# The Development of Environmentally Friendly PCs

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**Abstract**

The global objective today is "to develop toward the sustainable society." This will be done by balancing the global environment and human activities. Our PC business is deployed based on the two pillars of the global and life environments and factors that affect these environments are to be monitored throughout their lifecycles. This paper is intended to introduce our measures including those aimed at compliance with the European RoHS Directive. Also covered are measures that target hazardous substances such as efforts for the use of halogen-free and phosphor-free plastics, those for the use of bioplastics to prepare for the depletion of oil resources, those for noise reduction using the water-cooling technology and those for dealing with VOCs (Volatile organic Compounds).

**Keywords**

EcoSymbol, RoHS Directive, Nucycle, bioplastic, water-cooling module, VOC, sick house (building) syndrome

## 1. Introduction

In the PC business, environmental friendliness is considered to be one of the most important management issues. The importance of environmental harmony is stressed over the entire PC lifecycle, from planning & development to production, marketing, maintenance and support as well as reuse and recycling.

In 1998, we introduced the EcoSymbol labeling system that is approved for leading environmentally friendly products. This policy was aimed at promoting our environmentally friendly products for company in-house and external uses. A product is awarded the EcoSymbol labeling only when it meets the three conditions of; 1) achieving environmentally friendly criteria (including both the all-house common criteria and per-product group criteria); 2) maintenance of advanced characteristics (superior environmental friendliness with regard to traditional in-house and external products); 3) securing transparency (positively opening up the environmental information of the product to the public). Based on this strategy, the first EcoSymbol labeling for PCs was approved in 1999, and all PC products have obtained such labeling since 2002.

In the planning & development phase, we are tackling the "development of environmentally friendly PCs with regard to their impact both on the human being and the environment." This is being achieved by promoting measures such as compliance with product assessment, LCA (Life Cycle Assessment) and environmental labeling systems (EcoSymbol, PC Green Label, etc.), measures against hazardous substances (European RoHS Directive, environment-friendly materials, etc.), energy-saving design, resource-saving design, and low-noise design, etc. (**Fig. 1**).

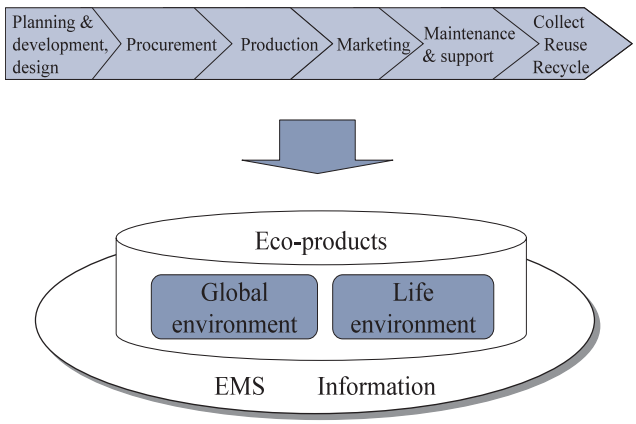


Fig. 1 Environmental measures for PCs throughout their lifecycle.

The present status and the projected future trends of environmental measures for PCs are described in the following.

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## 2. Technological Developments for the Global Environment

### 2.1 Measures Aimed at Compliance with the RoHS Directive

The European RoHS (Restriction of the use of Certain Hazardous Substances in Electrical and Electronic Equipment) Directive prohibits the use of six substances. These include lead, mercury, cadmium and hexavalent chromium in electrical and electronic equipment marketed on and after July 1, 2006. As seen in studies for similar legalization conducted in China as well as in Japan, the demand for environmentally friendly products without hazardous substance content is currently high at the global level.

Among the prohibited substances, one of the most difficult technical innovations was the elimination of lead based solder for use in connecting electrical/electronic components to printed circuit boards. To make this possible with PCs, we focused efforts on the practical implementation of low-melting-point Sn-Zn solder because the traditional nitrogen reflow system makes it possible to maintain the current heat resistance specification of the parts and excellent connection reliability can be ensured if soldering is performed correctly. We improved the Sn-Zn solders-pastes with the cooperation of the solder manufacturers, improved various aspects of the process, and eventually succeeded in establishing material and production technologies, releasing a notebook PC featuring the use of lead-free solder in October 1999. In addition, we also developed a process that covers both the reflow operation of Sn-Zn solder and the flow operation of Sn-Ag-Cu solder and applied it to the production of desktop PCs. This process is also independent from the temperature resistance of individual components.

Our promotion of countermeasures against hazardous substances such as lead and hexavalent chromium has resulted in the commercialization of products that will be either compliant or semi-compliant to the RoHS Directive by the fall of 2005. In the future, we will further promote the elimination of lead in narrow-pitch surface treatment including whisker countermeasures for FPCs (Flexible Printed Circuit) and FFCs (Flexible Flat Cables). These are currently semi-compliant and we aim to make all PC models completely compliant with the RoHS Directive by the end of fiscal 2005 (March 2006).

### 2.2 Halogen- and Phosphor-Free Plastics

Electronic equipment cabinets, including those of PCs employing a variety of plastic materials.

Although phosphorated fire retardants are used frequently with plastics, the use of phosphates (organic phosphor, etc.) is not desirable from the viewpoint of environmental safety because they may pollute the soil and water, which can result in chronic toxicity. The effect of organic phosphorus compounds on health is an issue that is currently under discussion. Based on the above background, we have adopted a silicone fire retardant in developing an innovative fire-retardant plastic "Nucycle" as one of the next-generation plastics and have applied it as one of the cabinet materials for desktop PCs and LCD monitors. Subsequently, we improved the fluidity and strength of Nucycle during its manufacture process aiming at notebook PCs that have thinner cabinets than for desktop PCs. The improved Nucycle began to be used in the notebook PC launched in January 2004 and its further application is being currently expanded.

In parallel with the development and practical application of environmentally friendly materials featuring a reduction in hazardous substances, we have also been applying measures to deal with the depletion of oil resources by adopting recycled plastics and bioplastics[1)].

### 2.3 Bioplastics

A report has warned that the production of oil, the raw material of plastics, will be halved by around 2030. Concern about such an eventuality has led to an increase in attention toward environmentally friendly plastics based on an effective use of recyclable resources, particularly the bioplastics made of polylactic resin, which is obtained by refining plants such as corn. However, as bioplastics lack strength and heat resistance as they are, a kenaf-added bioplastic was developed by adding kenaf fibers (**Fig. 2**). This type of bioplastic can be prepared by adding kenaf fibers as a reinforcement material to the polylactic resin by an amount of 15% to 20%. The resulting product features high global warming prevention effects. This can improve the heat deformation temperature and strength (bending modulus) compared to the traditional bioplastics based on polylactic materials and it also provides characteristics that are superior to the traditional external finish resins made from oil. We applied this material for the first time in the memory dummy card of a notebook PC launched in September 2004 and models using this material have continued to be expanded up to the present.

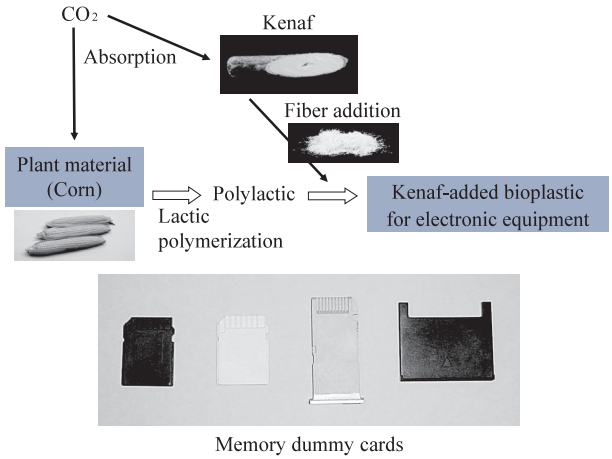


Fig. 2 Kenaf-added bioplastic.

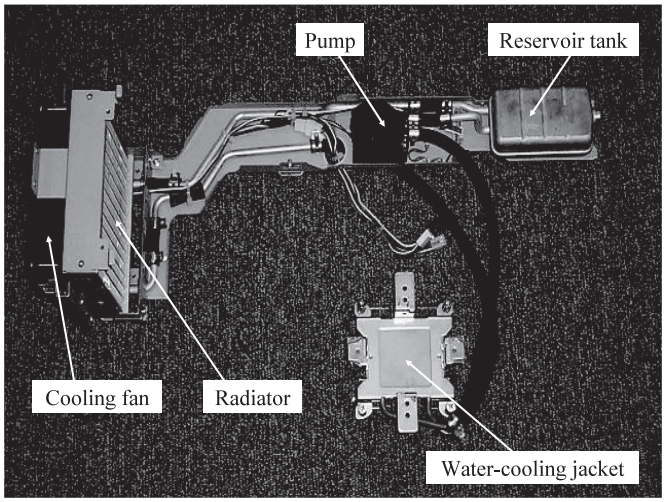


Fig. 3 Water-cooling module.

## 3. Technological Developments for the Life Environment

### 3.1 A Low-Noise PC Based on Water-Cooling Technology

Recent increases in the speeds of the CPUs used in PCs have led to an increase in the amounts of heat generated by them. The CPU is usually cooled using a fan, but the increased heat generation has also increased the noise generated by the cooling fan. Moreover, as a result of the advanced enhancement of TV tuners and home server functions, PCs are now frequently installed in the living rooms of households and this trend has increased the need for lower noise levels. In order to meet these mutually conflicting requirements, in May 2003 we introduced the CPU water-cooling system and launched a desktop PC that features a coexistence of high performance and low noise. Models that are applying this system are currently being expanded.

The water-cooling module uses the coolant in the water-cooling jacket fixed above the CPU to absorb the heat generated by the CPU and circulates it into the radiator at the rear of the PC in order to radiate the accumulated heat (**Fig. 3**). We have conducted various tests which confirm that the module has a life expectancy of over 5 years, even under severe environmental conditions (maximum CPU load under a 35°C environment). We have estimated that the life of the module under actual use will be as long as 10 years. The module is designed maintenance-free and the coolant need not be refilled from outside. The module has a reservoir tank in its inside, which serves two purposes. The first is to conserve the coolant. The module is designed to be free of leakage but a very small amount of water molecules may escape from between the molecules of the resin materials used in the tubes, etc., so the reservoir tank holds coolant of an amount such that can it compensate for any loss of coolant. The other purpose of the reservoir tank is to prepare for freezing the coolant; 1/3 of the reservoir tank volume is dedicated to an air room. Although the coolant is an anti-freezing solution, it resembles sherbet at a temperature of -20°C or below. The air room is used to absorb changes in the coolant volume in such a case[2].

### 3.2 Measures against VOCs (Volatile Organic Compounds)

Recent advancements in the heat insulation and air tightness of buildings has increased the problem of "sick building syndrome," in which pollutants including chemical substances produced in the normal home environment stagnate in a room or house and cause health problems such as headaches and dizziness. The PCs are usually ignored in consideration of this problem because of its low production of chemical substances. However, we assumed multiple PCs usage in schools and such facilities and are promoting measures against the use of VOCs and aldehydes in PCs as part of our activities in offering safer, more comfortable products.

Our PC department became aware of this problem as early as in 2002 and then began to measure the actual pollutants productions from our PCs and we can now provide the confirmed

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data to schools, etc. upon request. We began measurements by using our original method, but later on, in the fall of 2005 we adopted the measurement method prescribed in the VOC Guidelines for Personal Computers[3] given by JEITA (Japan Electronics and Information Technologies Industries Association). These guidelines target seven substances, including the six substances specified in the Criteria for Indoor Air Concentrations of the Japanese Ministry of Health, Labour and Welfare (toluene, xylene, p-dichlorobenzene, ethylbenzene, stylene and formaldehyde) and the acetoaldehyde. The values given in the guidelines were determined, so that the predicted maximum concentration of each substance should be about 10% of the above-mentioned Criteria when 40 PCs are installed in a room with a volume of 180m$^3$, the room being aired 2.2 times per hour. We measured our notebook PCs based on the guidelines and confirmed that all of our models comply with the air concentration values suggested by the guidelines. In the future, we intend to measure the desktop PCs at the same time as making efforts at the production stage to meet guideline requirements.

## 4. Cases of Development of Environmentally Friendly PCs

This section introduces actual environmentally friendly PCs we have developed by incorporating the technologies described above (**Photo**).

VALUESTAR X is a flagship low-noise PC incorporating a "Third-Generation Water-Cooling System," that features an excellent cooling efficiency capable of cooling a 130W CPU.


VALUESTAR X


VALUESTAR G Type C


LaVie T

Photo Environmentally friendly PCs.

It provides an independent air inlet to radiate heat from the water-cooling module and for cooling the cabinet/power supply block to improve the cooling efficiency. It also adopts thorough noise reduction measures for its individual parts including the graphic accelerator, HDD and DVD drives. The cooling fans are 120mm square and are rotated at low speeds. As a result, the noise level during full CPU operation has been reduced in spite of the extensive use of the latest technologies to about 30dB, which is a similar level to that of whispering voices. The system also features advanced RoHS Directive compliance measures by using environmentally friendly materials such as the lead-free solder used in printed circuit boards packaging and hexavalent chromium-free steel plates in the cabinet.

VALUESTAR G Type C incorporates the "Third-Generation Water-Cooling System" with a 95W CPU cooling capability in a slim cabinet with a width of 115mm, achieving a low noise characteristic of about 30dB. The two cooling fans have a size of 80mm square and are rotated at low speeds. The environmentally friendly materials are basically the same as VALUESTAR X and "Nucycle" containing silicone fire retardant is additionally used in the plastic parts of the cabinet.

LaVie T is a notebook PC that is compliant with the RoHS Directive. It features the use of kenaf-added bioplastic in the memory dummy card and the use of "Nucycle" containing silicone fire retardant in about 75% of the plastic parts of the cabinet. The plastic materials in other cabinet parts contain a phosphor fire retardant (a kind of ester phosphate) but this material is known to produce hardly any of the triphenyl phosphate, which is the component that affects human health. The extensive use of these environmentally friendly materials has enabled a reduction in the incidence of sick building syndrome and organic phosphor contamination to an extremely low level.

## 5. Conclusion

As reviewed in the above, our PC business has been deployed from a large variety of viewpoints and is based on the two pillars of the global and life environments. In the future too, we are determined to advance "The development of environmentally friendly PCs by considering issues that are relevant to both the human and earth environments." In this way we aim to contribute to the creation of a sustainable society.

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