification systems are listed in Table 5.

Table 5. Security standards and computer equipment certification systems

Conditional abbreviation	Full name, developer	Purpose and characteristics
CE (Conformité Européenne)	European certificate of conformity, European Union	Testifies to compliance with all European safety standards and other requirements, is a mandatory condition for the sale of radio-electronic products in EU countries
FCC	Federal Communications Commission	Determines compliance with electromagnetic compatibility and other aspects related to the electronics quality and safety
ISO 9241	International Organization for Standardization	Defines workplace ergonomics requirements for work with display screen equipment
ISO 13406	International Organization for Standardization	Sets the classification of defects on LCD screens
Certification ENERGY STAR		Establishes requirements for energy efficiency of electronic products
EPEAT Certification	Electronic Product Environmental Assessment Tool	It takes into account such aspects as energy efficiency, material use, recycling and other parameters
RoHS Directive	Restriction of Hazardous Substances	Limits the use of certain hazardous substances (lead, mercury, cadmium and others) in the production of electronics, monitors in particular
TÜV Certification System	Technischer Überwachungsverein, Germany	Tests and certification to ensure the safety and quality of electronic products, monitors in particular
MPR II	National Department of Sweden (SWEDAC – Swedish National Board for Measurement and Testing)	Establishes requirements for electromagnetic radiation levels at a distance of 50 cm from the monitor, permissible level of electromagnetic field intensity: • in the frequency range from 5 Hz to 2 kHz – 25 V/m; • in the frequency range from 2 to 400 kHz – 2.5 V/m.
TCO'92	The Swedish Confederation of Professional Employees, Sweden	Regulates even lower radiation levels at a distance of 30 cm from the PC monitor. Contains requirements for the efficiency of energy consumption of monitors, as well as electrical and fire safety

Table 5. Continued

Conditional abbreviation	Full name, developer	Purpose and characteristics
TCO'95	The Swedish Confederation of Professional Employees, Sweden	Contains requirements for extended range of PC parameters, ergonomic and environmental properties, radiation, power consumption, monitor screen generation, image brightness and keyboard requirements
TCO'99	The Swedish Confederation of Professional Employees, Sweden	Contains stricter requirements for radiation level. Permissible level of electromagnetic field strength: • in the frequency range from 5 Hz to 2 kHz – 10 V/m; • in the frequency range from 2 to 400 kHz – 1 V/m, ergonomic, environmental indicators, energy consumption of monitors, system units, keyboards
TCO'03 TCO'06	The Swedish Confederation of Professional Employees, Sweden	Contains strict requirements for environmental indicators
Certified Certification Standard	Sweden	Defines requirements for environmental and ergonomic quality of computer equipment, monitors in particular
The DfE Approach	Design for Environment	It includes the development of products with the aim of minimising the impact on the environment at all stages of their life cycle: production, use and withdrawal from circulation
UL	Underwriters Laboratories	Certification of safety and other properties of electrical and electronic products

Source: developed by the author based on Computer review (2022)

Individual organisations develop recommendations to ensure the safety of electronic equipment and computer systems. For example, the International Electrotechnical Commission (IEC) and the European Committee for Electrotechnical Standardization (CENELEC) develop safety standards for personal computers and other electronic devices. In addition, countries can define their own national standards and requirements for the security of electronic devices, including personal computers. For example, in the EU, products must meet the requirements of the Electromagnetic Compatibility Directive (Directive 2014/30/EU, 2014) and the Low Voltage Directive (Directive 2014/35/EU – Low Voltage Directive, 2014).

Compliance with electromagnetic compatibility is important in order to prevent negative effects on other electronic devices and to ensure the normal functioning of the computer monitor. Despite the statements of consumers regarding the possible negative impact of electromagnetic radiation (thermal, non-thermal and specific types) on health, scientific studies do not yet provide clear confirmation of a large risk. The arguments of scientists are reduced to the fact that the existing standards for electromagnetic compatibility establish permissible levels of radiation for electronic devices in order to protect users. A large amount of scientific research has been aimed at studying the thermal effect on the temperature of tissues as a result of exposure to an electromagnetic field. Generally, electronic devices, particularly computers, do not generate enough energy to have a significant thermal effect. Some studies are looking into possible non-thermal effects, but so far scientists have not reached a consensus

on the existence of a major risk to the health of users. Specific effects are the subject of studies examining the possible effects of electromagnetic radiation on specific aspects of health, namely sleep, cardiovascular and nervous system functioning, fertility, etc. (Badea *et al.*, 2022).

A significant argument regarding the potential danger is the use of PC monitors, that was the reason to approve the user safety and health requirements when working with screen devices (Order of the Ministry of Social Policy of Ukraine No. 207, 2018). Most digital devices, including PCs, emit blue light when in use. Artificial light displays contain high energy light with a high frequency spectrum. Research results conducted in Japan by Y. Mineshita *et al.* (2021), proved the negative impact of blue light from computer screens on the circadian cycle, sleep duration, energy metabolism, and academic performance of primary school students. This is due to the nature of the short waves, which are perceived as blue, in the visible light spectrum, and which have a significant effect on the phase delay of the circadian rhythm (Wahl *et al.*, 2019). According to the results of experiments conducted by L. Tähkämö *et al.* (2019) it was established that disruption of the circadian rhythm and decrease in sleep quality of users of digital technological devices, computer monitors in particular, occurs as a result of melatonin suppression.

Although the average user spent 21 minutes less on the Internet in 2022 compared to 2021, this indicator increased by 4 minutes in 2023. The data in Table 6 prove that the time prescribed by sanitary and hygienic standards was exceeded.

Table 6. Duration of time spent by consumers on the Internet per day

Years	2019	2020	2021	2022	2023
Duration, hours	6.38	6.54	6.58	6.37	6.41

Source: developed by the author based on Official website of the State Statistics Service of Ukraine. Statistical Information (2024)

According to the data of the global overview report (Digital 2022: Global overview report, 2022), the largest time spent (in hours) on connected technologies per day is observed among users of: South Africa (10.46); Philippines, Colombia, Brazil (9.25); China (5.15); Japan (4.5). A significant decrease in the duration of Internet use in 2023 by 56 minutes of PC consumers in

Japan can be explained by the tradition of taking care of their health, culture, and the majority of the country's population are middle-aged people, which is confirmed by the data of the digital report (Digital 2023. October global statistics report, 2023). Figure 3 shows a direct relationship between the age of consumers (users) and the length of time spent using the Internet.

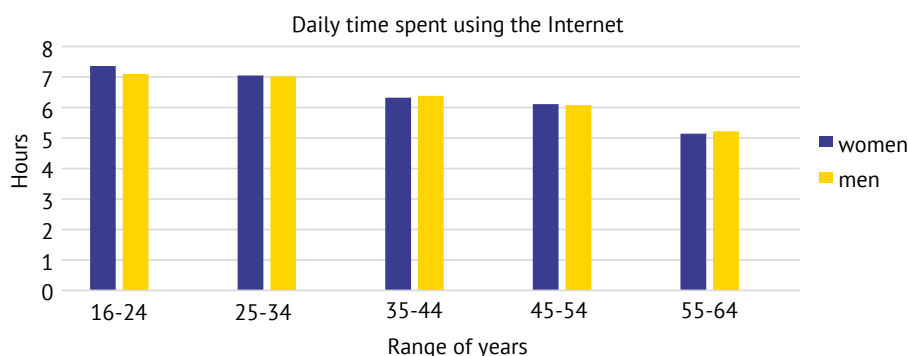


Figure 3. The amount of time spend by consumers using the Internet

Source: developed by the author based on Digital 2023. October global statshot report (2023)

In general, the average time spent on the Internet is characterised by a tendency to decrease when the consumer age increases. Due to the increasingly widespread use of the Internet, the duration of time spent by primary school students at the computer monitor is growing annually. The effect of radiation is especially dangerous, blue light in particular, on consumers – students of primary school and teenagers, who spend in front of computer screens extra time.

Ukraine, having 4% of GDP in the field of information technologies, is confidently advancing in the market of IT-services. During 2013-2023, a lot of information appears regarding the study of solid waste, which includes electronic waste, both consumers (users) and producers themselves are responsible for. Scientists M.V. Ruda *et al.* (2021), I.Yu. Yegorov *et al.* (2022), M.-H. Le *et al.* (2023) and many other have devoted their research works to the problems of handling and management of electronic wastes

It is important to follow the recommendations specified in the standards of international organisations in order to guarantee the safe use of electronic devices and computers. It is also related to the general impact on human health. Significant risks to the health of a person who actively uses electronic devices have not been sufficiently proven, so research in this area will be continued.

Conclusions

According to the research results, it was noted that sustainable development is impossible without taking into account the competitive advantages of commercial products. In today's digital society the determining criteria for the competitiveness of personal com-

puters is determined by their compliance with safety requirements, regulated in view of European practices. Safety for PC users is regulated by the requirements of the European Council Directive, which defines the following principles: prevention of occupational risks, safety and health protection, elimination of accidents, employer and staff responsibilities and informing about the results of risk assessment for PC users and management. The UN has defined access to the Internet as a "fundamental human right" and declared the global connection of the world's population to the Internet by 2030. However, according to research, there is an insufficient level of accessibility to Internet services.

Studying the level of satisfaction of consumer demand for safe computer devices is important both for the possibility of the most complete satisfaction of ergonomic and environmental needs. The study of security requirements is aimed at determining the factors affecting the change in demand for PCs. It has been confirmed that most PC monitors become sources of danger, therefore they must comply with the regulations of safety standards. The given characteristics of standards and certification systems prove the change of safety requirements to implementation of stricter parameters.

Consumers and companies are paying increasingly more attention to compliance with the requirements of personal computer safety regulations, environmental and ergonomic ones in particular. Due to the fierce competition in the world of computer technology and devices, opinions about safety differ among manufacturers, medical professionals and consumers. To stay in trend manufacturing companies and are placing greater emphasis on the ecological parameters of their products. The production of energy-efficient and easily

recyclable components, as well as the implementation of secondary use programs, are becoming relevant.

It has been proven that absolutely safe monitors and processors do not exist, as the consequences of exposure to hazardous factors on the consumer's body for several years, or on their descendants, are unknown. In addition, scientists are considering the issue of the negative "informational" impact of the electromagnetic field on consumers.

Considering environmental requirements, consumers can choose electronic devices with better environmental performance, and manufacturers can focus their efforts on creating sustainable, environmentally-friendly equipment. It is shown that due to the rapid development of technologies and a short service life, it causes the rapid replacement of old modifications of devices with new ones, which affects the rapid accumulation

of electronic waste. It is also relevant and expedient to direct scientific research in the following works to the issue of determining the main trends of the world, in particular, European and Ukrainian policies in the field of electronic waste management and minimising harm to the environment and directly to the health of consumers.

A further research perspective is the analysis of the state of improvement and implementation of the main norms of normative legal acts aimed at improving the guarantee of consumer safety from potentially hazardous factors of PCs influence.

Conflict of interest

None.

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Вимоги до безпеки персональних комп'ютерів

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Анотація. Актуальність дослідження полягає у гарантуванні безпеки персональних комп'ютерів для споживачів (користувачів) та дотримання вимог технічних регламентів в цій частині. Метою дослідження було визначення та аналіз чинників формування асортименту персональних комп'ютерів в умовах дії невизначеності економіко-соціальних особливостей сучасності із фокусуванням на аспектах безпеки та екологічної відповідальності комп'ютерної техніки, як механізму пріоритетності для споживачів. Зроблений акцент на кібербезпеці, важливості захисту персонального комп'ютера від кібератак. У дослідженні були використані методи системного аналізу статистичних баз даних. Відзначені високі темпи розвитку України у сфері комп'ютеризації багатьох ділянок господарства, економіки за 1993-2023 роки. Доведено, що у кожному господарстві, станом на 2024 рік, є по одному персональному комп'ютері, планшету, ноутбуку чи нетбуку. Показано зміни в економіці, політиці, технологічних аспектах та інших зовнішніх чинниках, які можуть впливати на ринок персональних комп'ютерів. Відзначена здатність компаній пристосовуватися до змін і вимог, як ключового джерела їхнього успіху. Наведені ергономічні, антропологічні, психофізіологічні вимоги до екранних пристроїв, що гарантують безпеку споживачів (користувачів). Визначені умови відповідності персональних комп'ютерів вимогам технологічних регламентів в частині екодизайну, спрямованих на покращення екологічної складової безпеки згідно із вимогами споживачів. Показано, що сучасний ринок персональних комп'ютерів має декілька ключових тенденцій у формуванні асортиментної політики, а саме: гнучкі конфігурації та індивідуалізація; підвищена увага до геймерського сегменту; розвиток технологій штучного інтелекту; підвищення обсягів пам'яті та швидкодії; екологічна відповідальність; розвиток бездротових технологій; висока мобільність; орієнтація на високопродуктивні робочі станції. Визначено, що для бізнесу є важливим дотримання вимог екологічної безпеки, оскільки компанії, які приділяють увагу екологічній відповідальності, можуть мати конкурентну перевагу. Показано, що найпоширенішими є стандарти та системи сертифікації персональних комп'ютерів, які є серією сертифікаційних стандартів, що визначають вимоги до екологічної та ергономічної якості комп'ютерного обладнання, зокрема моніторів. Практична значимість результатів полягає у підвищенні конкурентоспроможності персональних комп'ютерів, із урахуванням рекомендацій безпеки споживачів (користувачів) відповідної техніки щодо посилення ролі екологічних аспектів та вимог кібербезпеки

Ключові слова: комп'ютерна техніка; регламент; безпека; кібербезпека; споживач; екологічна відповідальність