

# Guideline for Green Design of Computer Products

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**Abstract.** This paper regulates the purposes and basic principles of green design of computer products, and provides the green design requirements and procedures of computer products. This paper will provide the guiding targets for the computer product manufacturer, standardize the enterprise behaviour of computer product, and lead the computer product enterprise to implement the product green design, which is of great significance in promoting the transformation and upgrading of computer product, enhancing the green manufacturing level and increasing the green product supply.

## 1 Introduction

With the progress of science and technology and the rapid development of various computer technology and network technology, the development of computer products has entered a fast and new era. Computer has been developed from single function and large volume to complex function, small volume, resource networking and so on. At present, China is experiencing an important period of industrial structure adjustment. The industry has changed from resource intensive and labor-intensive to capital intensive and technology intensive. Therefore, there is a huge demand for the development of the computer industry. In 2021, China's total output of computer products has reached 450 million, including about 230 million laptops and 70 million desktops, and others are tablet computers, workstations, industrial control terminals, and so on.

The green design of computer product is also called "environmental conscious design", "green design" or "design for the environment". It intends to optimize the environmental impact of computer product and bring the environmental factors into the product design and development activity, so as to improve the environmental performance of computer product within its life cycle. As shown in the study, 80% resources consumption and environmental impact are subject to the product design phase. At the design phase, it is required to fully consider the existing technical conditions, raw materials guarantee and other factors, and optimize the solution against the resources and environmental problems at each link, which may maximize the resources conservation and reduce the environmental pollution from the source [1, 2].

## 2 Purposes and basic principles of green design of computer products

The purpose of computer product green design is to reduce the environmental pollution, and enhance the recyclability rate of computer product, so as to reduce the adverse environmental impact of computer product during its entire life cycle, and develop the more ecologic, economic and sustainable computer product system.

The basic principles for green design of computer product include: the requirements-oriented, advanced technology, scientific methods, environmental-friendly, economic rationality, and abidance by law.

## 3 Green design process and key points of computer products

Computer product ecological design usually includes the following processes: a) Product demand analysis; b) Identification of environmental factors; c) Introducing environmental factors into the process of product ecological design; d) Life cycle analysis and evaluation; e) Ecological design information sharing.

### 3.1 Product Demand Analysis

Designers should carry out product green design while meeting product functions, and comprehensively consider factors such as resources, energy and environment, as well as the needs of laws and regulations, technical standards and customer market, so as to meet the goal of product green design.

Product demand analysis includes but is not limited to the following points: a) Product green design objectives;

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b) Product function design; c) Requirements of laws and regulations; d) Technical standards; e) Customer and market needs.

### 3.2 Identification of Environmental Factors

Identifying typical environmental factors and corresponding environmental impacts is an important prerequisite for

computer product green design. Designers can identify environmental factors according to GB/T 28179 [3]. The identification and analysis of these environmental factors can provide a basis for ecological design, identify, evaluate and determine important environmental factors as soon as possible, and consider introducing these factors in the process of product design and development, so as to improve the environmental performance of products. See Table 1 for the identification process of environmental factors of computer products.

**Table 1.** Identification process of environmental factors of computer products

Environmental factor	Design considerations	Product life cycle phases involved				
		Raw material acquisition	Manufacturing	Transportation and distribution	Use and maintenance	End of life disposal
Hazardous substances	Compliance and reduction of hazardous substances in raw materials (parts, coatings, etc.)	√	√		√	√
	Compliance and reduction of the use of hazardous substances in packaging materials	√		√		√
	Compliance and reduction of the use of hazardous substances in production accessories	√	√			
	Compliance and reduction of the use of hazardous substances in consumables	√			√	√
Material efficiency	Reduce the types of raw materials	√			√	√
	Reduce the consumption of raw materials	√		√		
	Green process of material processing		√			
	Improve the recycling performance of raw materials	√				√
	Reduce the environmental impact of raw material production stage	√				√
	Reduce the consumption of packaging materials	√		√		√
	Improve the recycling performance of packaging materials	√				√
	Reduce consumption of consumables	√			√	√
	Improve the recycling performance of consumables	√			√	√
	Reduce the consumption of production auxiliary materials	√	√			
Battery or power supply	Battery or power supply compliance	√			√	√
	Consider the disassembly of battery or power supply				√	√
	Consider the life of the battery or power supply				√	√
Energy consumption	Improve product energy efficiency				√	

Environmental factor	Design considerations	Product life cycle phases involved				
		Raw material acquisition	Manufacturing	Transportation and distribution	Use and maintenance	End of life disposal
	Reduce energy consumption in product production process		√			
Pollutant emission	Reduce the emission of harmful substances in the use stage of products				√	
	Reduce noise emission during product use				√	
Product longevity	Reasonably extend product longevity (modular design, parts replaceability, software upgrade)				√	
Recycling, utilization and disposal	Consider reuse, recycling and reasonable disposal					√
	Reduce environmental toxicity of final waste					√

### 3.3 Introducing environmental factors into the process of product ecological design

#### 3.3.1. Product Function, Performance and Process Design.

The design and development of products shall meet the requirements of GB/T 9813.1 [4] and GB/T 9813.2 [5], including the appearance and structure, function and performance, process, safety, power adaptability, noise, electromagnetic compatibility, environmental conditions, reliability, and so on.

On the basis of meeting the requirements of product function and performance, the concept of life cycle management is incorporated into the design and development process of the whole product life cycle, including the conceptual design and structural design before product finalization.

#### 3.3.2. Improve Material Efficiency.

The method of improving material efficiency can be considered in the process of product green design according to GB/T 34144 [6]. When selecting materials, the designer should consider the following factors: a) Reduce the types of materials used; b) Reduce the amount of materials used, so as to reduce the weight of products; c) Use materials that have little impact on the environment; d) Use materials that are easy to recycle.

#### 3.3.3. Restrict the Use of Hazardous Substances.

Reducing or eliminating the use of hazardous substances and products should be one of the priorities in product design. Designers need to know the management list of banned hazardous substances and hazardous products in international, regional and product export target countries

in time to ensure that the products sold in the target countries meet the requirements of relevant laws, regulations and standards. Minimize the use of substances that require special separation or disposal at the end of product life. For substances requiring special treatment or disposal, provide appropriate information to product users and recyclers. The use of restricted substances in products should be identified in accordance with SJ/T 11364 [7], and the inevitable use of hazardous substances and reasons should be recorded in the design process. Appropriate design methods should be adopted to reduce the possibility of using harmful substances in parts with high risk, such as microcomputer product shell, keyboard and various keys, mouse shell, touch panel and external power cord.

#### 3.3.4. Reduce Chemical Emissions.

Appropriate design methods should be adopted to reduce the possibility of chemical emissions with negative environmental impact during the use of products, such as volatile organic pollutants.

#### 3.3.5. Reduce Noise Emission.

The designer shall consider the technology to reduce noise emission, so that the product shall meet the requirements on noise in accordance with GB/T 9813.1. The method of reducing noise emission should be adopted in accordance with GB/T 34959 [8].

#### 3.3.6. Improve Energy Efficiency.

The product should be designed and developed to meet the requirements of GB/T 28380 [9] on the energy efficiency limit and energy efficiency grade of microcomputer. The method in GB/T 34959 should be adopted to improve the energy efficiency of products. In the energy-saving design, the expected use mode of microcomputer products should be fully considered, including working mode, energy-saving mode, off mode and no-load mode. Appropriate design

methods shall be adopted to minimize the energy consumption under various modes, such as passive cooling to avoid the additional energy consumption caused by the use of fans.

### **3.3.7. Consumables.**

Consider the design and disposal of consumables based on the principle of reduction, modularization and reuse: the function of reducing or saving the use of consumables; Convenient replacement or maintenance of consumables. The manufacturer can provide users with information about the correct use of consumables and, where appropriate, the end of life processing information of consumables.

### **3.3.8. Battery.**

The design of batteries in computer products should be considered from the aspects of battery type, control of harmful substances in batteries, battery durability, easy disassembly and recycling, and so on.

### **3.3.9. Reasonable Extension of Product Life.**

When technically and economically feasible, the service life of the product design shall be reasonably extended and matched with the service life of components, and it is easy to upgrade and repair. The methods to reasonably extend the service life of products include: a) Using common mechanical packaging (such as cover and chassis) or common parts or product types, which are the same parts used by multiple models or the same parts used by the same product for multiple generations, and allowing the reuse of common parts; b) Use standardized components, which can be easily replaced or repaired; c) Modular design; d) Whenever the reuse of modules, components and products is applicable, the reused components should be identified.

When considering the design method of prolonging product life, computer products can be designed in terms of modularity, compatibility and upgrading; The CD-ROM drive, hard disk and main memory randomly configured for desktop microcomputer can be upgraded.

### **3.3.10. Reuse, Recycling and Reasonable Disposal.**

The design of products should be convenient for reuse, recycling and reasonable disposal at the end of product life. The requirements for reuse, recycling, recycling, treatment and disposal of waste products shall be implemented in accordance with GB/T 23685 [10].

Designers need to understand the regulations and standards related to the disassembly and recycling of waste electrical and electronic products to ensure the compliance of product sales in the target countries. The end-of-life disposal of products should be designed according to GB/T 31371 [11] and GB/T 31372 [12].

### **3.3.11. Packaging.**

When determining materials and designing packaging, designers should consider the following options: Reduce the

use of packaging materials through reasonable structural design and material selection, so as to reduce the weight and size of packaging when fully protecting products; Use materials that have little impact on the environment; Use recyclable materials; Use renewable / recyclable materials.

The minimum requirements for designers shall ensure compliance with relevant domestic and foreign regulations and standards related to the following contents: Restricted use of hazardous substances and hazardous products; Regeneration capacity, such as reuse or recycling; The proper identification of packaging materials should be in accordance with the marking requirements of GB/T 18455 [13].

## **3.4 Product Life Cycle Analysis, Evaluation and Continuous Improvement**

In order to confirm and improve the level of product ecological design, the method of life cycle analysis and evaluation can be used to establish and implement the procedure of ecological design review and continuous improvement. The process of product life cycle analysis, evaluation and continuous improvement of product ecological design includes the following steps:

- a) Product Description: determine the product boundary and objectives of the design, including: model, specification, function and performance, product life expectancy, and so on;
- b) Product demand analysis: requirements of interested parties in product function, resources, energy, environment, and so on;
- c) Product life cycle diagnosis: analyze the whole life cycle of benchmark products, put forward the potential to improve environmental performance, identify key environmental factors and put forward improvement needs;
- d) Preliminary evaluation of product ecological design scheme: conduct preliminary evaluation on the improved scheme and confirm the product ecological design scheme;
- e) Product life cycle assessment: complete the whole life cycle assessment report of benchmark products and target products according to Appendix A in GB/T 24040 [14], GB/T 24044 [15] and GB/T 34664 [16];
- f) Product environmental performance evaluation: analyze and compare the environmental performance of the whole life cycle evaluation report of the target product and the benchmark product, and give the conclusion of the environmental performance of the target product;
- g) Scheme selection: select the ecological design scheme of target products and benchmark products;
- h) Scheme review: review the best scheme;
- i) Scheme output: confirm whether the design scheme of the target product meets the product requirements. If so, carry out design implementation, effect evaluation and information sharing; If the expected product demand is not met, continue to put forward improvement suggestions, and re-evaluate the scheme after adjustment until the expected product demand is met.

### 3.5 Ecological Design Information Sharing

As part of the ecological design process, organizations in the supply chain should disclose relevant information about products or product types to other organizations related to design and development, so as to enable these organizations to achieve the ecological design objectives.

The contents of information exchange include: products, manufacturing processes and relevant resources used in product operation; Relevant emissions of products; Guidelines for improving environmental performance; Treatment at the end of life; Declaration of compliance with regulations and requirements of interested parties.

## 4 Conclusions

Green design of computer products is to provide guidance for enterprise designers in green design when carrying out product design and development, from the basic principles of product green design, product demand analysis, environmental factor identification, design and development process, life cycle analysis and improvement, and information sharing, etc. Identify environmental factors at all stages of the life cycle, such as waste recycling, propose green design requirements for products in terms of resources, energy and environment, improve the renewable utilization rate of products, reduce adverse environmental impacts in the entire life cycle of products, and develop more ecological, economic and sustainable product systems.

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5. GB/T 9813.2 General specification for computer—Part 2: Laptop microcomputer
6. GB/T 34144 Guidance on material efficiency considerations in environmentally conscious design of electrical and electronic products
7. SJ/T 11364 Marking for control of pollution caused by electronic information products
8. GB/T 34959 Audio/Video, information and communication technology equipment—Environmentally conscious design
9. GB/T 28380 Minimum allowable values of energy efficiency and energy grades for microcomputers
10. GB/T 23685 General technical specifications of recovering for waste electrical and electronic equipment
11. GB/T 31371 Requirements of disassembly and treatment for waste electrical and electronic product—Desktop microcomputer
12. GB/T 31372 Requirements of disassembly and treatment for waste electrical and electronic product—Portable microcomputer
13. GB/T 18455 Package recycling marking
14. GB/T 24040 Environmental management - Life cycle assessment - Principles and frameworks
15. GB/T 24044 Environmental management - Life cycle assessment - Requirements and guidelines
16. GB/T 34664 General assessment principles for electrical and electronic eco-design products