The China Sustainable Energy Program

The David and Lucile Packard Foundation
The William& Flora Hewlett Foundation in partnership with
The Energy Foundation
Project No.: G-0402-07265

Technical supporting report for China energy efficiency standard for external power supplies

China National Institute of Standardization

December 2005

Technical supporting report for China energy efficiency standard of external power supplies

Project Manager: Zhang Guoqin

Project researchers:

Chen Haihong	Senior Engineer	China National Institute of Standardization
Li Aixian	Senior Engineer	China National Institute of Standardization
Li Aizhen	Senior Engineer	China Standard Certification Center
Li Zhanshi	Professor	China Power supplies Society
Liu Qunxing	Senior Engineer	China CEPREI Laboratory
Song Danmei	Senior Engineer	China CEPREI Laboratory
Chen Dawei	Senior Engineer	China Electronics Standardization Institute
Lin Dong	Manager	Delta Electronics (Shanghai) Co., Ltd.
Cheng Jianhong	Senior Engineer	China National Institute of Standardization
Liu Wei	Senior Engineer	China National Institute of Standardization

Contents

List of Figures

List of Tables

Executive Summary

(I) Project Outline

In recent years, coupled by the rapid development of our national economy and in particular the blind investments and low-level expansion of some regions and high energy-consuming industries, China has been witnessing an ever-worsening shortage of power supplies. About 20 provinces are obsessed to different degrees by the short power supplies and the restricted use of electricity each year, imposing some negative impacts on the regular production and life. The 16th National Congress of the CPC set up the great goal of quadrupling the GDP in 2010 when compared to that in 2000, and realizing the industrialization. However, together with the population increase, the accelerated process of industrialization and urbanization, and especially the rapid growth of heavy chemical industry and transportation, the energy demands will increase dramatically and the economic development will face more serious energy-related restraints and problems. Considering the relative energy shortage of our country and the huge investment, long cycle and a series of restrictive problems like the transportation and water resources, the energy conservation is an essential measure of easing the energy shortage and resolving the energy and environment problems, an important way to increase the quality and benefit of economic growth, and an inevitable demand for enhancing the enterprise competitiveness.

Our country has always paid much attention to the energy conservation. In recent years, for the purpose of relieving the conflicts of energy restraints, a series of policies and measures have been promulgated. In 2003, the principle of "prioritizing the energy conservation and deeming the efficiency as a basis" was ranked the first of the eight energy strategies in our country. In 2004, the State Council issued the Document No.30, namely, the Circular on Developing the Resources-Saving Activities across the Country, calling upon the whole country to develop the national energy conservation activities and publicities for three consecutive years. In 2004, the State Development and Reform Commission and the General Administration of Quality Supervision, Inspection and Quarantine of the People's Republic of China jointly issued the Measures for Administration of Energy Efficiency Labels. In November 2004, the State Commission of Development and Reform issued for the first time the Long and

Medium-Term Special Plan on Energy Conservation. In December 2004, General Secretary of the CPC, Hu Jintao made an important speech at the central economic working conference, and pointed out that “it’s necessary to formulate and force the implementation of more rigorous energy conservation, material-saving and water-saving standards”. In 2005, the Ministry of Finance and the State Commission of Development and Reform jointly issued the Implementation Opinions on Government Procurement of Energy Conservation Products. The 5th Plenary Session of the 16th Central Committee of CPC that has just concluded sets up the goal of “the Eleventh Five-Year Plan”, namely, quadrupling the GDP per capita in 2001 when compared to that in 2000 and reducing the energy consumption per unit GDP by about 20% when compared to the end of “the Tenth Five-Year Plan”. It’s proved again that the energy conservation work is crucial to the sustainable development of our national economy. Thanks to the limited investment and fast effect, the formulation of energy-consuming products, the implementation of energy efficiency standards and labels, the certification of energy conservation products and the attainment of energy conservation and environment-friendly goal are one of the most preferential policy tools and also one component for all the countries to shape the trade barriers. According to the statistics of International Energy Agency, 34 countries have successfully implemented the energy efficiency standards and labels. On January 1, 1998, China promulgated and implemented the Law of the People's Republic of China on Conserving Energy, and explicitly put forward the certification system of energy conservation products and the elimination system of high energy-consuming products to boost the continuous increase in the energy conservation technical level of our energy-consuming products, and to create a standardized market with fair competition. In order to coordinate the implementation of the Law on Conserving Energy, China has developed and promulgated, under the attention and support of the State Commission of Development and Reform and the National Standard Committee, 21 compulsory national energy efficiency standards.

As the living levels of Chinese people continuously rise and the conditions of office work increasingly improve, a growing number of electric products with external power supplies (also called the power adapters), e.g., the cell phones, laptop computers, digital cameras and MP3 players have entered the families and offices. The rapid popularization of cell phones, laptop computers and digital products has enabled a radical rise in the production of external power supplies. There are 10 billion external power supplies across the world, of which the external power supplies in China approximate 0.7 billion. Since the external power supplies can be defined as the labor-intensive industry, the tremendous amounts of low-cost labor resources attract an increasing number of labor-intensive enterprises to China. As a result, China has developed into the largest producer and exporter of external power supplies. According to the investigation data of foreign institutions, the AC-DC single-output power supplies achieved the sales income of USD 723 million dollars, about 60% of the total market maintenance of power supplies. The sales income is expected to increase by 12.4% from 2002 to 2007.

Because the external power supplies converts the high voltage of AC power grid into the steady DC or AC low voltage, the conversion process of high and low voltage will experience the loss of energy. The test data indicate that some external power supplies only have the converting ratio of 20% or 40%, but the high-efficiency external power supplies claim the converting ratio as much as 90%. It’s estimated that the efficient power designs will save the power supplies by 15% to 20%, and they’re all the technologies with mature application. Therefore, the increased efficiency of external power supplies and the popularization and adoption of efficient power products will becomes the best means to reduce the energy consumption for China, whose market maintenance of power products expands rapidly, further decreasing the negative environmental impacts.

The increased efficiency of external power supplies has constantly been neglected. One of the important reasons is that almost all the external power supplies are sold along with the end products such as cell phones, laptop computers and digital cameras. The manufacturers of end products purchase the external power supplies rather than the consumers paying the electricity bills. The external power supplies lack the uniform energy efficiency standards, and the consumers lack any labels or messages to familiarize themselves with the energy consumption of their products, and any independent right of choice. In addition, the fierce industrial competition and the lowered profits reduce the initiatives of all the enterprises to increase their energy efficiency.

In 2003, the energy efficiency problems of external power supplies started to draw much concern from the related domestic institutions and the preliminary industrial investigations were conducted as well. This project received the financial support from American Energy Foundation and listed as one of the sustainable energy projects of China by American Energy Foundation in 2003. In May, 2003, China National Institute of Standardization Certification Center (the former China Energy Conservation Product Certification Center) started to formulate the demands for certification technology of energy conservation products. In the meantime, the Energy Star Project of the U.S. Environmental Protection Agency, the California lowest energy efficiency standard project, the lowest energy efficiency standard project of Australian Greenhouse Office began to study the test methods and technical demands at the same time. America, China and Australia have developed the in-depth exchange and cooperation, and conducted the comparison of sample test and experimental methods in their own countries. With the sufficient attention of relevant international organizations, the Global Senior Symposium on Power supplies was held in California of the United States in February 2004. The representatives from the U.S. Environmental Protection Agency, the U.S. California Energy Commission, China National Institute of Standardization, China Standard Certification Center, Australia Greenhouse Office, International Energy Agency, European Commission, American Energy Foundation, the U.S. Lawrence Berkeley National Laboratory, as well as from the related institutions of Canada, New Zealand, Japan and South Korea attended the meeting. Through their discussion, they reached a consensus on the first global uniform energy efficiency project with external power supplies, namely, the creation of unified test methods and the development of a set of uniform technical index demands based on all the test data from different countries. All the countries may, according to their respective national conditions, select the dates of implementation to facilitate the international trade and the mutual acceptance of certification results. In May 2004, China National Standardization Technical Committee for Energy Basis and Management started to apply for the initiation of national energy efficiency standard project, and received the vigorous support from the State Development and Reform Commission and Standardization Administration of the People's Republic of China. In May 2005, the national energy efficiency standard on external power supplies was officially ranked among the national standard formulation and revision plans. The code of planned project is 20050974－Q－469.

(II) Main Working Process

The drafting process of standards can be divided into four phases. During the first phase, the test methods shall be determined and published. In 2003, China Standard Certification Center, China National Institute of Standardization and the U.S. Environmental Protection Agency received the positive responses and supports from China CEPREI Laboratory, National Computer Quality Supervision and Test Center, the U.S. California Energy Commission (CEC), Australia Greenhouse Office, the U.S. Berkeley National Lab, the U.S. UL Lab, European Commission Joint Research Center and other units and institutions when they organized the experts and relevant institutions to draft the test methods. By seeking the comments from many sources and conducting the comparative experiments, they completed the test methods in March 2004, and started to apply these methods to the collection of data and the establishment of technical indices.

During the second phase, the test data are collected. In 2003, China CEPREI (Headquarters) Lab tested 500 power-supply products of China. At the same time, the cooperative institutions from the United States and Australia also sampled 300 power-supply products with different models for test. As a result, the test data of 800 products were submitted in the form of summary to the drafting team for technical demand of energy sources under the U.S. "Energy Star" project.

During the third phase, the certification technical demands of energy conservation products were drafted and promulgated. Based on the analysis of test data, the drafters of cooperative institutions from China, the United States and Australia created in March 2004 the first draft of technical demands of external power-supply products through their consultation. In addition, the power-supply manufacturers, business consumers and experts from the United States and China were summoned to discuss about the improvement suggestions. The second draft of technical demands was created in June 2004. Afterwards, the power-supply manufacturers, business consumers and experts from the United States and China were summoned again to discuss about the possible improvements and solicit the comments online. According to the improvement suggestions from various sources, the third draft of technical demands was issued in August 2004, and the comments were solicited on the website of the U.S. Energy Star. The U. S. Association of Home Appliance Manufacturers (AHAM), in consideration of its own benefits, demands the narrowed scope of products, namely, excluding the power supplies used by the following products and capable of chargeable functions through chargeable batteries.

- Electric torches;
- End products capable of the mechanical movements, air flow or heat production (e.g., electric tools and re-filled vacuum tubes);
- Separable batteries used by the above products;

Based on the suggestions of AHAM, the U.S. Energy Star made the corresponding revisions and issued the fourth draft of technical demands. China Standard Certification Center solicited through visits, telephones and e-mails the comments from the domestic enterprises and experts when it comes to the scope of products involved in the definition of technical demands. Finally, it's determined to adopt the third draft rather than the fourth draft. Meanwhile, the U.S. California Energy Commission (CEC) and the Australia Greenhouse Office also disagreed to the revisions made by the AHAM. From September to November 2004, the drafting team, through the personal talks and telephone conferences, conducted the repeated consultations with the U.S. Energy Star, the U.S. California Energy Commission (CEC) and the Australia Greenhouse Office. The U.S. Energy Star adopted the fourth draft of technical demands, which was revised according to the AHAM suggestions, but other parties all agreed to the third draft of technical demands. In December 2004, China Standard Certification Center, following the review and approval, officially promulgated the Technical Demands for Certification of Single-Output AC-DC and DC-DC Energy conservation Products with External Power Supplies. On January 15, 2005, China Standard Certification Center worked together with the U.S. Energy Star to launch the certification of energy conservation products with external power supplies.

During the fourth phase, the national energy efficiency standards were drafted. In accordance with the project planning, the energy conservation evaluating values of national energy-efficiency standards will be directly integrated into the technical demands issued by China Standard Certification Center. According to the project progress, National Energy Standard Commission organized in Dongguan of Guangdong Province the first symposium in April 2004. The participants at the symposium included the representatives from China National Institute of Standardization, China Standard Certification Center, China Power supplies Society, China Ceprei (Headquarters) Lab, Shenzhen Sanma Electric Appliance Co., Ltd., Phihong (Dongguan) Electronics Co., Ltd., Liande Electronics (China) Co., Ltd., Zhuhai Mitsumi Electric Co., Ltd. and Guangbao Electronics Co., Ltd. The experts from the U.S. ECOS Co., Ltd. introduced the project and participated in the discussion through telephones. The representatives reached the agreement on the following issues after their discussion about the first draft of standards.

1. Further define the single-output external power supplies;

2. Further define the scope of power applicable to the standards;

3. Further study whether the linear mode power supplies and the switched mode power supplies shall have the uniform minimum limited value;

In September 2004, the China Standard Certification Center organized in Beijing the Sino-U.S. Symposium on Energy Conservation Certification Projects of High-Efficiency Power Supplies. The participants at the symposium included about 40 representatives from the State Development and Reform Commission, China Standard Certification Center, China National Institute of Standardization, China Power Supplies Society, the U.S. Environmental Protection Agency, ECOS Co., Ltd., China Ceprei (Headquarters) Lab, Guangzhou Test & Inspection Institute for Household Electrical Appliances, China Environmental Protection Foundation, National Computer Quality Supervision and Test Center, Epson (China) Co., Ltd., Canon (China) Co., Ltd., ICF Consulting Co., Ltd., Apple Computer Inc., Orth Asia-Pacific Center, Potrans Electrical Corp. Ltd., Phihong Electronics Co., Ltd. Dell Computer (China), Co., Ltd., Panasonic Corporation of China, HP Computer Co., Ltd., Yokogawa Electric Corporation, Huaxun Electronics Co., Ltd., Sony (China) Co., Ltd., Power Integrations Inc., Hong Kong Memec (Asia-Pacific) Co., Ltd., Yada Electronics Co., Ltd., Huizhou Qiao Xing Communication Industry Co., Ltd., ON Semi-conductor Co., Ltd., Fujian Start Computer Equipment Co., Ltd., Nanjing Tong Hua Telecom Co., Ltd., PanPower Ab Corp., MEA Corp. and the U.S. University of California Lawrence Berkeley National Laboratory. At the symposium, the participants discussed about the definition, scope of application, energy conservation evaluating value and national energy efficiency for the single-output external power supplies, and further clarified the necessity for the continued study of linear mode power supplies.

In March 2005, China National Standardization Technical Committee for Energy Basis and Management held in Beijing a small symposium. The participants included the representatives from the China National Institute of Standardization, China Standard Certification Center, Electronic Measurement Center of Ministry of Information Industry, Taida Energy Technical (Shanghai) Co., Ltd., Tianjin Mitsumi Electric Co., Ltd. and Kong Bao Electronics Co., Ltd. At the meeting, the participants put forward the suggestions on the further industrial investigations and study of energy conservation potentials.

In May 2005, China National Standardization Technical Committee for Energy Basis and Management held in Hangzhou the second large symposium on the national energy efficiency standards. The participants at the symposium consisted of about 30 representatives from the China National Institute of Standardization, China Standard Certification Center, Electronic Measurement Center of Ministry of Information Industry, Zhejiang University, Taida Energy Technical (Shanghai) Co., Ltd., Dell Computer (China), Co., Ltd., Sony (China) Co., Ltd., Siemens (China) Co., Ltd., Yokogawa Shanghai Trading Co., Ltd., ON Semi-conductor Co., Ltd., Salom Electric (Jiaxing) Co., Ltd., Shezhen Huntkdy Power Technology Co., Ltd., Tiancheng Plastic Electronic Co., Ltd., Fengguan Motor Electric Co., Ltd. and Nanjing Tong Hua Telecom Co., Ltd. The representatives mainly considered and discussed about the allowable values for energy efficiency, and reached an agreement on revising the third draft according to the principle of being geared to the international standards in the shortest time possible. The draft for comment was revised based on the meeting consensus.

From July to September 2005, China National Standardization Technical Committee for Energy Basis and Management arranged the issue of 54 drafts for comment in the form of e-mails, and published the drafts for comments on www.energylabel.gov.cn and www.cecp.org.cn to solicit the comments from relevant specialists, test institutions, manufacturers and users. 22 written comments were received from four units.

As the technical demands with same international standards are developed, the U.S. Environmental Protection Agency and Australia Greenhouse Office, for the purpose of monitoring the trading activities, developed a set of the international compliance labels for external power suppliers, and officially suggested that China, as the major participants in the international coordination project, could adopt this label so as to promote the popularization of this label. In an aim to explore the feasibility of introducing the label into China energy efficiency standards, China National Standardization Technical Committee for Energy Basis and Management held in Beijing the International Symposium on National Energy Efficiency Standards and Labels of External Power Supplies on September 26, 2005. The guests at the meeting included Bai Rongchun, Vice Chairman of the Energy Bureau of State Development and Reform Commission and China National Standardization Technical Committee for Energy Basis and Management, Dr. Xiao Han, Industry and Transport Department of China National Standardization Committee, Ms. Zhang Ruiying, the project leader of American Energy Foundation, the sponsor of this project, Mr. Mark Ellism, the Australian project expert, Mr. Stuart Jeffcott, the international expert, Li Zhanshi, Deputy Secretary-General of China Power Supplies Society, China Standardization Certification Center, the representatives from the external power supplies test institutions, the important users, manufacturers and component manufacturers of external power supplies, as well as the standard drafters.

Having listened to the project introduction, and Mark Ellism's introduction of the international program and national plans of external power supplies and the international compliance labels of external power supplies, the participants at the meeting conducted the warm discussions about the two topics including the opinions of official replies to the drafts for comment on the national energy efficiency standards of external power supplies, and the feasibility of implementing the international compliance labels of external power supplies in China, and arrived at the preliminary consensus as follows.

1. The definition of external power supplies shall not be too restrictive.
2. The test conditions of experiment methods shall be described in a flexible manner to facilitate the operation and examination, and the national differences shall be taken into consideration as well.
3. Since the energy conservation product certification system and the energy efficiency label system have been created in China, it's necessary to cautiously consider the relations between the international compliance label of external power supplies, the energy conservation certification and the energy

efficiency labels, as well as the establishment of supervision and guarantee system for implementation of international compliance labels when we take into account the differences between the international compliance label of external power supplies, the certification labels of energy conservation products and the forms and contents of energy efficiency labels. Therefore, it takes in-depth research to introduce into China the international compliance labels of external power supplies. Yet, because China is a major exporter of external power supplies and the United States, Australia and European Union will treat or have treated as an imperative trading condition the international compliance labels of external power supplies, it proves necessary, as one countermeasure of international trade, to familiarize the domestic manufacturers with the gradation indexes and demands of international compliance labels of external power supplies. Thus, the related contents of international compliance labels of external power supplies will be treated as the informative appendices.

According to the meeting consensus and the Agreement on the International Compliance Labels of External Power Supplies, we revised and supplemented the Informative Appendix B, and completed the drafts for review.

On December 2, 2005, China National Standardization Technical Committee for Energy Basis and Management held in Beijing the examination and approval meeting of national standard of Energy Efficiency Allowable Values and Energy Conservation Evaluation Values for Single-Output AC-DC and AC-AC External Power Supplies. The related leaders from the State Development and Reform Commission and the Standardization Administration of the People's Republic of China attended the meeting. 28 guests at the meeting included the relevant experts of China National Standardization Technical Committee for Energy Basis and Management and China Power supplies Society, the related representatives from the important manufacturers of external power supplies, the technical supervision department of national standards, and China Certification Center for Energy Conservation Products, as well as the drafting personnel of standards and the project leader of American Energy Foundation, the sponsor of this project.

The examination and approval group was composed of 18 experts. Bai Rongchun, Vice Chairman of the Energy Bureau of State Development and Reform Commission, assumed the post as chairman of examination and approval group. The group listened to the description of the standard drafting group about the formulating background, drafting process, and major contents of the standards, and also made some inquiries. The examination and approval group, based on the principle of scientific integrity, active responsibility and coordination and consistency, discussed about all the contents of draft for review in a sufficient, earnest and meticulous fashion, examined each chapter and article, and suggested the major revisions as follows.

1. Defining the “low voltage” in the scope of “Low-voltage DC or AC output”;
2. Omitting the documents as quoted;
3. Omitting Item 7 of Definition 3.1 and 3.2;
4. Adjusting Table 2 ---- Technical Index;
5. Omitting Chapter 6 --- Energy Efficiency Labels;
6. Other lateral revisions.

According to the opinions of examination and approval meeting, the project group revised the standard and submitted the draft to the Standardization Administration of the People's Republic of China for approval.

I. Technical Overviews of Power Supplies

(I) Overviews of Power Supplies

As the electronic & information technology experiences a continuous growth, an increasing number of mobile and portable electronic products have entered the work and lives of ordinary people. An overwhelming majority of these equipments need the power supplies or recharging through external power supplies. Currently, the power supplies are used in a broad range of fields. It's estimated that there are 6 billion power supplies in the global use.

The power supplies are the electronic devices to convert the voltage of AC power grid into the DC or AC low voltage. Their basic structures include the covers, power transformers, rectifying circuits, stabilizer circuits and filter circuits.

At present, the Chinese mainland is the largest production base of power supplies in the world. There're 2800 manufacturers of power supplies, which achieved the annual output of 3.4 billion power supplies in 2004, around 40% of the global total. Moreover, the domestic output of power supplies enjoys an annual growth rate of 11% on average, and it's expected that the annual output will reach 4 billion and 4.8 billion in 2005 and 2006 separately.

(II) Classification of Power Supplies

According to different natures, the power supplies fall into different categories. The common methods of classification are described as follows:

1. According to different working methods, the power supplies are divided into the ones with the linear mode power supplies (LMPS) and the switched mode power supplies (SMPS). This is the most basic method of classification for power supplies. The power supplies sold at the market are mainly the ones with SMPS.

2. According to different types of output voltage, the power supplies are divided into the AC output mode (AC-AC, DC-AC) and the DC output mode (AC-DC, DC-DC).

3. According to different locations in the powered devices, the power supplies are divided into two types including the external and internal power supplies. The internal

power supplies, located inside the power-consuming devices, serve as one part of power-consuming devices (as indicated in Figure 1). The external power supplies (namely the power adapters) located outside the power-consuming devices, are independent of the devices. Based on different modes of connection, the power supplies with external power supplies are divided into the plug-in mode and desktop mode (as indicated in Figure 2).

Figure 1: Built-in Power supplies

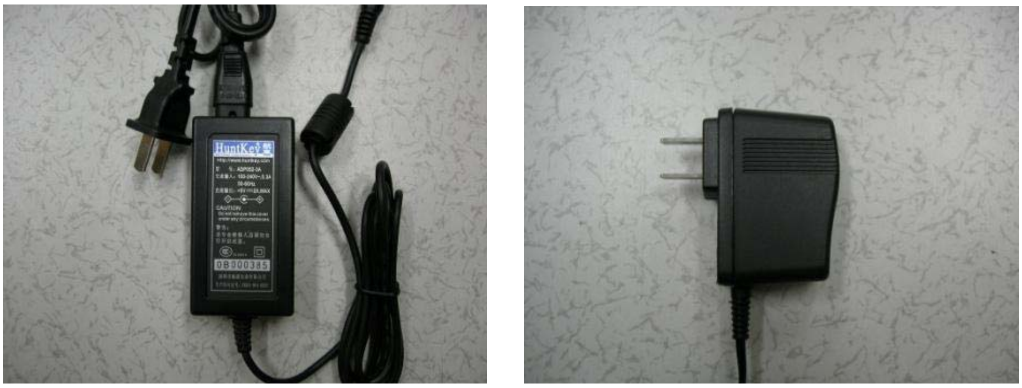


Figure 2: External power supplies

Desktop power supplies **Plug-in power supplies**

The power supplies as discussed in this report all mean the AC-AC and AC-DC external power supplies unless there're special descriptions.

(III) Structure of Power Supplies

According to the basic circuit structure, the power supplies are divided into the linear mode power supplies (LMPS) and the switched mode power supplies (SMPS).

1. LMPS:

As a traditional power supplies, LMPS has been in use for a long time. LMPS claims the mature technology and such advantages as the sound stability, low output ripple voltage and reliable use thanks to huge quantities of integrated linear voltage stabilizing modules. However, it usually requires the large and clumsy industrial frequency transformer as well as the filter with large size and weight. Since its regulator tubes work inside the enlarged zone, the power consumption was large and the power efficiency was as low as some 45%. The internal structure of LMPS is indicated in Figure 3. The industrial frequency transformer lies behind the wiring board.

Figure 3: Internal Structure of Linear Mode Power supplies

LMPS, by changing the conducting degree of power regulator tube, enables its operation within the linear zone and stabilize the output voltage through adjusting the inter-tube voltage. Its typical structure is indicated in Figure 4.

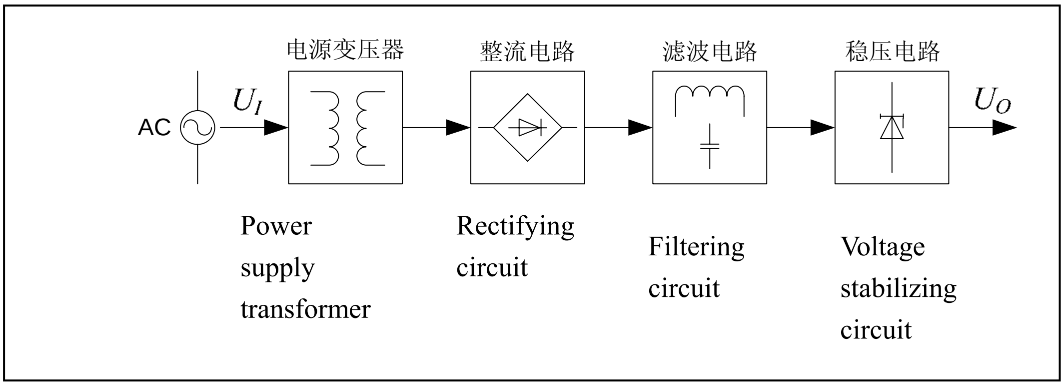


Figure 4: Basic Linear DC Power supplies Circuit

Power supplies transformer: It converts the AC linear voltage into the AC low voltage as required to guarantee that the regulator tube of voltage stabilizing circuit operates within the enlarged scope. Meanwhile, the power supplies transformer can also separate the AC input voltage from output voltage. As the largest energy consumer of LMPS, the transformer is an important component for increasing the energy efficiency.

Rectifying circuit: It can convert the sinusoidal AC with changing size and direction into the single-pulsating DC through the single-conducting property of rectifying components (such as the rectifying diodes, crystal brake tubes and rectifying bridges).

Filtering circuit: The energy-storage components (such as the capacitor and inductor) and the compound circuits are used to filter away the ripple factors of single-pulsating DC voltage or output voltage. The compound filtering circuit is divided into three types including LC filtering (as indicated in Figure 5a), л-shaped LC filtering (as indicated in Figure 5b) and л-shaped RC filtering (as indicated in Figure 5b). The filtering circuit of LMPS consists of two sections, namely the input filtering and output filtering.

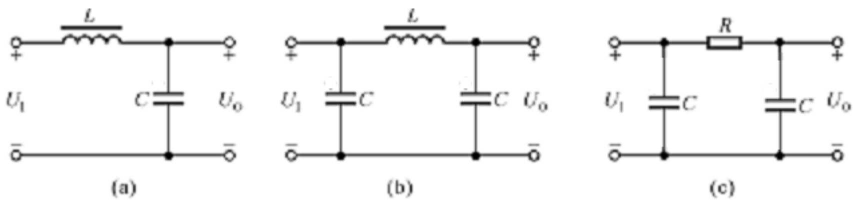


Figure 5: Compound Filtering Circuit

Voltage stabilizing circuit: Since the output voltage can be changed by the variation of load or input line voltage, it's required to use the voltage stabilizing circuit to perform the feedback control of output DC voltage so that the output voltage is not influenced by the load or input voltage and remains relatively stable.

According to different voltage stabilizing modes, LMPS is divided into the mode of voltage-stabilizing tube, the serial voltage-stabilizing mode and the integrated voltage-stabilizing mode.

(1) Mode of voltage-stabilizing tube:

This is the simplest kind of linear voltage-stabilizing mode (as indicated in Figure 6). The current-limiting resistor (denoted by R) and the voltage-stabilizing tube (denoted by D_Z) make up the voltage-stabilizing circuit, and R_L functions as the load resistor.

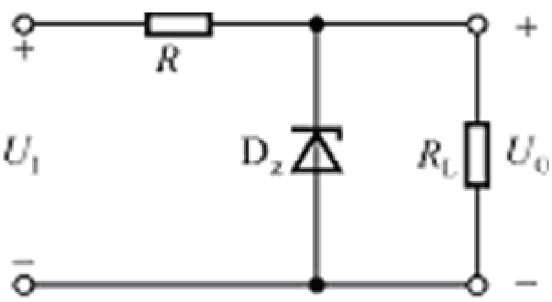


Figure 6: Voltage-stabilizing Circuit with Voltage-stabilizing Tube

As one of the simplest voltage-stabilizing methods, this method has some disadvantages like the slow voltage-stabilizing responses, inaccurate voltage stabilization and large power consumption due to the resistors in series, adversely influencing the efficiency of power supplies. This is the voltage-stabilizing method adopted in the past and rarely in current use.

(2) Serial voltage-stabilizing mode:

Figure 7 indicates the general structure diagram of serial feedback voltage-stabilizing circuit, in which T denotes the regulator tube and A is the comparative amplifier. The resistors including R1, R2 and R3 make up the sampling resistor network to achieve the sampling of output voltage. The output voltage through sampling, amplified by the comparative amplifier, controls the voltage between the collector and emitter of regulator tube T, achieving the purpose of stabilizing the voltage. Since the regulator tube T is connected in series with the load resistor RL, the power supplies of this kind are called the serial voltage-stabilizing power supplies.

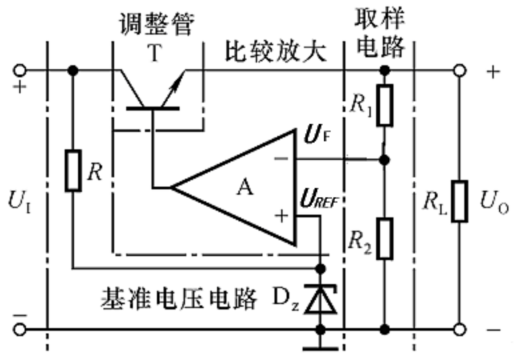
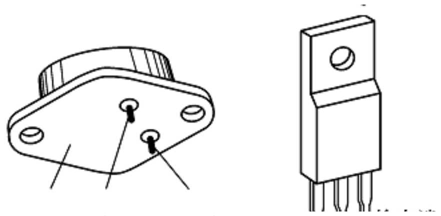


Figure 7: General Structure Diagram of Serial Feedback Voltage-stabilizing Circuit

Regulator T
Comparative amplification
Sampling circuit
Benchmark voltage circuit

(3) Integrated voltage-stabilizing mode:

As its name implies, the integrated voltage-stabilizing mode is to stabilize the voltage through the integrated voltage-stabilizing devices. The integrated voltage-stabilizing devices consist of tri-end fixed mode and tri-end adjustable output mode, including the input end, output end and public end (as indicated in Figure 8).



Public end (cover) Input end Output end （a）

Public end (cover) Input end Output end (b)

Figure 8: Configuration of Integrated Voltage Stabilizer

The circuits inside the integrated voltage stabilizer are capable of protection against overflow, overheating and short circuit, and enjoy the advantages like safety and liability, simple wiring and easy maintenance. The tri-end voltage stabilizer consists of the sampling, benchmark, enlarging and regulating units. It has the same voltage-stabilizing principle as the serial feedback voltage-stabilizing circuit. The difference lies in the fact the integrated voltage stabilizer integrates the serial feedback voltage-stabilizing circuit into one device.

2. SMPS

SMPS came into being later than LMPS. Its functional tube operates within the saturation zone and cut-off zone, namely the switched condition. With the power semi-conducting device as the switch, SMPS adjusts the output voltage by controlling the duty ratio of switch. Under the condition of same output power, the higher switching frequency, the smaller size the power supplies will have.

Figure 9: Internal Structure of Switched Mode Power supplies

The typical structure of switched mode power supplies is indicated in Figure 10.

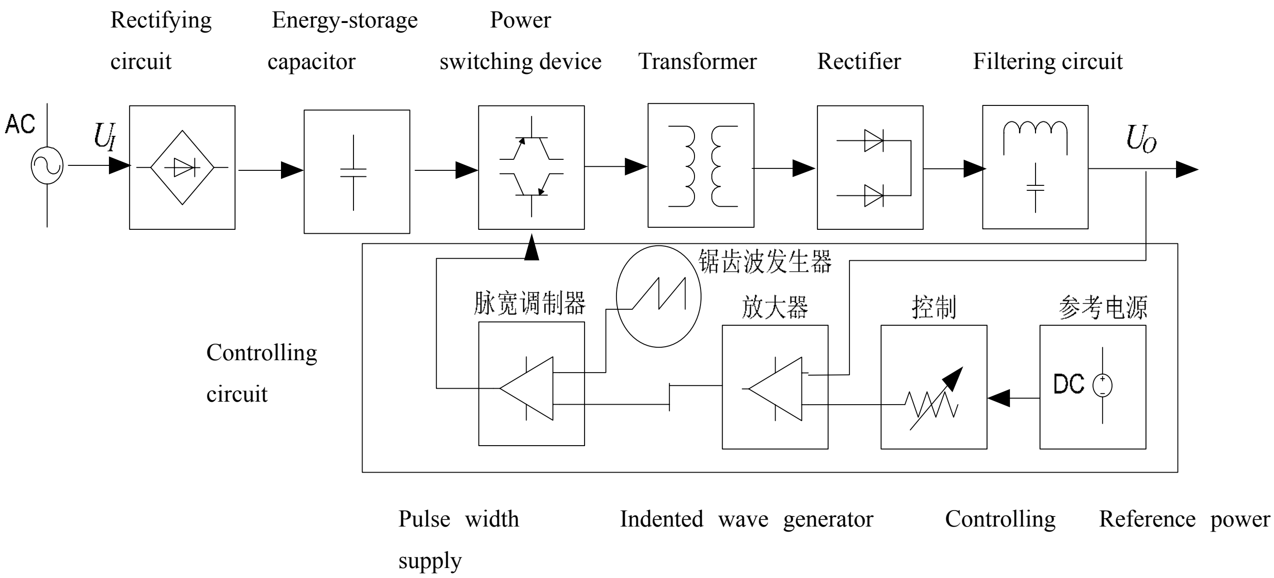


Figure 10: Basic Switched DC Power supplies Circuit

All the components have the following functions:

Rectifying circuit: The single-conductivity of rectifying components (e.g. the rectifying diodes, crystal brake tubes and rectifying bridge) will convert the AC input voltage into the single-pulsating DC high voltage.

Energy-storage capacitor: It stores electricity and prevents the lowered output voltage caused by the decrease of input voltage or the sudden expansion of load current.

Power switching device: The high-frequency connection and disconnection of switching devices can control the power fed to load and as a result, control the voltage. The higher switching frequency is, the smaller the rate of size and weight to output power will be.

Filtering circuit: The energy-storage components (e.g. the power capacitor and inductor) or their compound circuit are used to filter away the ripple factors of single-pulsating DC voltage, ascertaining the stability of output power supplies.

Transformer: The high-frequency voltage generated by switching devices is converted into the proper voltage. This transformer has a basic difference from LMPS transformer, namely, the former works at high frequency and is defined as high-frequency transformer.

SMPS usually claims the advantages like the small size and weight, sound liability, high efficiency, large power density and broad scope of input voltage, but the disadvantages like the considerable ripples (in contrast to LMPS).

In addition to the basic circuits as mentioned above, the practical power supplies also have a variety of protective circuits, for instance, polarity protection, program protection, deficient-voltage protection, overflow protection, overheating and output-short protection. Some power supplies have the power compensation circuit, voltage-regulating circuit, output voltage switching circuit and other function units.

(IV) Main Technical Parameters of Power Supplies

The quality of power supplies directly influences the performance and safety of powered equipments. Thus, the performance index of power supplies is of much importance. The performance index of power supplies is divided into three types including the input characteristic index, output characteristic index and supplementary performance index.

1. Input characteristic index means the performance indexes related to the input of power supplies, mainly including the input voltage and scope of voltage change, the frequency of input voltage and scope of frequency change, the input phase number, the input power factor, the input current and the input resonance wave.

2. Output characteristic index means the performance indexes related to the output of power supplies, mainly including the output power, output voltage, ripple, voltage-stabilizing accuracy and output characteristics. The voltage-stabilizing and current-stabilizing accuracy parameters include the voltage regulating rate, load regulating rate and temporal deviation.

3. Supplementary performance index means the performance that influences the

function of power supplies, but includes other performance than those covered by above two indexes, for instance, the power density, time of maintenance, transient recovery time, temperature coefficient, insulated resistor, insulated voltage and thermal resistance coefficient.

The following is a brief introduction of several key parameters.

Power supplies regulating rate: It refers to the capacity of power supplies to provide the stable output voltage as the input voltage changes. In general, under the fixed load, measure the corresponding output voltage $V_{out-\min}$, $V_{out-nomal}$ and $V_{out-\max}$ under the condition of minimum input voltage $V_{\min}$, normal input voltage V_{nomal} and maximum input voltage $V_{\max}$. The calculation formula is $\max[(V_{out-nomal} - V_{out-\min})/V_{nomal}, (V_{out-\max} - V_{out-nomal})/V_{nomal}]$.

Load regulating rate: It refers to the capacity of power supplies to provide the stable output voltage as the output load current changes. In general, under the normal input voltage, measure the corresponding output voltage $V_{out-\min}$, $V_{out-nomal}$ and $V_{out-\max}$ under the condition of maximum load $L_{\max}$, normal load L_{nomal} and minimum load $L_{\min}$. The calculation formula is $\max[(V_{out-nomal} - V_{out-\min})/V_{nomal}, (V_{out-\max} - V_{out-nomal})/V_{nomal}]$

Output ripple: It refers to the voltage value of periodic and random difference values of average DC output voltage as the input voltage and output load current remain unchanged.

Scope of input voltage: It refers to the allowable scope of maximum input voltage changes as the power supplies normally operate.

Efficiency: It refers to the ratio of output power to input power, namely $\eta = (P_{out} / P_{in}) \times 100\%$.

Power density: It refers to the maximum power provided by the power supplies per unit size.

Transient recovery time: It refers to the time for the power supplies to witness the step change following output voltage and then recover the voltage-stabilizing values.

Time of maintenance: It refers to the time for the power supplies to cut off the input power supplies and lower the output voltage till the stabilized voltage.

Table 1 provides the main performance index of LMPS and SMPS.

Table 1: Main Technical Indexes of LMPS and SMPS

Characteristic index	LMPS	SMPS
Power regulating rate	0.02~0.05%	0.05~0.1%
Load regulating rate	0.02~0.1%	0.1~1.0%
Output ripple	0.5~2mV (RMS）	25~100mV（P-P）
Scope of input voltage	±10%	±50%
Efficiency	40~65%	60~85%
Power density	0.5W/in^3	2~3W/in^3
Transient recovery time	50ms	300ms
Time of maintenance	2ms	32ms

Moreover, the international and domestic markets raise some demands for the electric safety and electromagnetic compatibility of power supplies.

II. Relevant Standards of Power Supplies

Currently, there're many relevant international and domestic standards on power supplies. Moreover, these standards focus on the electric safety and electric performance test. However, there're few standards on the efficiency of power supplies. The following is a brief introduction of international and domestic standards.

(I) Relevant International Standards

Internationally, there're many standards on power supplies, like a series of standards issued by IEC (International Electrotechnical Commission) and UL (Underwriter Laboratories Inc.). The brief introduction is available as follows.

IEC has formulated some standards on power supplies, for example, the standards on DC stabilizing power supplies: IEC478.1-1974 Terminology of DC Output Stabilized Power Supplies, IEC478.2-1986 Rated Value and Performance of AC Output Stabilized Power Supplies, IEC478.3-1989 Benchmark Level and Measurement of Conducting Electromagnetic Interference of DC Output Stabilized Power Supplies, IEC 478.4-1976 Test Methods of DC Output Stabilized Power Supplies except the Radio-frequency Interference, IEC686-80 AC Output Stabilized Power Supplies, and IEC478.5-1993 Measurement for the Components of Reactance Near-field Magnetic Fields of DC Output Stabilized Power Supplies.

The power supplies standards issued by UL attach more importance to the electric safety. The related standards include UL1012-power supplies equipment standards at other level than the second level (promulgated on June 28, 1994) and UL1310-power supplies equipment standard at the second level (promulgated on July 28, 1994).

When it comes to the standards on energy efficiency of power supplies, the European Union and the U.S. Energy Star has developed or are developing the corresponding standards and codes.

1. Standard of America Energy Star:

Energy Star is a voluntary certification organization of energy efficiency with the governmental background in the United States. It aims to provide the efficient solutions for the manufacturers and users. Energy Star plays a significant role in the efficient use of energy sources in America, and its energy efficiency standards have a huge impact in the world.

The energy conservation evaluation methods of Energy Star for power supplies were implemented according to two stages. The technical demands for the first stage were implemented since January 1, 2005, and the technical demands for the second stage were implemented since July 1, 2006.The demands for the first stage were indicated in Table 2 and Table 3.

Table 2: Average Efficiency Index of Energy Star

Nominal value of output power W	Minimal average power （indicated in decimal numbers）
0 <Po <1	0.49 * Po
1≤Po <49	0.09 * Ln (Po) + 0.49
Po ≥49	0.84

Table 3: Standby Power Index of Energy Star

Nominal value of output power Po W	Maximum non-load effective power W
0 <Po ≤10	0.5
10 <Po ≤250	0.75

Currently, Energy Star is developing the indexes for the second stage.

2. Compulsory minimal energy efficiency standards of California:

The U.S. California Energy Commission is responsible for formulating and promulgating the minimal energy efficiency standards in the form of law to impose the compulsory implementation. In consideration of energy sources in short supply, the energy conservation standards in California are usually very rigorous. However, once the energy efficiency standards have been implemented in California for a certain period, these standards will be adopted by other states and even finally integrated into the federal law on energy conservation to achieve the compulsory implementation on a national basis. California power supplies project was developed at the same as Energy Star Project, and joined hands with the Power Supplies Manufacturers of America from February 2004 to March 2005 to launch one international design contest for the sake of awarding the power supplies design products with the highest energy efficiency. The compulsory minimum energy efficiency standards of California adopted the implementation framework, by which the technical demands for the first phase was implemented on July 1, 2007 and the technical demands for the second phase was implemented on January 1, 2008. The technical indexes are indicated in Table 4 and Table 5.

Table 4: Average Efficiency of Compulsory Second-stage Power Supplies of California

Nominal value of output power W	Minimal average efficiency （indicated in decimal numbers）
0 <Po <1	0.5 ×Po
1≤Po <51	0.09×ln（Po）+0.5
Po ≥51	0.85

Table 5: Non-load Efficiency of Compulsory Second-stage Power Supplies of California

Nominal value of output power Po W	Maximum non-load effective power W
0 <Po ≤10	0.5
10 <Po ≤250	0.5

3. Compulsory minimal energy efficiency standards of Australia:

The minimal energy efficiency standards of Australia was implemented by Australia Greenhouse Office and enacted by Australia Standard Agency as the national standards of Australia and New Zealand. Soon after the power supplies project of China and America was launched, Australia participated in the project and offered almost 80 test data, and pursued the broad and in-depth exchange and cooperation with China and America. The implementation framework of minimal energy efficiency standard in Australia was that the technical demands for the first phase was implemented in 2006, and the technical indexes shall be the same as those of Energy Star for the first phase; the technical demands for the second phase may be subjected to the compulsory implementation in 2010, and the technical indexes shall be the same as those of California for the second phase. The standards are being reviewed and approved.

4. EU Instructions:

European Union promulgated the energy efficiency instructions for power supplies as early as 2003, but the technical indexes mainly applied to the non-load and full-load power. Following the revised EU instructions, the technical indexes included the non-load and average power. The specific implementation framework is indicated in Table 5 and Table 6. The implementation period for the first phase lasted from January 1, 2005 to December 31, 2006. The efficiency index is indicated in Table 6, or the first-phase efficiency index of Energy Star as indicated in Table 1. The implementation period for the second phase started from January 1, 2007. The efficiency index is that of Energy Star for the first phase, as indicated in Table 1. The non-load power index is indicated in Table 7.

Table 6: Efficiency of Power Supplies with EU Instructions

Rated output power W	Table 1: Minimal average efficiency or full-load efficiency %
0<Po <1.5	30
1.5< Po <2.5	40
2.5< Po <4.5	50
4.5< Po <6.0	60
6.0< Po <10.0	70
10.0< Po <25.0	75
25.0< Po <150.0	80

Table 7: Non-load Power with EU Instructions

Rated output power W	Non-load power W	
	2005.1.1	2007.1.1
0.3< Po <15	0.30	0.30
15< Po <50	0.50	0.30
50< Po <60	0.75	0.30
69< Po <150	1.00	0.50

(II) Relevant Domestic Standards

Many relevant standards on power supplies are available in China, and they mainly focus on the electric safety and electromagnetic compatibility. These standards are usually formulated according to the international standards. Therefore, their systems and structures are basically consistent with the international ones.

The national standards are described as follows:

GB4943-2001: Safety of information technical equipment

GB8898-2001: Safety demands for the audio, video and similar electronic equipment

GB9254-1998: Limited value and measurement method for radio disturbance of information technology equipment

GB17625.1-2003: Limited value of electromagnetic compatibility and limited value of harmonic current emission (the input current per phase≤16A)

GB17618-1998: Limited value and measurement method for immunity to disturbance of information technology equipment

GB13028-1991: Technical condition for isolating transformer and safe isolating transformer

GB/T14714-93: General specification of switching power supplies for mini-micro computer system

GB/T14715-93: General specification for uninterruptible power supplies of information technology equipment

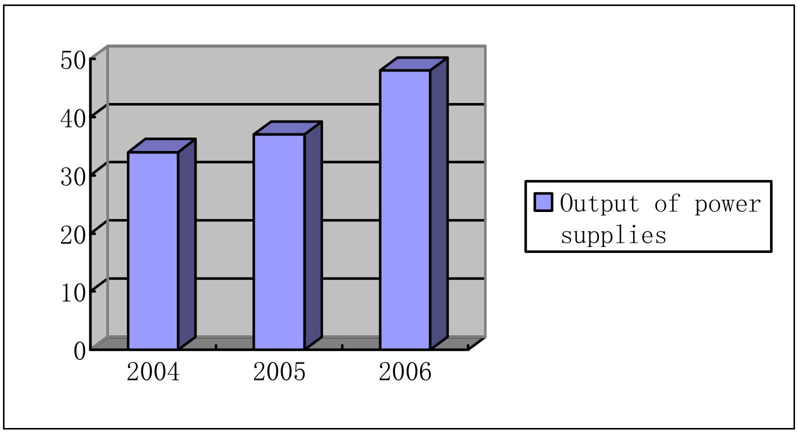
Besides, many domestic electronic industrial standards (the former the Ministry of Electronic Industry), e.g. SJ/T10541－94 General Specification for Anti-disturbance AC Voltage-stabilized power supplies, SJ/T10542-94 Test Methods for Anti-disturbance AC Voltage-stabilized Power supplies, SJ/Z9035-87 Terms of Stabilized Power Supplies for Measurement, SJ1670-80 Terms for Power Supplies of Electronic Devices, SJ2811.1-87 Terms, Definition, Performance and Rated Value of General DC Stabilized Power Supplies and SJ2811.2-87 Test Methods for General DC Stabilized Power Supplies. These industrial standards boost the scientific research and production of DC stabilized power supplies in China, and the development of our power supplies industry.

III. Market Condition of Power Supplies

(I) Overviews of Power Supplies Market

As the largest production base of power supplies in the world, China has over 2800 power supplies manufacturers at present. In 2004, China achieved the annual output of 3.4 billion power supplies, 40% of the global total. In addition, the output of power supplies undergoes an annual rise of some 10%, and it's expected that the output will approximate 3.7 billion in 2005 and exceed 4.8 billion in 2006(source of data: Global Resources Report), as indicated in Figure 11.

Figure 11: Output Trend of Power Supplies in China



Based on the inconclusive statistics, SMPS accounts for 75% of the domestic market and LMPS makes up 25%. The large enterprises specialize in the production of SMPS and the small and medium-sized enterprises usually manufacture the ordinary power supplies and LMPS. Currently, some manufacturers are developing the power supplies with the mixed mode (linear and switched mode) power supplies.

1. LMPS power supplies market:

At present, LMPS claims a small market share of around 25% and LMPS from abroad has a smaller market share. This is attributable to the rapid development of SMPS technologies, outshining the performance and price of LMPS. The LMPS (e.g. clumsiness and low efficiency) lags far behind the SMPS due to the intrinsic defects of the former. The output power of LMPS at the market is usually less than 12 W since LMPS is less favorable in terms of price than SMPS as far as the output power of more than 12 W is concerned.

The LMPS power supplies are mainly targeted at the cordless phones, electronic organs and some medical equipment, as well as a few power-consuming products which have been out of production but in limited use. The LMPS manufacturers are often the small and medium-sized power supplies manufacturers.

2. SMPS power supplies market:

SMPS adopts the power semi-conductor as switch, and regulates the output voltage by controlling the duty ratio of switch. SMPS directly rectifies, filters and adjusts the voltage of power grid, then achieves the stabilized voltage through switch adjusting tube. The industrial frequency transformers with clumsy size are unnecessary. The internal structure of SMPS is indicated in Figure 15. Owing to the small power consumption of switch tube, SMPS enjoys the small power consumption and the efficiency as much as 70% to 95%.

(II) Introduction of Main Domestic Power Supplies Enterprises

There're about 2800 power supplies manufacturers in China. The major power supplies include Taida, Guangbao, Feiwhuang Yashi, Yada Electronics and Feihong Electronics at the current domestic market. A majority of these manufacturers are the Taiwan manufacturers with their production bases in Mainland China. Designed by Taiwan, a vast majority of products are intended for exporting. The power supplies manufacturers on Chinese mainland are usually small in size. The large manufacturers include Shenzhen Huangjia Chiyuan Science & Technology Co., Ltd. and Zhejiang Fenghua Plastic Electronics Co., Ltd.

The controlling chips for power supplies are mostly produced by the large foreign companies like PI and ST. There're also some mature manufacturers of power supplies management products such as Nanjing Tonghua Chip Micro-electronic Co., Ltd., whose products are mainly focused on the research and development of low-power power supplies IC.

The products of large manufacturers mainly include the power supplies for laptop computers and cell phones. The power supplies products usually have very sensitive prices and are in most cases the customized products.

(III) Main Factors to Promote the Development of Domestic Power Supplies

The cell phones, laptop computers, mobile media players and other portable electronic devices witness a dramatic rise in their market shares, constituting the most important impetus to drive the market development.

Take the cell phones for example. In 1998, the cell phones claimed the domestic output of 8 million, 4.6% of the global total. However, in 2004, the domestic output of cell phones reached 233 million, 35.2% of the global total. Figure 12 shows the comparison between the annual domestic and global output of cell phones from 1998 to 2004.

Figure 13 indicates the proportion of domestic output of mobiles phones in the global output.

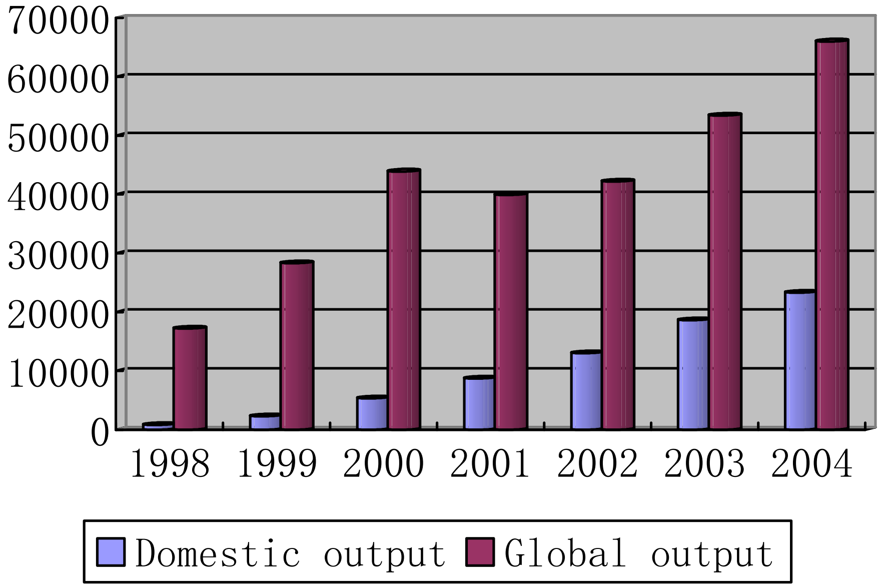


Figure 12: Annual Output of Cell phones from 1998 to 2004

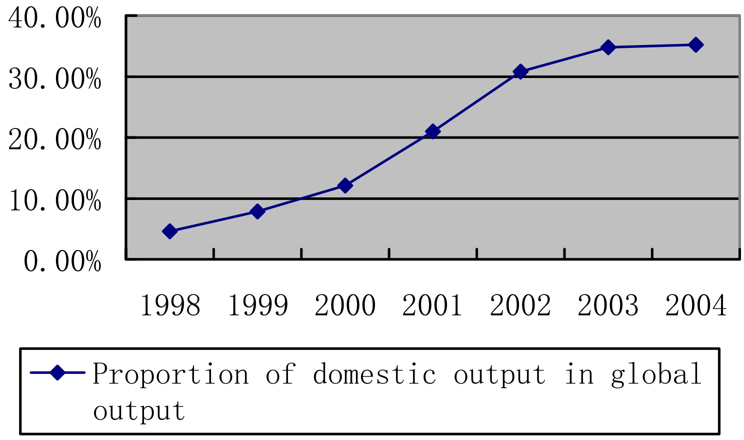


Figure 13: Proportion of Domestic Output of Cell phones in Global Output

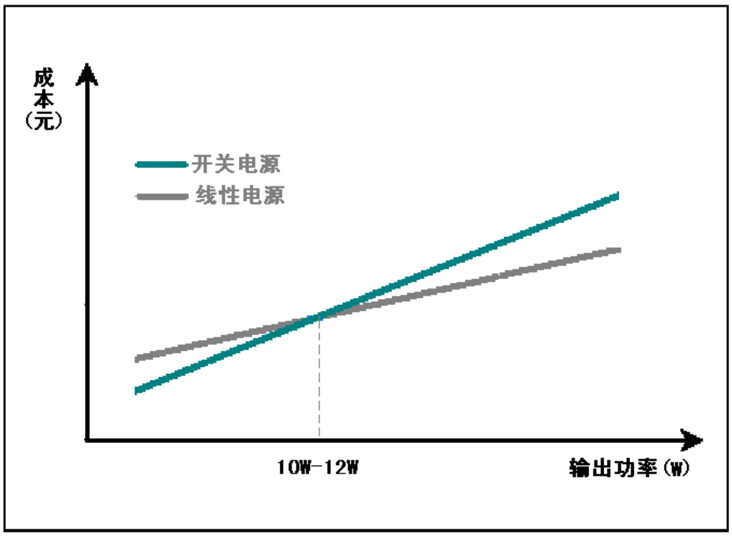
(2) Thanks to the low labor cost and many favorable domestic policies of China, lots of large power supplies manufacturers in the world shift their production bases to the Chinese mainland.

SMPS power supplies, as one kind of power supplies with the widest use, constitute around 75% of global power supplies market. Their use is expected to further expand.

(IV) Costs of Power Supplies

Due to different production scales and production techniques, the power supplies from different manufacturers may vary in the costs and prices.

LMPS and SMPS also differ in price. In general, LMPS claims the pricing advantage as far as the range of 10 W to 12 W is concerned (as indicated in Figure 14). However, when it comes to the large power, LMPS has a higher cost than SMPS. Thus, LMPS mainly has the power of less than 12 W.



SMPS
LMPS
Cost (RMB)
Output power (w)

Figure 14: Cost Comparison of Power Supplies

Our research indicates that SMPS has a rough cost of RMB 1/W and LMPS has a rough cost of RMB 8/W (less than 12 W).

IV. Factors Influencing the Power Supplies Efficiency and Methods to Improve the Efficiency

There’re two standards for assessing the energy efficiency level of power supplies and the two contents shall be involved in increasing the efficiency level accordingly, namely, reducing the standby power and increasing the average efficiency. For the purpose of raising the energy efficiency level of power supplies, it’s necessary to analyze first of all the factors to influence the energy efficiency of power supplies.

(I) Factors Influencing the Power Supplies Efficiency

Since the power supplies have two different kinds of basic structures, there’re radically different factors to influence the energy efficiency of SMPS and LMPS. Hence, we present the separate introduction of those factors influencing the energy efficiency of power supplies. As regards SMPS and LMPS, different circuits differ a lot in their methods of power consumption. We only provide several methods of power consumption in the circuits.

1. LMPS:

The factors to influence the LMPS efficiency are mainly the magnetic core loss (iron loss) and winding loss (copper loss), regulator tube loss and line loss, of which the most important is the transformer loss.

1) Transformer loss:

The transformer loss is divided into the iron loss and copper loss. The iron loss includes the hystereses loss and eddy loss. The hystereses loss is incurred by the ferromagnetic heating related to the magnetic hystereses. The eddy loss means the energy loss when, following the electrification of primary winding, the magnetic flux produced by the winding flows in the iron cores and the vertical plane of magnetization line will have the induced EMF, which produces the closed circuit and current on the cross section of iron core. The copper loss of transformer means the energy loss in the form of heat when the winding wire of transformer has the electric resistance and the electric resistance will witness the power consumption for the flowing current.

The copper loss will decline as the working frequency rises, but the iron loss will expand as the working frequency rises. Since the LMPS transformers work at the frequency of less than 50Hz, their transformer loss is mainly the copper loss, namely, the loss incurred by the electric resistance of winding wire.

2) Loss of regulator tube:

Since the LMPS regulatory tube works inside the linear amplification zone, the collector of regulator tube will have much loss ($P = U_{CE} I_O$) at the moment of considerable load current, consuming large amounts of energy.

3) Loss of circuitry and peripheral control circuit:

The line loss means the loss caused by the circuitry resistance and power lead on the printed circuit board of power circuit. The peripheral control circuit like the reference voltage generator, voltage comparator circuit and various protective circuits will also consume some power.

2. SMPS

The SMPS power loss mainly includes the switching loss, transformer loss, on loss and peripheral control circuit loss, of which the most important is the switching loss.

1) Switching loss:

The switching devices are controlled by the grid or base control switches in case of the large voltage or current. Since the voltage and current will not be zero at the same time during the switching process, there'll be the overlapping zone of voltage and current (as indicated in Figure 15). As a result, the existing current of switching device has the voltage difference and claims the power consumption. The loss caused by the switching process is called the switching loss.

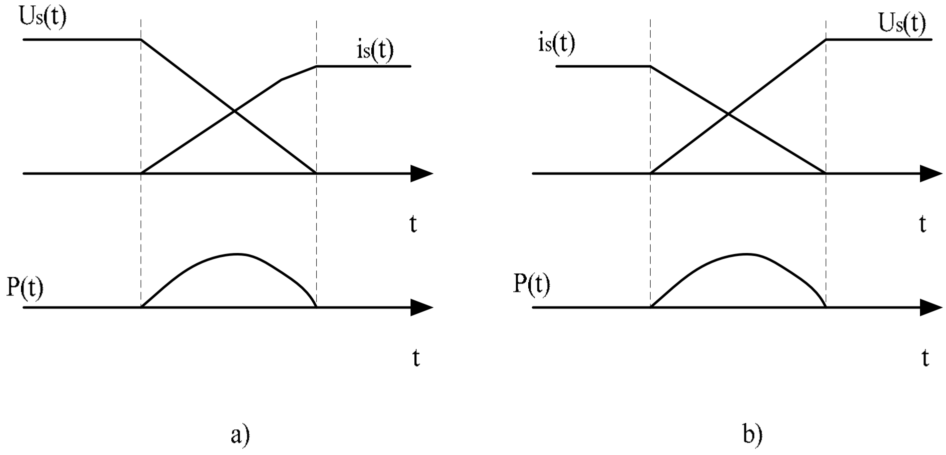


Figure 15: Switching Process of Hard-switching Circuit

a) Hard-switching On Process **b) Hard-switching Off Process**

Instantaneous power consumed by the switching power:

$$p(t) = u_s(t)i_s(t)$$

The switching loss of SMPS makes up almost 5% to 10% of total input power. Therefore, the switching loss is the major factors to influence the SMPS efficiency.

2) On loss:

On loss is incurred by the current that flows through the impedance components. Owing to the high efficiency of SMPS, the loss of this kind claims a considerable proportion. On loss is in direct proportion to the square of leakage current. However, this kind of loss can be ignored as the power supplies are in the state of standby.

3) Transformer loss:

SMPS transformer loss, the same as the LMPS transformer loss, also includes the iron loss and copper loss. Because the SMPS transformer operates at a high frequency, the loss incurred is mainly the iron loss. SMPS transformer and LMPS transformer differ in iron loss since the former has the iron loss incurred not just by winding resistance but by skin effect.

4) Peripheral control circuit loss:

The peripheral control circuit, like the reference voltage sources, saw wave generator circuit and comparator circuit will consume some power, reducing the

SMPS efficiency.

(II) Methods to Improve the Power Supplies Efficiency

Based on the analysis of various factors for power loss, the measures can be taken to increase the energy efficiency level accordingly. According to the methods of power loss as stated above, the corresponding solutions are provided as follows.

1. LMPS:

1) Improving the transformer performance:

The transformer loss of LMPS is mainly the copper loss, namely the loss incurred by the winding resistance of transformer. The copper loss may be reduced by increasing the winding conductivity and improving the winding method. The iron loss is mainly the hystereses loss. It's advisable to choose the soft magnetic materials as the iron core of transformer.

2) Reducing the power dissipation of regulator tube:

The regulator tube loss functions as another important factor for influencing the LMPS efficiency. The loss may be decreased by using the regulator tube with low on-state resistance and lowering the voltage difference at the two ends of regulator tube.

3) Reducing the loss of line and peripheral control circuit:

The line loss can be reduced by improving the topological structure and wiring methods of power supplies. As far as the peripheral control circuit is concerned, it's advisable to adopt the loss-free absorption technology.

2. SMPS:

1) Reducing the switching loss:

Under the normal working condition, the power loss of SMPS is mainly caused by the switching loss. Currently, the soft switching technology can be used to reduce the switching loss.

The soft switching technology is to use the harmonic resonance of capacitor and inductor so that the current (or voltage) of switching devices will experience the sine-based changes. In case of zero current, the devices will be switched off; in case of zero voltage, the devices will be switched on, achieving the zero switching loss (as indicated in Figure 16). According to the control methods, the soft switching technology includes three methods like the pulse frequency modulation (PFM), pulse width modulation (PWM) and pulse shifted (PS).

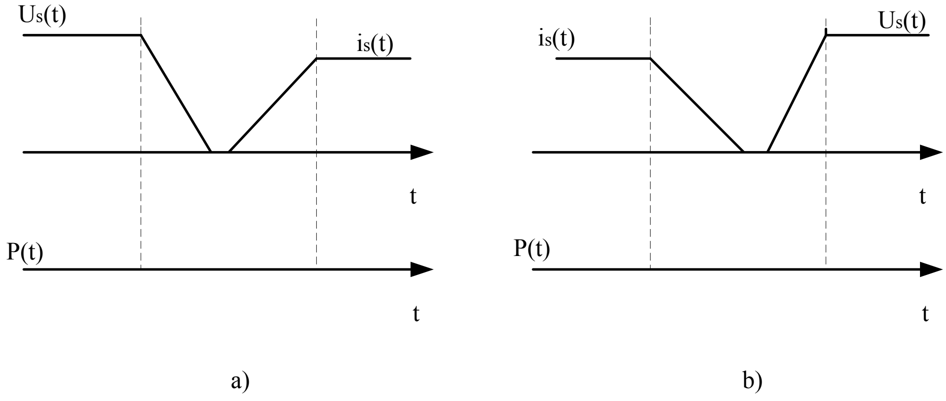


Figure 16: Switching Process of Soft-switching Circuit

a) Soft-switching On Process **b) Soft-switching Off Process**

2) Reducing the on loss:

In order to reduce the on loss, it’s advisable to adopt the aforesaid method of reducing the linear regulator tubes.

3) Method to reduce the transformer loss:

The transformer loss of SMPS is mainly the iron loss, namely the loss incurred by the hystereses and eddy current. It’s advised to improve the size, structure and winding method of transformer (e.g. flat transformer, film transformer and chip transformer), and use the good magnetic core materials to reduce the transformer loss. Besides the above method, it’s also feasible to use the power factor correction (PFC) technology, loss-free absorption network and improved topological structure of power supplies to improve the power efficiency as a whole. However, the extra circuit will increase the power loss of equipment under the small or free load.

There’s certain contradiction between the reducing standby loss and the increasing average working efficiency to some degree. Because the increase in average efficiency will sometimes involve more additional circuits and these additional circuits may consume some power, the standby loss can be increased as a result. Thus, it's imperative to find a balance between them so that the energy conservation effects will be optimum.

(III) Potential and Feasibility of Improvement of the Energy Efficiency of Power Supplies

1. Energy-efficiency improvement potentials of the power supplies:

Currently, the energy-efficiency level of domestic power supplies still claims certain improvement potentials, and this is especially true of those low-end products. Therefore, the related standards and regulations must be issued to regulate the power supplies market so that the energy-efficiency level of power supplies in current use can increase by 10% to 15%, conserving huge amounts of power in China.

However, the domestic market of power supplies with large and medium-sized power (50-220W) is almost dominated by several big companies. The advanced technologies and high energy-efficiency level render the improvement potentials quite limited.

Thus, the energy-efficiency improvement of power supplies is mainly focused on those with the power of less than 50W. This is especially true of the power supplies with power of 10-50W since their standby loss (an average of 1.2W) is higher than the standby loss (an average of 0.7W) of the products with power of more than 50W.

2. Technologies for increasing the energy efficiency of power supplies:

1) Optimization of transformer: The transformers shall be improved from the magnetic core (material, structure and parameter), winding (structure and winding method) and overall transformer structure (the new piezoelectric mode and planar mode).

2) Using the highly efficient semi-conductor devices, such as the rectifying devices, filtering devices and switching devices, and optimizing the matching parameters of these devices.

3) Using the new power supplies management and chip control method, and improve the power supplies control method.

4) Increasing the additional power-saving circuits like the power factor correction (PFC) circuit, loss-free absorption network and parallel current-sharing circuit.

5) Optimizing the topological structure of power supplies: The topological structure is intended to convert, control and adjust the power switching components of input voltage and the different configurations of energy-storage components.

3. Relations between the increased energy efficiency and the increased costs:

Any increase in the energy-efficiency level of power supplies will raise the costs, for instance, the development costs of new products and the additional costs of new devices and techniques.

As the energy-efficiency level is raised, it's necessary to asses the economic performance. Together with the manufacturers, we have verified some energy-efficiency increasing experiments and assess the effects and increased costs. Table 8 shows the conclusive data.

Table 8: Comparison of Improved Effects and Increased Costs of Power Supplies

Input specification	Average efficiency increase	Standby power decrease（W）	Increased cost（RMB）
$5V \times 0.45$	14.1%	0.045	2
$5V \times 2A$	13.2%	0.204	2
$12V \times 2A$	10.5%	0.115	3
$19.5V \times 5$	6.1%	0.127	8
$24V \times 5A$	5.2%	0.213	7

V. Technical Contents of Energy Efficiency Standard

(I) Basis and Considerations for Formulating the Standard

As the standard is formulated, the following principles shall be deemed as the considerations for formulating the standard.

1. The contents of this standard shall be designed according to the requirements and provisions of GB/T1.1-2000.

2. This standard shall be geared to the related international standards and regulations, but it's necessary to fully consider the actual condition and development level of domestic external power supplies products so that the standard is highly scientific, advanced and operable, promoting the development of domestic external power supplies products and increasing their competitiveness at the domestic and international markets.

3. The contents of this standard constitute the technical basis for formulating our national energy policies, so its technical demands shall reflect the orientation of these policies.

(II) Introduction of Main Technical Contents of Standard

This standard mainly includes three aspects.

The first aspect is the demands for the energy-efficiency restriction of external power supplies. The demands shall be the compulsory index for implementing the standard. Since the limited value of energy efficiency is the minimal energy-efficiency value allowed by the state, the products that fail to match the value, as the eliminated products according to the related national regulations, shall not enter the market. The low energy-efficiency products not merely consume lots of energy sources, but increase the energy-related costs of customers. In accordance with the related provisions of the Law of the People's Republic of China on Conserving Energy, the energy-efficiency limited value is the basis for supervising and managing the external power supplies industry, preventing the low energy-efficiency products from the market and eliminating the high energy-efficiency products.

The second aspect is the demands for energy conservation assessment of external power supplies. As the recommended index, the demands are the technical basis for developing the certification of energy conservation products. The certification of energy conservation products, as an important energy conservation management system as defined by the Law of the People's Republic of China on Conserving Energy, aims to guide and stimulate the energy utilization rate of products. When the products reach the demand for energy conservation assessment values, it's advisable to apply to the national energy conservation product certification institution for the certification of energy conservation products and receive the energy conservation labels and certificates issued by the institutions.

The third aspect is the target limited value. It specifies the energy-efficiency limited value to become effective in two years. The index provides the manufacturers with the information on national energy policies so that the manufacturers can have enough time to improve their energy conservation technologies for energy-consuming products, ameliorate the product structure or production, enable a steady rise of energy efficiency in a favorable environment, further boost the product updating and upgrading and enhance the product competitiveness.

1. Scope:

The external power supplies fall into four categories, including the AC-DC dual-function single output, AC-DC dual-function multiple output, DC-DC single output and DC-DC multiple output. Since these four types of products differ in the test methods, this standard applies only to the first type of products, namely the external power supplies with AC-DC and AC-AC single output (hereinafter referred to as the power supplies). The specific definitions are detailed as below:

1) Converting the voltage of AC power grid into the DC and AC low voltage.

2) Only one fixed DC voltage output available for each use;

3) Sold and used together with the power-consuming load;

4) Separated from the power-consuming load;

5) Connected with the terminal products through wires, cables or other permanent connections;

6) Absence of any batteries;

7) Rated output power of no more than 250W.

The energy-efficiency standards for other three types of products will be gradually formulated. In an aim to expand the scope of application, the examination and approval meeting omitted the words like “without the chemical batteries, the optional switches and indicators, and the indicators of charging state” in the definition.

2. Standardized quotation document:

In the draft for review, there’s one standardized quotation document, namely GB/T 17478 Characteristics and Safety Demands of Low-voltage DC Power supplies Equipment. Some units suggest that the sampling schemes for out-of-factory tests be determined independently by the enterprises according to their quality control level. Hence, it’s advisable to omit in the draft for comment GB/T2828 Check, Counting and Sampling Process and Sampling Form by Batch (applicable to the check of continuous batches), and GB/T2829 Periodic Check, Counting and Sampling Procedure and Sampling Form (applicable to the stability check of production process). GB/T17478 applies only to the low-voltage DC power supplies, but this standard also applies to the low-voltage AC power supplies. Therefore, it’s not comprehensive enough to merely quote GB/T17478. In addition, the safety demands, as the compulsory demands, must be put into force. As a result, based on the comments of examination and approval meeting, the quotation document is omitted in the draft for approval.

3. Definition:

In an effort to facilitate the comprehension of its contents, this standard separately defines the single output AC-DC external power supplies, single output AC-AC external power supplies, working condition, non-load condition, working efficiency, average efficiency and energy-efficiency limited value and energy conservation assessment value. Six restrictive conditions are provided for the definition of two power supplies, strictly explaining the scope of application. The working and non-load conditions are two conditions when the power supplies have and haven’t the loads. Though the energy consumption during working condition claims 70% of the total energy consumption, the non-load condition of some products usually lasts for a long period. Given the fact that the non-load power loss is reactive power loss, it proves very crucial to lower the non-load power loss. Since the average power is an index for this standard to check the energy efficiency of power supplies, it’s necessary to define the working and average efficiency. As two fixed terms in the energy-efficiency standard, the energy-efficiency limited value and energy conservation assessment value are defined in the standard.

4. Determination of energy-efficiency parameters:

There're two parameters to evaluate the energy efficiency of power supplies in this standard.

1) Average efficiency under the working condition: It means the average value of energy efficiency as the tested samples have the rated output current of 100%, 75%, 50% and 25% under the working condition.

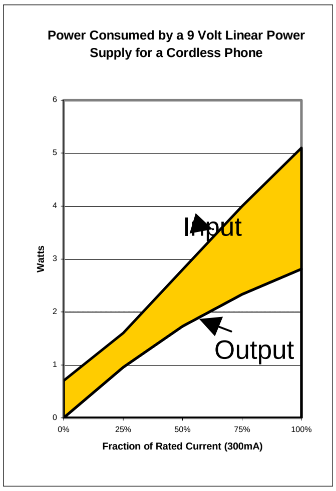
2) Active power under the non-load condition: It refers to the active power as the power input end is connected to the power grid while the power output end is not connected to the load or the load consumes no power.

In an aim to effectively assess the power efficiency of products under the standby and working conditions, the products must meet two demands simultaneously.

1) Energy-efficiency limited value and targeted energy-efficiency limited value:

The energy-efficiency limited value and targeted energy-efficiency limited value in the standard, both as the compulsory indexes, are determined following the statistical analysis of more than 800 test data in China, America and Australia. The principle is to consider the domestic market condition and the progress of related international standards, and to achieve the integration with international practices as much as possible.

Since the LMPS products are still available at the domestic market, one hard problem concerning the formulation of energy-efficiency limited value remains, namely, whether it's possible to develop the technical demands for LMPS and SMPS separately. The test data indicate that the average and non-load efficiency of samples claims very large dissipation degree, but witnesses nothing like the noticeable difference. LMPS has the average efficiency of 15% to 76% and the average value of 49%, and the non-load efficiency of 0.35-3.8W and the average value of 1.02W. SMPS has the average efficiency of 17% to 88% and the average value of 64%, and the non-load efficiency of 0.1-3.8W and the average value of 0.92W. The typical LMPS and SMPS input-output curve is indicated in Figure 17.



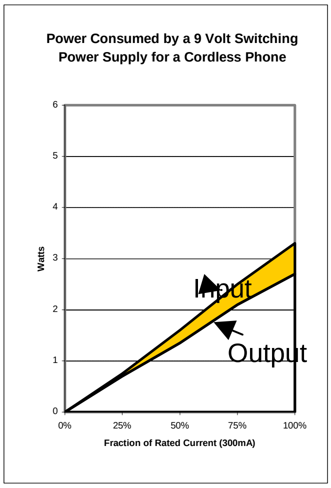


Figure 17: Input-output Curve of LMPS (Left) and SMPS (right) with the Same Output Power of 9W

As indicated in Figure 17, SMPS has the better performance than LMPS in terms of non-load power and working power since the former has a larger power consumption. Therefore, the most effective way to enhance the energy efficiency is to increase the market share of SMPS and gradually eliminate LMPS. The market research shows that LMPS, thanks to the price advantage, is mainly concentrated in the products with small power of less than 12W, but witnesses no price advantage for the products with the power of more than 12W. As a result, LMPS is gradually replaced by SMPS. Since there're only price factors available, this standard will not take LMPS into special consideration. In other words, we only develop a set of technical indexes applicable to LMPS and SMPS.

The energy-efficiency limited value is indicated in Table 9, Table 10, Figure 18 and Figure 19.

Table 9: Energy-efficiency Limited value of Average Efficiency

Rated output power W	Minimal average efficiency （indicated in decimal number）
0 <Po <1	0.39 × Po
1≤Po <49	0.107 × Ln (Po) + 0.39
Po ≥49	0.82

Table 10: Energy-efficiency Limited Value under Non-load Condition

Rated output power Po W	Maximum active power under the non-load condition W
0 <Po ≤10	0.75
10<Po ≤250	1.0

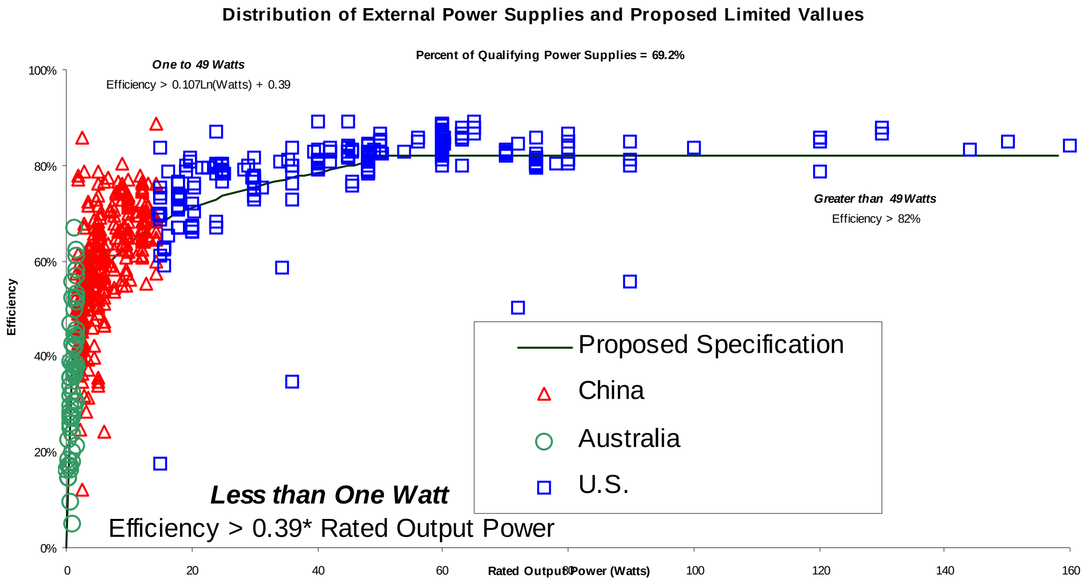


Figure 18: Test Data of Average Efficiency of Samples and Compliance with the Energy-efficiency Limited Value

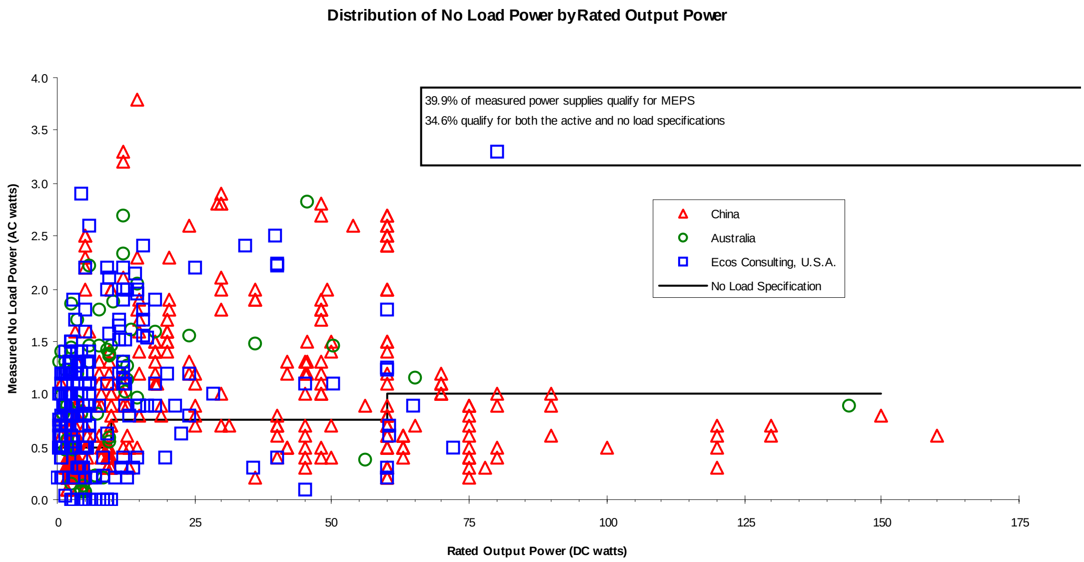


Figure 19: Test Data of Non-load Efficiency of Samples and Compliance with the Energy-efficiency Limited Value

The test result of current samples can satisfy the index demands for energy-efficiency limited values, as indicated in Table 11.

Table 11: Satisfaction of Energy-efficiency Limited Value by the Test Result of Current Samples

Rated power W	Compliance rate of average efficiency %	Rated power W	Compliance rate of non-load efficiency %
0< Po <1	59.38	0< Po ≤10	42.65
1≤ Po ≤10	67.35		
10< Po <49	71.27	10< Po ≤60	25.12
49≤ Po ≤250	61.86	60< Po ≤250	85.71
Average	69.21	Average	39.90
Compliance with both items	34.60		

In an aim to achieve the clear spread of national energy conservation policies, and offer the enterprises more time for rectification so that they can increase their energy-conservation technologies in a piecemeal and planned mode, the standard, in addition to the energy-efficiency limited value, also specifies the targeted energy-efficiency limited value to be enforced in two years. According to the consensuses at Hangzhou meeting, the original third draft for discussion requires that the demands for the first phase of Energy Star be reached. The representatives believed that the integration with the international standards would help the enterprises to arrange their production, export their products and increase their competitiveness. Thus, the draft for comment adjusted the deadline of targeted energy-efficiency limited value as two years later (namely the year 2008), that is, the demands for the first phase of Energy Star shall be matched two years later.

2. Energy conservation assessment values:

The energy conservation assessment values in the standard are determined following the statistical analysis of more than 800 test data in China, America and Australia. The principle is that about top 20% products in terms of energy efficiency meet the demands. Since the data averages of all the average efficiencies are fitted into one index curve, the analysis shows that there're three indexes available according to different rated output powers. As the output power ranges from 0-1 W, the average efficiency is greatly influenced by the output power, and the average efficiency and the output power claim the linear relations. As the output power ranges from 1-49 W, the average efficiency and the output power claim the exponential relations. As the output power ranges from 49-250W, the average efficiency is slightly influenced by the output power and will be a fixed value. The test data indicate that the non-load power at the market has a large distribution and huge energy conservation potential.

The non-load power in the standard is specified mainly in line with the progress and trend of lowering the standby energy consumption of home appliances in the international market, and following several discussions and comment-soliciting in China, America, Australia and European Union. For the purpose of mutually acknowledging the certification results, the energy conservation assessment values are completely synchronized and consistent with the U.S. Energy Star. The energy conservation assessment values are indicated in Table 12, Table 13, Figure 20 and Figure 21.

Table 12: Average Efficiency Energy Conservation Value

Rated output power(Po) W	Minimal average efficiency （indicated in decimal number）
$0 < Po < 1$	$0.49 \times Po$
$1 \le Po < 49$	$0.09 \times \ln Po + 0.49$
$49 \le Po \le 250$	0.84

Table 13: Energy Conservation Assessment Value under Non-load Condition

Rated output power(Po) W	Maximum active power under the non-load condition W

0 <Po ≤10	0.5
10 <Po ≤250	0.75

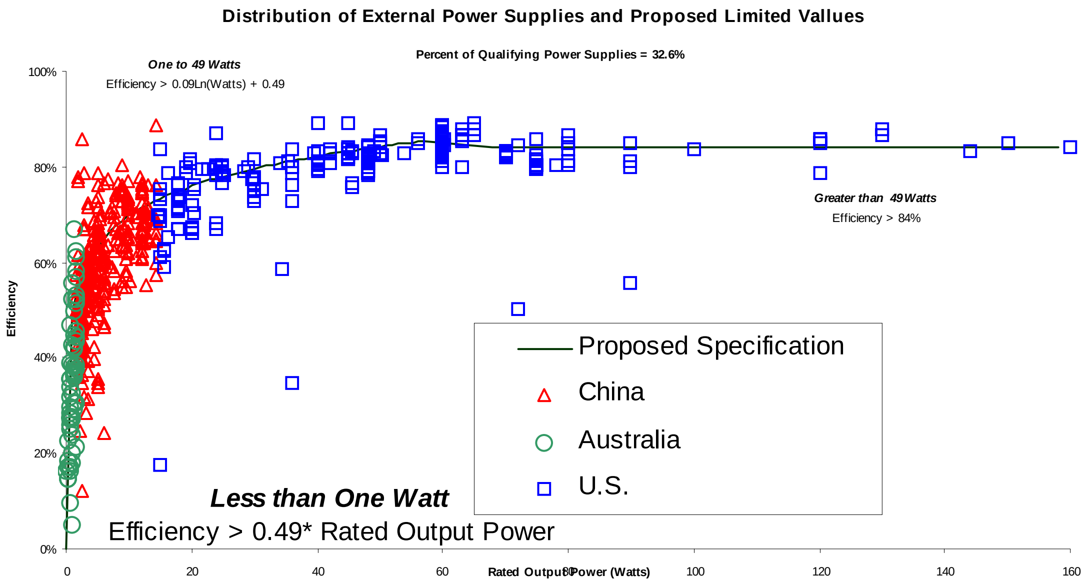


Figure 20: Test Data of Average Efficiency of Samples and Compliance with the Energy-efficiency Assessment Value

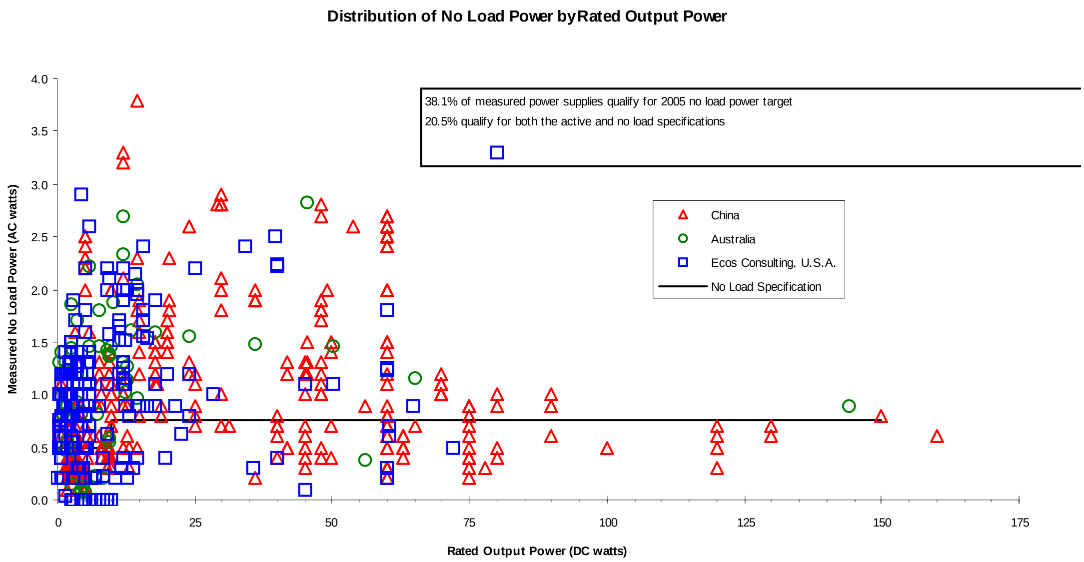


Figure 21: Test Data of Non-load Efficiency of Samples and Compliance with the Energy-efficiency Assessment Value

The test result of current samples can satisfy the index demands for energy-efficiency assessment values, as indicated in Table 14.

Table 14: Satisfaction of Energy-efficiency Limited Value by the Test Result of Current Samples

Rated power W	Compliance rate of average efficiency %	Rated power W	Compliance rate of non-load efficiency %
0< Po <1	31.25	0< Po ≤10	42.65
1≤ Po ≤10	28.23		
10< Po <49	33.70	10< Po ≤250	31.44
49≤ Po ≤250	44.33		
Average	32.6	Average	38.1
Compliance with both items	20.5		

5. Test method:

This standard provides in the form of standardized appendix of the test method for average efficiency and non-load power of power supplies. The test method was jointly developed by China, America and Australia. The test method is divided into three parts including the basic test requirement, test method and test result judgment.

1) Test environment:

- ✓ Environmental temperature: 23±5℃;
- ✓ The air flow velocity close to the samples shall be no more than 0.5m/s;
- ✓ The external fans, air-conditioners or radiators shall not be used to reduce the temperature of samples to be tested;
- ✓ The samples shall be placed on the heat-insulating materials.

2) Test voltage and frequency:

In order to match the different national voltages and frequencies:

- ✓ According to the comments of examination and approval meeting and for the purpose of matching the demands for consistency of international trade, it's necessary to test two modes with the voltage and frequency as 115V and 60Hz, and 230V and 50Hz as far as the wide-range products are concerned. As regards the single-voltage products sold at the domestic market, the national conditions are satisfied by using the test point of 220V and 50Hz.

- ✓ The voltage-stabilizing power supplies shall be used in the test process and the fluctuation shall be no more than ±1％.
- ✓ The maximum power provided by the power supplies shall not be lower than 10 times as much as test power.
- ✓ The total harmonic distortion of 13 harmonic waves for voltage-stabilizing power supplies shall be no more than 2%.
- ✓ The peak value of test voltage shall range from 1.34 times to 1.49 times as much as the usable value.

3) Test devices:

- ✓ The active power of 0.5W or above shall have the uncertainty degree of no more than 2%;
- ✓ The active power of less than 0.5W shall have the uncertainty degree of no more than 0.01%;
- ✓ The active power on power meter shall have the test precision of no less than 0.01W;
- ✓ The tested voltage and current shall have the test precision of no more than 2%;
- ✓ The test loop shall as short as possible.

4) Test method:

- ✓ The samples to be tested shall be warmed up for half an hour;
- ✓ The output current shall change in line with the sequence of 100%, 75%, 50% and 25% of rated output current;
- ✓ It's the output current rather than output power that changes.

VI. Technical and Economical Analysis of Typical Products Using High-efficiency Power Supplies

In an effort to conduct the analysis and research of typical products using the high-efficiency power supplies, define the energy conservation potentials of products and raising the suggestions on policies and measures, China National Institute of Standardization, China Standard Certification Center, and the U.S. Lawrence Berkeley National Laboratory, financially supported by the American Energy Foundation, perform the technical analysis of energy conservation potentials of terminal products.

(I) Analysis Model

In the course of analysis, the project team shares the same analysis model as the U. S. LBNL Laboratory. In other words, the current power supplies products are replaced through the efficient power supplies to define the energy conservation capacity and environmental benefits. This analysis model is based on the market structure, quantity and power consumption of current products with external power supplies, the energy-efficiency level and habit of use for typical products. The future energy conservation capacity is predicted by replacing the efficient products with the current products.

In an aim to determine and analyze the products, the project team takes into comprehensive consideration of the energy conservation potentials, market competitiveness and distribution channels of products. In the course of analysis, the analysis merely forecasts the product replacement. If we consider the adjustment of market structure and the effect of technological advance, the expected energy conservation potentials will be greater. The data in this analysis will also provide the further reference for analyzing the overall energy conservation potentials.

(II) Selection of Typical Products

Since the external power supplies are widely used, the project team, in the course of analysis, consults and learns from the previous experience and some results of similar analysis in the United States, and takes into full consideration our domestic conditions and the channel and accuracy of data collection. The project team determines the list of typical products with external power supplies and develops the analysis.

Table 15: Typical Terminal Products with Power Supplies of External Power Supplies

Serial No.	Field of product	Name of product/equipment
1	Communication	Cordless phone
2	Audio & video	MP3 player
3	Communication	Cell phone
4	Computer and office equipment	Computer speaker
5	Computer and office equipment	Ink-jet printer with external power supplies
6	Computer and office equipment	Laptop computer
7	Comprehensive application	Credit card reader (POS)
8	Computer and office equipment	PDA

9	Computer and office equipment	LCD monitor with the external power supplies
10	Home appliance and charger	Independent charger
11	Computer and office equipment	Heat transfer printer with the external power supplies
12	Home appliance and charger	Digital camera

(III) Sources of Data and Forecast

1. General demands:

For the purpose of analysis, the project team collects the following data for each type of chosen products.

1) Product data:

- Total quantity of products (number)
- Rate of external power supplies available
- Total quantity of external power supplies
- Annual sales amount of products in 2002
- Annual sales amount of products in 2003

2) Energy-consuming data:

- Energy consumption of single products under working condition
- Energy consumption of single products under sleeping condition
- Energy consumption of single products under power-off or standby condition

3) Use data:

- Daily working hours
- Daily sleeping hours
- Daily standby or power-off hours

- Daily hours of disconnection with power grid

4) Property of power supplies:

- Typical power supplies products
- Energy efficiency of current products
- Energy consumption of potential substitutes

2. Source of data for typical products:

In an effort to guarantee the reliability of analysis results, the project team strictly stipulates the data involved in the analysis process. Given the wide use of power supplies products, the project team, based on the related international analysis and domestic research results, provide the rational hypothesis of some data. The specific data are described as below:

1) Cordless phone:

According to the related reports of the Ministry of Information Industry, the quantity of our domestic cordless phones approximated half a million in the year 2000. The research result of CCID Consulting shows that the domestic cordless phones achieved the sales of 4.1 million in 2001, and will experience an annual growth of some 12% in sales volume. On the basis of these data, we can predict that the social quantity of our domestic cordless phones will approximate 14.335 million. In the meantime, we assume that all the cordless phones use the power supplies with external power supplies. As indicated by the test results of National Computer Quality Supervision and Test Center, one typical cordless phone claim the following energy consumption.

Working condition	Sleeping condition	Power-off or standby condition
1.73 W	1.61W	1.29 W

In the process of analysis, we have used the investigation data of China Standard Certification Center on the habit of use and assumed the typical telephone uses of domestic consumers.

Working hours	Sleeping hours	Power-off or standby

		hours
2.0	20	2.0

2) MP3 player:

As a new type of personal electronic entertainment device, MP3 player has risen to much popularity for last three to four years. According to Moore's Law famous in the IT world, this kind of products usually has a life cycle of no more than three years along with the continuous increase in technical level. Therefore, in the course of analysis, we assume that the market maintenance of MP3 player products is the total of the sold products for last three years. CCID research shows that the domestic MP3 player products achieved the market sales of 0.224 million units in 2001, 0.528 million units in 2002 and 1.773 million units in 2003. Thus, it's assumed that the market maintenance of MP3 player products is 2.525 million units. Since most of MP3 player products are charged through batteries, we assume that about 10% of MP3 products are charged through the external power supplies.

According to the research and test of China CEPREI Laboratory, the power supplies of MP3 player products claims the energy consumption of about 4.1W under the working condition and the energy consumption of 0.4W under the sleeping and power-off condition. Since MP3 products are a kind of new and fashionable products with much popularity among the young people, and these young people demonstrate the global similarity in their habits of use, our analysis used the data involved in the analysis of the U.S. LBNL Laboratory.

3) Cell phone:

As IT and telecommunication technology undergoes a rapid development, the cell phones has enjoyed a rapid application and popularity in China. The related data of the Ministry of Information Industry indicate that the market maintenance of cell phones in China reached 0.32 billion in 2003. One external power supplies shall be available for each cell phone.

Based on the test result of the National Computer Quality Supervision and Test Center, one typical charger of cell phone will have the energy consumption as below:

Working condition	Sleeping condition	Power-off or standby condition
3.29W	1.92W	0.94W

As far as the habit of use is concerned, we assume that the cell phones shall be charged once every four days, and it will take 12 hours to complete each charging process. Of 12 hours, the power supplies work for 8 hours to charge the batteries and stand by for other 4 hours (namely the batteries under the state of saturation). According to the habit of use of our domestic consumers, they will plug off the power supplies following each charging process of cell phones. Hence, we assume the following habit of use in the analysis.

Daily working hours	Daily sleeping hours	Daily power-off or standby hours
2.0 H	1 H	21.0 H

4) Computer speaker

According to the research of the Ministry of Commerce, there're about 80 million computers in current use. We assume that almost 60% of these computers are equipped with the speakers and about half of these computer speakers use the external power supplies. Based on the assumptions, we predict that around 24 million computer speakers have used the external power supplies.

Since there's little difference in the computer products and their accessories, our analysis used the research data of the U.S. LBNL Laboratory on energy consumption and habit of use.

Working condition	Sleeping condition	Power-off or standby condition

20 W	----	4 W

Daily working hours	Daily sleeping hours	Daily power-off or standby hours
3.0	---	21.0

5) Ink-jet printer with the external power supplies:

Based on the research report of the Economic Reform and Operation Department of the Ministry of Information Industry, the domestic market maintenance of ink-jet printers reached 8.92 million units in 2003.

According to the test results of China CEPREI Laboratory, one typical external power supplies of ink-jet printer claims the energy consumption as follows.

Working condition	Sleeping condition	Power-off or standby condition
13W	7.8W	0.3W

In 2003, China Standard Certification Center investigated the energy consumption of government institutions and discovered the following habit of use for printers.

Daily working hours	Daily sleeping hours	Daily power-off or standby hours
2.0	7.5	14.5

6) Laptop computer:

According to the research data of CCID Consulting, the domestic market maintenance of laptop computers reached 12.6 million units in 2002. The reports on www.sohu.com state that the current market maintenance of laptop computers totals

14.11 million units in China. Thus, we assume in our analysis that the domestic market maintenance of laptop computers totals 14.942 million units. In the meantime, it's also assumed in our analysis that all the laptop computers have used the external power supplies.

Based on the test result of the National Computer Quality Supervision and Test Center, one typical laptop computer claims the energy consumption as below.

Working condition	Sleeping condition	Power-off or standby condition
34.88W	1.39W	1.47W

Meanwhile, during our analysis, we also assume that the domestic habit of use for laptop computers share the same data used by the related analysis and research of the U.S. LBNL Laboratory.

Daily working hours	Daily sleeping hours	Daily power-off or standby hours	Daily hours of disconnecting to the power grid
2.8	8.3	8.3	4.6

(7) Credit card reader (POS)

In accordance with the reports of the People's Bank of China, there're about 350000 credit card readers available in China. We assume in our analysis that all these products use the external power supplies.

The related energy-efficiency data of credit card readers are based on the research results of the U.S. LBNL Laboratory. In contrast to the energy consumption under working condition, these products under standby and power-off conditions may have their energy consumptions ignored. The typical products have the following energy consumption.

Working condition	Sleeping condition	Power-off or standby condition

8W	0	0

In our analysis, we also believe that the domestic card readers remain under the working conditions for a long time, and so we provide the following assumptions for the time of use under different conditions.

Daily working hours	Daily sleeping hours	Daily power-off or standby hours
24H	0	0

8) Personal digital assistant (PDA)

According to the Huicong research results, the PDA achieved the domestic sales volume of 2.594 million units in 2001, 2.7 million units in 2002 and 2.9 million units in 2003. Based on the above data, it's predicted that the domestic market maintenance of PDA products reached 8.194 million units. We also assume that these products all use the external power supplies.

Based on the test result of the National Computer Quality Supervision and Test Center, one typical PDA claims the energy consumption as below.

Working condition	Sleeping condition	Power-off or standby condition
1.77W	0	0.96 W

We assume in our analysis that the Chinese consumers have the following habits of use.

Daily working hours	Daily sleeping hours	Daily power-off or standby hours
12	0	12

9) LCD monitor with external power supplies:

According to the research data of CCID Consulting, the domestic market maintenance of LCD monitors reached 4.16 million units at present. We assume in our analysis that 70% of these LCD monitors use the external power supplies.

According to the test results of China CEPREI Laboratory, one typical external power supplies of LCD monitor claims the energy consumption as follows.

Working condition	Sleeping condition	Power-off or standby condition
31.5 W	3.5 W	2.95 W

In 2002, China Standard Certification Center investigated the energy consumption of government institutions and discovered the following habit of use for computer monitors.

Daily working hours	Daily sleeping hours	Daily power-off or standby hours
7.5	6	10.5

10) Independent chargers:

In line with the report of China power supplies industry, the domestic output of batteries approximates 19 billion at present, and about 10 million batteries are sold and used at the domestic market. We assume that only 1% of these batteries are chargeable. As a result, we estimate that one charger will be required for every ten chargeable batteries. We assume in our analysis that the domestic market maintenance of battery chargers reaches 10 million at present.

Based on the test result of the National Computer Quality Supervision and Test Center, one typical charger claims the energy consumption as below.

Working condition	Sleeping condition	Power-off or standby condition
4.16 W	3.9W	1.21 W

We forecast in our analysis that the domestic consumers have the following habit of use for battery charger.

Daily working hours	Daily sleeping hours	Daily power-off or standby hours
2	16	2

11) Heat transfer printer with the external power supplies

Based on the related data of China Computer Users Association, the domestic heat transfer printers have the market maintenance of about 550000 units at present. We assume in our analysis that all these printers use the external power supplies.

The related energy-efficiency data on heat transfer printers are based on the research results of the U.S. LBNL Laboratory. The typical products claim the following energy consumption.

Working condition	Sleeping condition	Power-off or standby condition
60W	--	0

We also assume in our analysis that the domestic heat transfer printers are connected to the power grid by the power supplies. The habit of use for typical products is described as follows.

Daily working hours	Daily sleeping hours	Daily power-off or standby hours
1.2	0	22.8

12) Charger of digital camera:

Based on the research data of China CCID Market Research Co., Ltd., the domestic market maintenance of digital cameras reached 3.8 million units at present. Recently, according to the research results of www.cmt.com, the digital cameras achieved the domestic sales of 185000 units in 2001, and 618000 units in 2002. The investigation of China Computer World indicates that the digital cameras achieved the domestic sales of 892000 units in 2003. On the basis of above data, we have finalized the digital camera market data and assumed that about 10% of these digital cameras use the external power supplies.

The test data are adopted from those of the U.S. LBNL Laboratory. Since most of these chargers have the long operation, we may ignore the energy consumption under the standby and power-off conditions. The typical digital cameras have the following energy consumption.

Working condition	Sleeping condition	Power-off or standby condition
5 W	--	--

The habit of use for digital cameras is described as follows.

Daily working hours	Daily sleeping hours	Daily power-off or standby hours
24	0	0

(IV) Results of Analysis

Based on the model analysis and calculation, we discover that the simple substitution of power supplies used by the analyzed products will promise the tremendous energy conservation potential. 12 kinds of products in our analysis claim the energy conservation potential of 12.324 kWh. The following table lists the potential energy conservation capacity and rate of each product.

Table 16: Potential Energy Conservation Capacity and Rate

Name of equipment/product	Energy conservation capacity after the replacement （Billion kWh/year）	Potential energy conservation rate
Computer speaker	0.4208	33.33%
Cell phone	0.3083	31.25%
Laptop computer	0.1472	22.22%
Ink-jet printer with external power supplies	0.1073	16.67%
Independent battery charger	0.0835	31.25%
LCD computer monitor with external power supplies	0.0681	22.22%
Cordless phone	0.0626	31.25%
PDA	0.0218	22.22%
Credit card reader (POS)	0.0072	29.41%
Digital camera	0.0028	16.67%
Heat transfer printer with external power supplies	0.0024	16.67%
MP3 player	0.0004	22.22%
Total	**1.2324**	**27.58%**

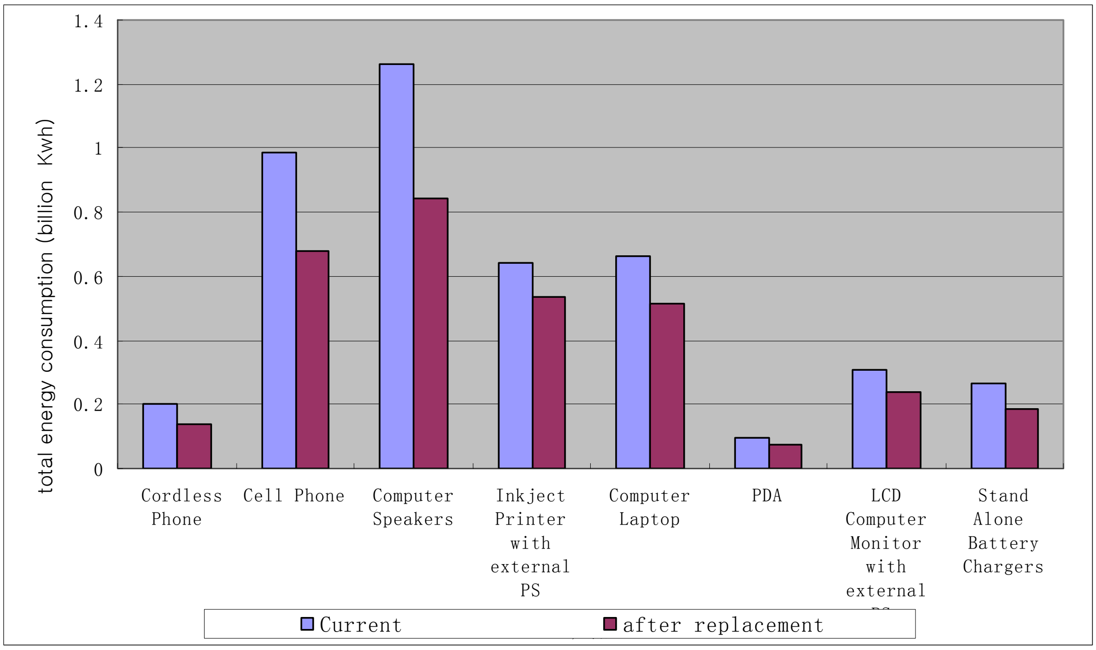


Figure 22: Comparison of Current and Post-replacement Energy Consumptions