EPA Energy Star Computers: The Next Generation of Office Equipment

Brian J. Johnson and Catherine R. Zoi, U.S. Environmental Protection Agency

Computer systems account for 5 percent of commercial sector electricity consumption. Dramatic, cost-effective improvements are available for both hardware power efficiency and the control of operating hours. This paper provides an overview of an innovative new program to realize this potential.

The Energy Star Computers program is a voluntary, market-based partnership effort between the U.S. Environmental Protection Agency (EPA) and computer manufacturers. Industry partners agree to manufacture and market equipment that simultaneously emphasizes high performance and increased energy efficiency. The cornerstone of the program is a signed agreement in which computer manufacturers agree to make efficiency improvements in their products and EPA commits to develop an EPA Energy Star logo that manufacturers can use to identify those efficient products to consumers.

This paper also discusses the issues involved in designing--in collaboration with manufacturers--an agreement to achieve dramatic energy savings that must apply to a broad range of existing and developing technologies, and provide the flexibility necessary to pursue technological innovation in a rapidly changing industry.

It is expected that through cooperation with the agency's corporate purchasing efforts, EPA Energy Star Computers will lead to savings of at least 25 billion kilowatt-hours (kWh) per year of electricity, and reduce CO_2 emissions from electricity generation by 20 million tonnes each year.

Overview of Computer Energy Use

Current Energy Consumption

In 1990 computers and their related peripherals consumed approximately 40 billion kilowatt-hours of electricity in the U.S., or 5 percent of commercial sector electricity (Norford et al 1990). This translates into emissions of approximately 30 million tonnes of carbon dioxide (CO_2), 200,000 tonnes of sulfur dioxide (SO_2) and 100,000 tonnes of nitrogen oxides (NO_x). As one of the fastest growing but most overlooked electricity loads, computer systems take on an even greater importance.

A typical desk-top system comprised of a personal computer, monitor and printer draws 150-250 watts of power and consumes about 700-1000 kWh of electricity annually. Of this, the computer typically consumes about half, with the monitor and printer each consuming approximately one-fourth (Harris et al 1988, Lovins and Heede 1990). Inside the computer, the major power consumers are the mechanical drives, power supply, processors and memory (see Figure 1).

Data collected by the National Research Council of Canada indicate that the vast majority--about 80%--of the time a typical computer is running it is inactive (Newsham 1991). Furthermore, many surveys indicate that 30-40 percent of all computers and printers are left running overnight and on weekends (Harris et al 1988; Lovins and Heede 1990). This somewhat surprising statistic was corroborated by an informal walk-through survey at EPA headquarters in Washington, DC.

There is a widespread--and unfounded--belief that turning computers off, even occasionally, shortens their life (major computer manufacturer personal communications 1991). Also untrue is the belief that "screen savers," which blank the monitor screen following a certain period of inactivity, reduce electricity consumption; measured data show that a typical desktop computer uses almost the same amount of electricity when it is idle as it does when it is active (Harris et al 1988).

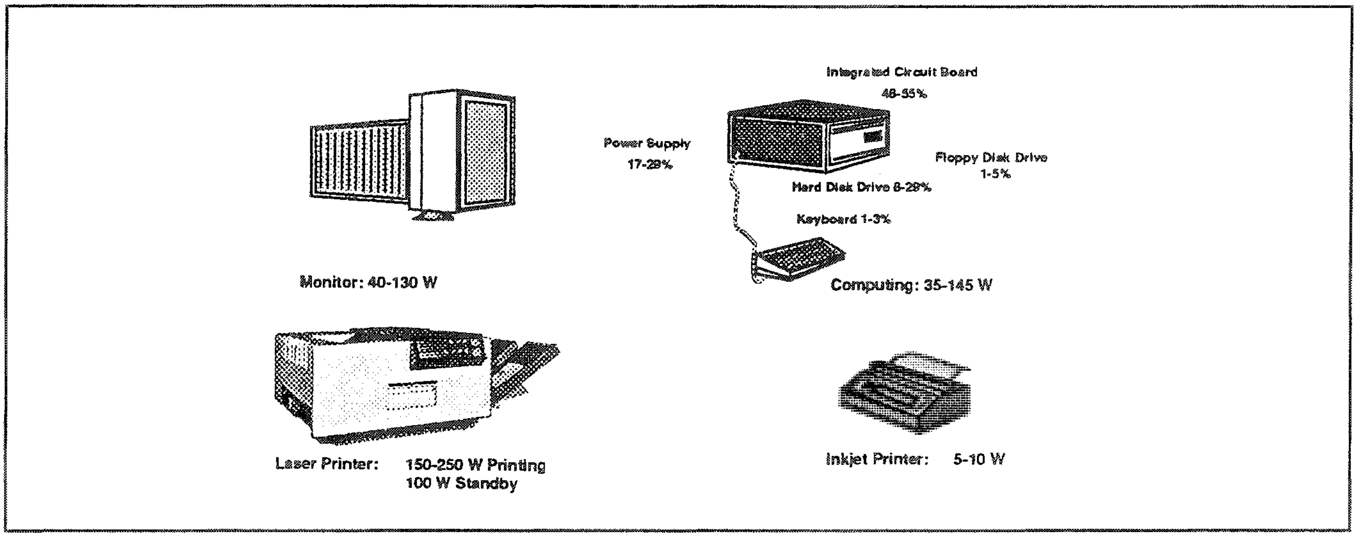

Figure 1. *Power Consumption for Typical Computer Products*

Trends In Future Consumption

Several contradictory trends will affect the energy consumption of tomorrow's computers. Factors exerting upward pressure on consumption include (1) sales growth through the mid-1990's, when saturation of eligible users is expected to be reached; (2) increased use of more energy-intensive peripherals such as laser printers and multi-media devices as their prices fall; and (3) increased use of large, high resolution, color cathode-ray tube (CRT) monitors.

One factor exerting downward pressure on energy consumption is "down-sizing" or "right-sizing". As desktop computing capabilities continue to increase, the industry has been evolving from one centered around large, central computers to one centered on smaller, networked computers. This trend tends to lead to a less energy-intensive computer system on a per user basis (Lovins and Heede 1990).

Of greater importance is the emergence of battery-powered laptop and notebook computers requiring extremely efficient components and sophisticated operating procedures--developments that provide spillover benefits for mainstream applications. Recent innovations include fully static microprocessors and memory chips that use little energy and allow the computer to cycle into a low-power rest or sleep state without losing information. These chips often incorporate a special level of functionality invisible to normal operations and tend to be more highly integrated than previous generations of microprocessors--attributes important both for power management and traditional computing capabilities. According to one major microprocessor manufacturer, a computer equipped with these features and a liquid crystal display screen (LCD) uses less than 10 percent of the electricity of a similarly capable desktop in full power mode, and less than 1 percent in sleep mode (*Introduction...Superset: Technical Overview* 1991).

In the past, LCDs received--and deserved--a bad reputation for poor readability. Now however, high quality color LCDs, which use only 15-20 percent of the electricity of a comparable CRT, have recently been commercialized. It is widely expected that they will outperform conventional screens and could begin appearing on desktops in mid-decade (computing trends consultant & major computer manufacturer personal communications). While it is not clear that all of the efficiency improvements seen in notebook computers will be cost-effective to implement across the board for mainstream applications (assuming the goal is to have prices comparable to today's most popular desktop machines) discussions with manufacturers indicate that substantial energy efficiency improvements can be achieved at negligible or even negative cost (major computer manufacturers and major microprocessor manufacturers personal communications).

These contradictory trends for future energy consumption magnify the inherent uncertainty regarding the future of the computer industry (the personal computer itself is barely a decade old) and make estimates of the future difficult, as evidenced by the range of scenarios exhibited in Figure 2. At the same time, the uncertainty presents a golden opportunity for timely action to address energy use in computer equipment.

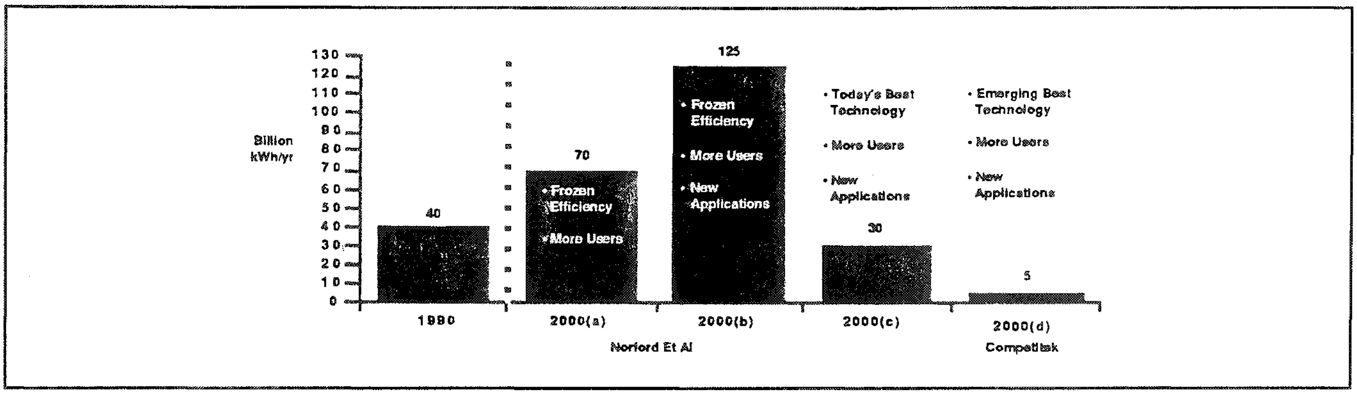

Figure 2. Electricity Consumption for Computer Systems: Load Growth Scenarios

As Figure 3 illustrates, significant reductions in energy use and the concurrent reductions in pollution emissions can be achieved with reasonable measures to address the energy wasted by inactive computers--under *any* scenario for the future.

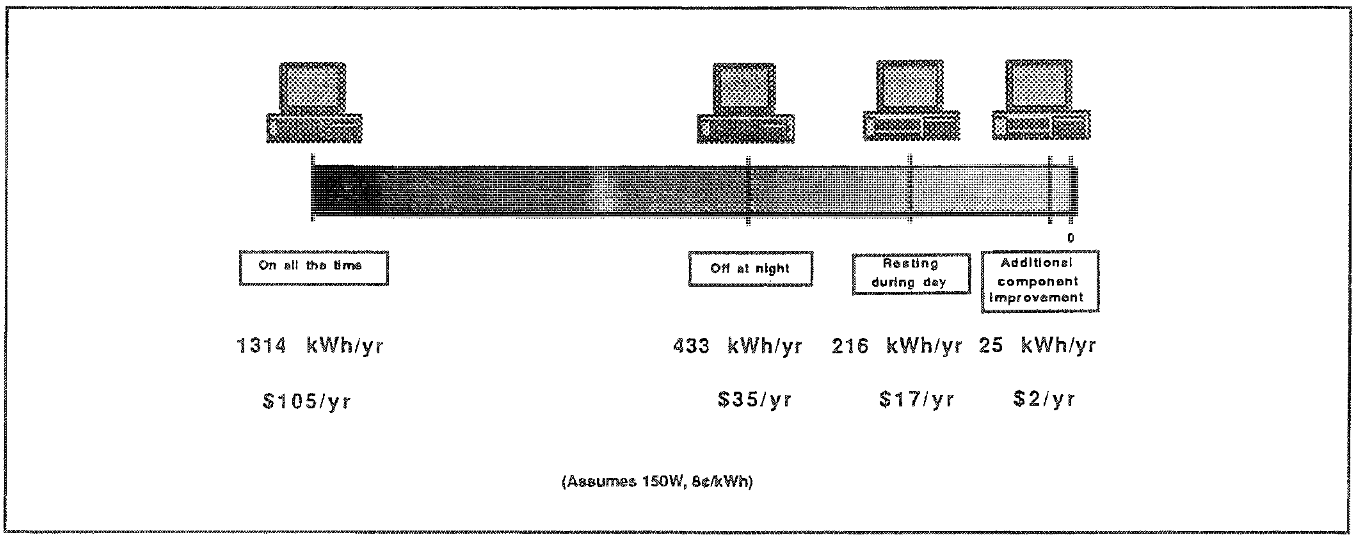

Figure 3. Electricity Consumption and Costs for Inactive Personal Computers

The Market for Energy-Efficient Computers

Encouraging Characteristics of the Computer Market

The computer industry inhabits a rapidly changing and ultra-competitive market. It consists of a large number of small companies selling what have become commodities as the market has matured. However, a few corporations--especially when they act in concert--can exert a measure of influence over the rest of the industry through technical prowess, a large installed user base, and/or a product that is a de facto standard.

Between 1972 and 1985, the price of computer equipment fell over 87%; prices for the newest technologies tend to fall the fastest (Office of Economic Projections database, US DoL). In many cases, there is an unclear relationship between cost and price in the computer market (e.g. it often appears that a model's relative *position* within the product line determines its price).

The computer industry operates in a market that rewards risk-taking and in which technological change is not resisted as it is elsewhere; in fact change is demanded. To date, equipment turnover has been rapid--four to six years (Lovins et al 1990).

Market Barriers to the Widespread Use of Highly Efficient Computers

Although in theory a market economy maximizes efficiency, in practice there exist distortions that inhibit the most productive use of resources and increase pollution emissions. Consumers' tendency to focus on purchase price--"first cost disease"--favors less efficient products with higher lifecycle costs. The resulting lack of market penetration by efficient products prevents economies of scale from developing and discourages research and development in superior technologies. Manufacturers therefore lag behind at getting advanced designs to market, and highly efficient products are left on the drawing board. Also, utility regulation and other barriers often do not reward efficient products or services. These market distortions are mutually reenforcing (e.g. an advanced product often is too expensive to sell rapidly, but will remain costly until production quantities increase).

Although computer manufacturers have been developing high efficiency products for the laptop market for several years, there has yet to be a movement to incorporate these energy savings into mainstream (i.e., desktop) product lines. Initial fears about adverse effects on component lifetimes may explain part of the delay. Cost premiums for efficient technologies undoubtedly were also a factor, although the gap appears to have narrowed significantly. Our meetings with manufacturers suggest that the most important reason that laptop-style efficiency improvements have not been widely adopted is unrelated to technical issues--there simply has not been a market. Compared to traditional marketing points such as performance and price, energy use has not been a big issue--if it has been an issue at all. During one meeting with representative divisions of a major computer manufacturer, a product development specialist remarked that they once considered incorporating low-power states into their mainstream product line, but that the marketing department advised them that it would not be worth the effort (major computer manufacturer personal communication 1992).

An existing EPA program--Green Lights--is tapping into a growing market for energy-efficient products. In Green Lights, EPA signs partnership agreements called Memoranda of Understanding (or MOUs) with organizations that commit to upgrade their facilities to the most energy-efficient lighting available, provided it is profitable and maintains or improves lighting quality. As of May of 1992, over two billion square feet of floorspace--more than all the leasable office space in the metropolitan areas of New York, Los Angeles, Chicago, San Francisco, Philadelphia, Dallas and Washington DC--was committed to energy-efficient lighting upgrades under the Green Lights program.[1]

Corporations who have signed agreements to procure energy-efficient lighting under EPA's Green Lights program and have been approached about expanding EPA's corporate purchasing efforts into other technologies have been overwhelmingly enthusiastic.

Consumers, long unaware of the energy impacts of computer systems and the opportunity for improvement, are beginning to take notice. Last year when a major corporation located in a skyscraper needed to add computing capabilities, the corporation discovered that the building's wiring load was incapable of handling more. The corporation went to its utility for advice and the utility to the computer manufacturer, only to find that there were no energy-efficient products available. The utility re-wired the building; the computer manufacturer is taking steps to make its computers more efficient.

EPA's Pollution Prevention Strategy

After years of heavy reliance upon command-and-control regulation to limit the release of pollutants, EPA is increasing its emphasis on pollution prevention. Recent EPA initiatives address market barriers by focusing on corporate and government purchasing, enhanced product markets, regulatory and legal reforms, and expanded international markets.

While each existing and developing EPA program is unique in many respects--Energy Star Computers is the first to identify energy-efficient products for consumers with a logo--common programmatic traits include a reliance on partnership agreements between EPA and outside organizations, and a decentralized and flexible philosophy. A program that encourages and allows innovation in individual settings can be more cost-effective and achieve a greater level of efficiency than one that relies upon standards that have to apply to a broad range of situations.

Furthermore, while industry usually opposes the imposition of standards, a properly designed market-based program engages industry in a proactive search for more advanced efficiency opportunities. Although a regulatory approach could perhaps achieve more rapid and more certain penetrations of a given technology, market-based programs have a greater potential for achieving ongoing achievements beyond the threshold of a given standard, and they are the preferred approach to EPA's pollution prevention initiatives.

Structure of the EPA Energy Star Computers Program

Given the nature of the computer market and the vast potential for energy savings in computer equipment, and recognizing that consumers and manufacturers would be willing to buy and sell efficient models if a credible mechanism existed to get the ball rolling, EPA initiated meetings with industry representatives to discuss the formation of the EPA Energy Star Computers program.

The Program Mission

EPA Energy Star Computers is a voluntary partnership with industry dedicated to the principle of manufacturing and marketing equipment designed to achieve the highest technical capability and maximum energy efficiency.[2]

The Memorandum of Understanding

The cornerstone of Energy Star Computers is the Memorandum of Understanding (MOU), a signed agreement between EPA and the manufacturer. The MOU serves as the contract outlining each party's commitments. The manufacturer, or Energy Star Computers Partner, agrees to achieve certain efficiency gains in its products. EPA commits itself to make available a logo for use by manufacturers to identify the high efficiency models for consumers.

Energy Star Computers Partner's Commitment

There are several possible approaches to take when defining the level of energy efficiency necessary to qualify a product to use the logo. In order to evaluate the efficiency criterion, several informal goals have been established:

- Maximize manufacturer input
- Maximize flexibility for manufacturers to meet the goal
- Design the efficiency commitment to achieve the maximum potential energy savings
- Design the efficiency commitment to secure support from as many manufacturers as possible
- Take steps to reduce inactive power consumption
- Do not favor "clunkers" or inferior products
- Make it easy for consumers to understand
- Make it applicable to next-generation computers not yet designed
- Make the framework transferable to other types of office equipment

Methods of Defining the Efficiency Criterion

Several methods of defining the efficiency criterion come to mind, each with particular strengths and weaknesses.

Maximum Power Consumption. Perhaps the most obvious solution is to set a maximum power consumption criterion for all models. Although simple, this method probably favors inferior products with less computing capability and does not directly address inactive operating hours (the majority of wasted energy). It also falls prey to the static nature inherent in almost all standards--they serve as "least-common-denominators" and do not encourage continuous improvement.

Energy Consumption Per User. In theory, an energy consumption per user criterion addresses the issue of energy wasted by inactive equipment because it requires consideration of operating hours as well as power consumption. This criterion would require a reliable estimation of usage patterns--the number and duration of a system's periods of use and inactivity--which can vary significantly depending on the user and application. This criterion would also require an estimate of each product's response to these usage patterns, such as the length of inactivity prior to entering a low-power state and the power consumption at each state. Many manufacturers are expected to offer several low-power states which are enacted progressively as the period of inactivity grows--and each user is likely to be given the opportunity to adjust the timing of each state's activation in order to suit that user's individual needs. The minimal degree of control manufacturers have over the use of their products makes this criterion difficult to define and even more difficult to verify that products qualify, once the criterion is in place.

Functional Characteristics. More satisfying is a functional criterion such as the ability to go to a low-power state. This criterion has the advantage of directly addressing the energy consumed when the product is inactive and it is relatively simple to define and understand. Of course, the meaning of "low-power" needs to be defined. For example, does the low-power state have to be below a certain number of watts, or does the reduction have to be a certain percentage? A possible disadvantage is that under this framework, it is technically possible for an energy intensive computer that has the requisite low-power state--and qualifies for use of the Energy Star logo--to consume more energy than a computer that has no low-power state--and no logo--but consumes a small amount of power to begin with. Realistically, however, these two products are unlikely to have similar computing capabilities; the former machine can be expected to be more powerful. The logo's value is in differentiating products that would be evaluated side by side and considered substitutes.

Related Issues in Program Development. Another relevant question when defining the efficiency criterion is whether to use a criterion that can be readily adopted by most manufacturers--and therefore yield products that can be more readily purchased and used, or whether to use a more aggressive criterion that would be adopted more slowly by manufacturers--and therefore yield products that would be more slowly purchased and used, but more efficient.

Similarly, does it make sense to have a two-tiered system with an "Energy Star Computers" criterion that achieves the significant energy savings available today and a "Super-Star Computers" criterion set at a more aggressive level to provide manufacturers with an incentive to continually improve their products? Should one criterion cover both entry-level and high-end personal computers?

Finally, fundamental design issues include how to address potentially incompatible operating systems and software, as well as how to address devices added to the system, such as disks, memory, monitors and printers.

The Energy Star Computers Efficiency Criterion. Following extensive discussions with many of the major U.S. computer manufacturers (see Table 1), EPA adopted a functional criterion for the efficiency commitment in the MOU. Personal computers capable of entering a low-power state with a reduction to 30 Watts or less--about a 70 percent savings from normal usage--will qualify for the Energy Star Computers logo. This criterion was chosen because it is simple to define and understand, because it directly addresses the problem of energy wasted by inactive computers, and because it will allow most manufacturers to market Energy Star computers in a very short time. In fact, manufacturers indicate that the typical Energy Star Computer will likely go significantly beyond this minimum criterion, and it is only a matter of time before most of the computers on the market incorporate this basic capability. EPA intends to develop similar MOUs in the near future for connected devices such as monitors and printers, and for other office equipment and small appliances over the next few years.

Table 1. Manufacturers Providing Input to Program Development

Apple Computer, Inc.
Compaq Computer Corporation
Digital Equipment Corporation
Hewlett Packard
IBM Corporation
NCR/AT&T
Smith Corona Corporation
Bull Information Systems

Promotion of Energy-Efficient Computers

EPA's Energy Star -- Pollution Preventer Logo. The second key element to the MOU, after the manufacturer's commitment to market more efficient products, is the use of a logo to identify those efficient products for consumers. Under the terms of the MOU, EPA has developed the EPA Energy Star -- Pollution Preventer logo. This logo can be used by Energy Star Computers Partners with products, literature and advertisements for products that voluntarily meet the terms of the partnership agreement as described above in order to promote the improved energy efficiency of their product. The logo is included as Figure 4.

Market analyses done by EPA with focus groups indicate that consumers desire and are willing to pay for products that are better for the environment than the alternatives. The market analyses also indicate that consumers have a very high regard for EPA and its programs. Products that voluntarily meet the energy efficiency provisions contained in the Energy Star Computers program and are designated with an EPA Energy Star -- Pollution Preventer logo will have a competitive advantage over models lacking that attribute. EPA desires only that consumers purchase more efficient computers, and does not endorse any particular company or its products. This fact will be noted wherever the EPA Energy Star -- Pollution Preventer logo is used.

Figure 4. The EPA Energy Star -- Pollution Preventer Logo

Purchasing Efforts. Over five hundred corporations, states, and utilities totalling two to three percent of the nation's commercial floor space are now committed to purchasing highly energy-efficient lighting products under the Green Lights program. A similar effort--dubbed Green Buildings--is under development to secure commitments to purchase energy efficiency heating, cooling and ventilation technologies. As EPA's purchasing programs expand, we will develop agreements under which corporations will commit to procurement procedures that consider energy-efficient technologies bearing the EPA Energy Star -- Pollution Preventer logo.

EPA is currently cooperating with a Federal inter-agency task force to refine government procurement policies regarding computer equipment. This effort is expected to lead to a large increase in demand for high-efficiency computers. The U.S. government is the largest purchaser of office equipment in the world, spending over $4 billion per year on computers and software, and spends some $125 million annually in electricity bills for its computer systems (Harris 1992).

Public Awareness. EPA is also working together with the computer industry, environmental groups, and utilities to publicize the environmental and economic benefits of energy-efficient office equipment. The public awareness effort includes media events and articles, both in the traditional news media and on electronic bulletin boards. Since May of 1992, when EPA Administrator William K. Reilly unveiled the EPA Energy Star -- Pollution Preventer logo the trade press has shown great enthusiasm for the program, which will benefit both of their audiences--the computer industry and computer users. In addition to our promotion of energy-efficient computers through the news media, organizations such as the American Council for an Energy Efficient Economy (ACEEE) may include computer equipment in their energy efficiency buyer's guides.

Conclusion

The EPA Energy Star Computers Program combines a signed commitment by computer manufacturers to significantly improve the efficiency of their products, an EPA Energy Star -- Pollution Preventer logo to identify the new high-efficiency equipment, and corporate and Federal purchasing efforts. From the manufacturers' perspective, the program makes possible a bold shift into a new generation of computer equipment that takes advantage of complimentary trends toward energy efficiency. Computer users will benefit from a more advanced system that minimizes annoying fan noise and excess heat. Corporations will save on electricity bills, capital needs for electrical and HVAC systems, and through increased worker productivity. A small company the size of EPA, with 16,000 employees, could save as much as $450,000 per year in electricity bills alone.[3]

When the Bush Administration presented the U.S. action plan to reduce greenhouse gas emissions, EPA Energy Star Computers--along with initiatives by utilities and other organizations to promote energy-efficient computers--was estimated to save 26 billion kWh of electricity in the year 2000 (U.S. State Department 1992).[4] For the U.S., this translates into avoided emissions of 20 million tonnes of CO_2--equivalent to 5 million automobiles--as well as 150,000 tonnes of SO_2 and 80,000 tonnes of NO_x. By leveraging market trends and working cooperatively with industry through programs such as Energy Star Computers, EPA is achieving significant, cost-effective reductions of greenhouse gas and acid rain emissions.

Endnotes

1. See also Robert Kwartin's paper regarding the EPA Green Lights Program in the Government, Non-Profit and Private Programs panel.

2. It should be noted that the EPA Energy Star Computers program focuses solely on energy efficiency and does not include any other environment-related aspect of computer systems.

3. Assumes 16,000 systems at a typical 200 Watts/system operating at 3500 hours per year, or 11.2 million kWh/y. A 57 percent energy savings is assumed. This is consistent with the efficiency improvement cited in the U.S. action plan for greenhouse gas reductions presented to the U.N. in "U.S. Views on Global Climate Change" (see endnote 4). It is also consistent with the terms of the MOU described in Section 6.4.5. for computers. [Assumes typical base power consumption of 100 W, a low-power state of 30 W, and operating hours of 3500/year and inactivity of 80%.] The assumed electricity rate is 7 cents/kWh.

4. The estimate is a result of an Administration interagency analysis in which both EPA and DOE participated. It assumes a 57 percent unit energy savings and a 65 percent market penetration.

References

Harris, Jeff. 1992. "Office Technologies and Energy: Background Briefing for the Federal Interagency Working Group on Energy-Efficient Office Technologies."

Harris, Jeff, J. Roturier, L.K. Norford, and A. Rabl. 1988. *Technology Assessment: Electronic Office Equipment*. Berkeley: LBL Applied Science Division.

Introduction to the Intel386 SL Microprocessor Superset: Technical Overview. 1991. Intel Corporation.

Lovins, A. and R. Heede. 1990. *Competitek State of The Art: Appliances*. Snowmass: Rocky Mountain Institute.

Newsham, Guy. 1991. "Energy Consumption and Desktop Computers." Institute for Research in Construction, National Research Council of Canada.

Norford, L., A. Hatcher, J. Harris, J. Roturier and O. Yu. 1990. "Electricity Use In Information Technologies." *Annual Review of Energy* 15: 423-53.

Office of Economic Projections database, Bureau of Labor Statistics, U.S. Department of Labor. Received January 1992.

U.S. State Department. April 1992. "U.S. Views on Global Climate Change." Presented at United Nations prior to the U.N Framework Convention on Climate Change.