Plug Loads and Energy Efficiency Programs: Focusing on the U.S. and China

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ABSTRACT

This paper reviews the roles of the two major players in plug loads, the U.S. and China. In the U.S. residential sector, electronic equipment is proliferating, with chargers that may be plugged continuously. Recent research of the commercial sector has shown a wide range of electronic equipment densities. In the past decade, test-procedure development, labeling, standards, design competitions and federal procurement have been employed as energy efficiency approaches for plug loads.

Ownership of consumer appliances and electronic equipment has increased sharply in China over the last two decades. As consumer appliances proliferate, residential electricity use has grown at a much higher rate than the overall growth of electricity use. Energy labeling run by the China Standard Certification Center has incorporated a requirement for standby power loss and use for electronic equipment including color televisions, computers, and printers.

California has maintained its per-capita electricity consumption at about the 1973 level, with savings attributable to the state's continuously rising codes and standards and its aggressive energy efficiency programs. The California Public Utility Commission has approved the largest energy efficiency programs ever for 2006-2008. The savings goals for these programs are very aggressive, compelling the California investor-owned utilities to search for all possible ways, including plug loads, to achieve savings.

Improvements in energy efficient chargers produced in China will benefit the U.S. and all other markets from access to more energy efficient chargers at lower costs. China's capacity as a supplier of virtually all power supply production creates a centralized point for influence.

Introduction

Due to their immense importance as producers and consumers of energy and electronics, the United States and China are lead players in the energy issues associated with plug loads. The current design of electronic equipment embeds "phantom" (standby) loads into electronic equipment whose manufacturers, unless subjected to legislative requirements, lack the incentives to produce equipment with reduced or eliminated phantom loads. Both countries have energy efficiency standards for appliances and for power supplies and have collaborated in efforts related to their efficiency. Nonetheless, the question remains as to what level of efficiency requirements will be required of the manufacturers and whether a harmonization of specifications can be achieved. If China, as a production base and supplier to the global electronics market, and the United States, as the largest consumer in the world, coordinate sufficiently in efficiency power supplies, there will be large benefits to the world.

How Significant Are Plug Loads and What Policies Are Related to Them?

We divide the content of this paper into four separate but related sections. The first two discusses the technical and policy trends related to plug loads in the U.S. and China. The third section looks at policy initiatives and energy programs for plug loads in California. The fourth section looks at the links between plug load issues in the U.S. and China. Finally, we offer ideas for the future of plug loads in the fifth section.

Technical and Policy Trends Related to Plug Loads in the U.S.

Electronic equipment continues to proliferate in the U.S. residential sector. Last year, American television ownership hit 3.1 TVs per household, up from only 2.4 sets the year before (TWICE 2005). People are buying new (or newly affordable) television technologies: plasma, LCD, DLP, high-definition, rear projection, etc., and sets continue to get larger. On the television horizon is the discontinuation of analog broadcasts (per Federal Communication Commission fiat), at which point older sets with analog tuners will require an adapter to convert the signal—yet another source of device proliferation. To go with their big-screen TVs, Americans are buying DVD players, digital video recorders, surround-sound systems, subwoofers, and video gaming systems. They're subscribing to cable or satellite services, which come with yet another box to plug in.

American households increasingly have more than one PC at home, with 80 million computers (desktop and laptop) in 60 million households in 2001 (US DOE RECS 2001). To go with our computers, we have modems (cable, satellite, DSL or "plain-old phone system"), printers, and routers. Real technophiles have a full wireless network with two PCs, two laptops, a satellite modem, two wireless routers, one printer for text and one for photos (this is the case for one of this paper's co-authors). For those on the bleeding edge, there's the potential to network all your information technology and consumer electronic devices together in one big home network.

Americans also seem to want to take everything with them on the go: cell phones, Personal Digital Assistants (PDAs), and laptop computers have proliferated in the last decade. Even within the home we don't want to be tied down by a cord. Phones, power tools, small appliances, and shavers and other personal items are increasingly going cordless. Each of these devices has a charger somewhere that gets plugged in, not only for the duration of the charge, but maybe all the time.

Little research has been done on plug loads in the commercial sector, with the exception of office equipment. Recently, however, Roberson, et al. (2004) performed a series of after-hours audits of commercial buildings in order to inventory and characterize the power state of plug-load equipment. Offices, educational buildings and medical office buildings were included in the audit, chosen for their comparatively high density of office equipment. Over 10,000 pieces of equipment were recorded at 16 sites. They found a wide range of equipment densities, 1.7 to 9.4 computers per 1,000 square feet of audited space (the lower densities seemed to reflect a high use of laptops, which were often absent at the time of the audits). Total equipment densities ranged from 11.7 units per 1,000 square feet (in an education building) to 41.1 units per 1,000 square feet (in a large office).

Table 1 shows how the sample broke down by major equipment category. Power equipment includes power strips, uninterruptible power supplies and battery chargers for a wide array of equipment. Office miscellany includes such items as electric staplers, pencil sharpeners, shredders, as well as common personal items such as clock radios and boom boxes. Portable HVAC consisted mostly of portable fans and heaters.

Table 1. Distribution of Plug Load Equipment by Category

Category	Percent of Observed Plug-Load Equipment
Computer	17%
Monitor	16%
Power	14%
Lighting (Portable)	10%
Peripheral	9%
Imaging	6%
Audio/Visual	5%
Office Miscellany	5%
Medical	5%
Food/Beverage	3%
Networking	3%
Medical Specialty	2%
HVAC (Portable)	2%
Laboratory	1%
Other	4%

Total devices=10,162

Although relatively few in number, food and beverage equipment was by far the largest consumer of electricity among non-office equipment. Only the high schools audited had conventional cooking facilities; the rest of the equipment was typically found in break rooms: refrigerators, coffee makers, microwaves, vending machines, and water coolers. Laboratory and medical equipment used the most energy in the medical buildings audited, exceeding even office equipment.

In reviewing policy trends, we are reminded that while major appliances have been on the energy-efficiency radar screen for many years, it wasn't until the early 1990s that office equipment and other miscellaneous plug-load equipment began garnering attention.

The Environmental Protection Agency's (EPA) Energy Star Program was perhaps the first program to attempt to mitigate energy consumption in these products. Conceived as a marketing program, the label gave manufacturers and retailers a tool to market energy efficiency as a product feature. In general, EPA chooses its efficiency requirements to identify the top 20-25 percent of products currently on the market. Plug-load products covered by the program include office equipment, audio and video equipment, telephony products, residential lighting fixtures, dehumidifiers, air cleaners, bottled water coolers, dishwashers, clothes washers, refrigerators and vending machines.

In the 1990s, attention increasingly fell on standby power, the power used when a device is nominally "off" but continues to draw power to support secondary functions such as remote control, maintaining memory, clock display, etc. Such power use could be non-trivial: in the late 1990's, TVs were found using 20 watts in standby mode (Floyd and Webber 1998). The Energy Star specifications for audio and video equipment addressed only power levels in standby mode, but did not take into account active power for these products. President Bush issued an executive order requiring that federal purchasers choose devices using less than one watt in standby. At the time the order was issued, identifying such device was extremely difficult, since most of the Energy Star specifications were higher than one watt. The Federal Energy Management Program stepped in to fill the gap. As the Energy Star program requirements have been revised, EPA has moved toward that one watt goal.

While standby energy use is significant, many consumer electronics spend a significant amount of time in active mode. Because active power is higher—sometimes much higher—there remained a large pool of untapped savings for these products (Foster et al. 2004).

Part of the problem with addressing active power has been the absence of test procedures for consumer electronics. Ecos Consulting has been instrumental in the development of active-mode test procedures (Foster et al. 2004). The monitor test procedure was revised first and was followed by a revision to the Energy Star monitor specification. Energy Star is also working to revise their computer specification, and test procedures have been a key step in that development.

Power supplies were early on identified as a way to tackle active power in a large number of product types at the same time, by developing a single test procedure. The California Energy Commission's (CEC) Public Interest Research Program (PIER) funded the development of a test procedure for external power supplies, which was finalized in August 2004. In 2004, the PIER program and Energy Star jointly sponsored an international design competition for energy efficient AC-DC power supplies. In January 2005, EPA introduced a label for Energy Star external power adapters.

The CEC approved minimum efficiency standards for external power supplies, scheduled to go into effect January 1, 2007. The requirements are identical to the Energy Star Program requirements. In July of 2008, the standard is tightened slightly, with required efficiencies for the highest output devices increasing from 84% to 85%. Also, the maximum energy consumption in no-load mode becomes 0.5 watts for all levels of output power (CEC, 2005).

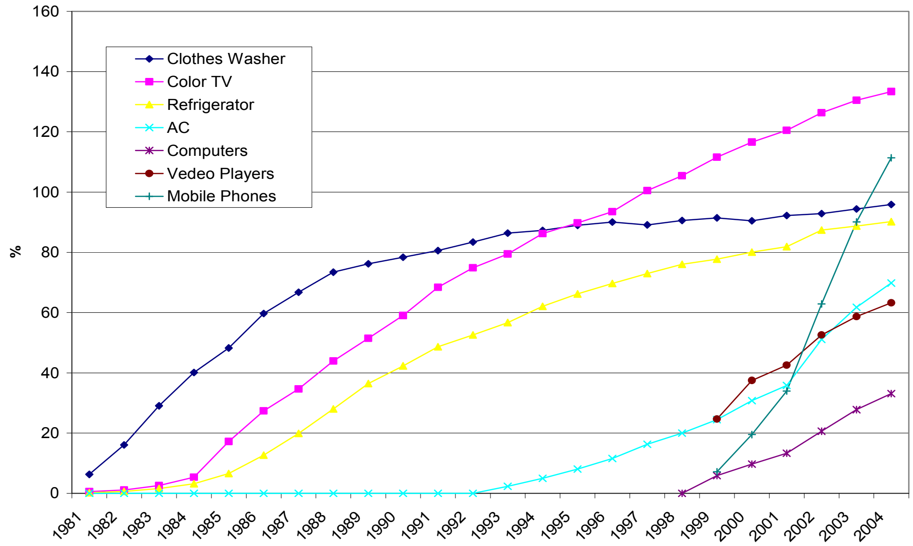
Rechargeable equipment, while it often incorporates external power supplies, presented particular difficulties under the external power supply test procedure. As a result, EPA excluded these devices under the power supply specification, and set about developing a separate battery charger specification. That specification went into effect January 1, 2006.

In the past decade, many of the tools in the energy-efficiency arsenal have been brought to bear on plug-load equipment. Test-procedure development, labeling, standards, design competitions and federal procurement have all been employed. With the exception of white goods, financial incentives (e.g., customer rebates) have typically not been used to promote efficient plug-load equipment.

Technical and Policy Trends Related to Plug Loads in China

Ownership of consumer appliances and electronics has increased sharply in China over the last two decades, due to rising incomes and greater availability of locally manufactured products. Almost all urban Chinese households have the modern essentials of refrigerators and clothes washers, and over two thirds had also installed air-conditioners by 2004. Ownership of color TVs and cell phones exceeds 100%, and over 60% own DVD players as well. Urban ownership of appliances in China is shown in Figure 1.

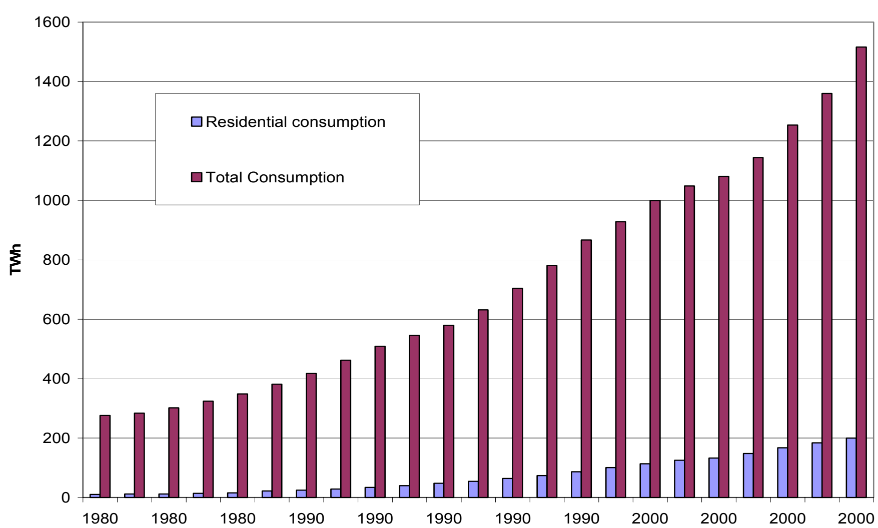
Figure 1. Urban Appliance Ownership, China



Source: China Statistical Yearbooks

Residential electricity use has grown rapidly in China, at an annual rate of 14% over the last 20 years. This is much higher than the growth of overall electricity use in China, about 8% per year (Figure 2). To address such rapidly increasing residential demand, China started its own appliance efficiency standards and labeling programs. In 2001, the voluntary energy labeling program run by the China Standard Certification Center (CSC) decided to incorporate the requirement for standby power loss in its specifications.

Figure 2. Electricity Consumption in China

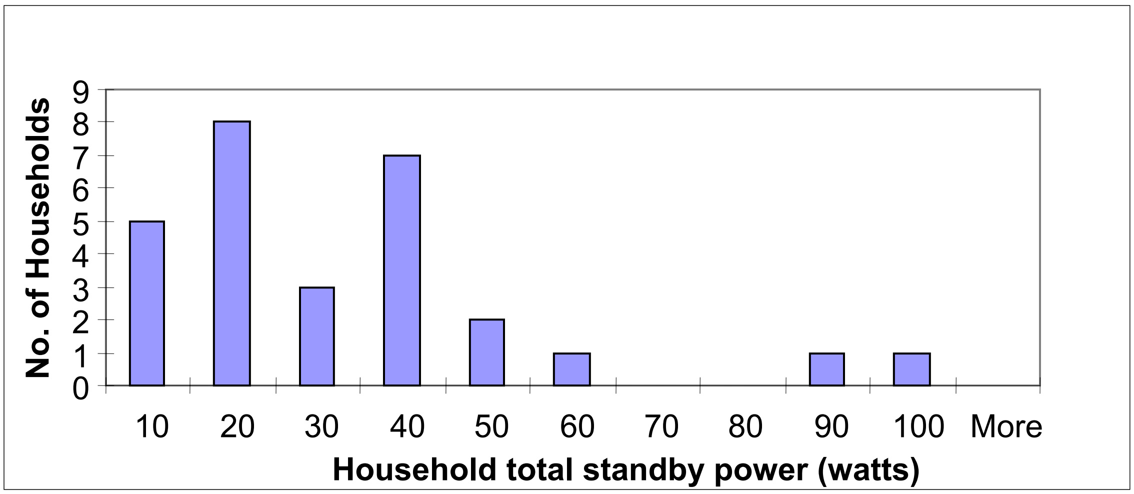


Source: China Energy Databook

A field survey in 2000 (Lin et al., 2001) found that Chinese appliances have higher standby power consumption on average[1]. For example, television sets and video players consume on average 9.6 and 13 watts, respectively. The highest standby power recorded was 44.8 watts for amplifiers, 21.8 watts for VCDs, 21.1 watts for television sets, and 20.2 watts for stereo systems. Due to their prevalence and high average standby power ratings, TVs and video players are the top two appliances that contribute to most of the standby power in these homes.

The total household standby power measured in this survey is summarized in Figure 3. The average standby power per household is 29 watts, while the highest is 100 watts. The majority of the households in this sample have a standby power between 20 to 50 watts, which is similar to the observation in other nations.

Figure 3. Distribution of Household Standby Power in China



Source: Lin et al, 2001 (29 households surveyed)

In 2002, the CSC launched its program on standby power use with a specification for color televisions, and expanded to printers, DVD players, computers, monitors, fax machines, copiers in subsequent years. The CSC has worked closely with the U.S. Energy Star program in developing its product specifications, which were all harmonized with the Energy Star specifications. Savings for the U.S. Energy Star program are documented in Webber et al. (2004).

This collaboration has also led to coordinated efforts between China, the U.S., Australia, and the European Union on the efficiency of external power supplies. On January 1, 2005, China launched a new energy efficiency labeling specification for external power supplies in tandem with those announced by the U.S. Energy Star program. It is hoped that through the harmonization of specifications in both the largest producer (China) and largest consumer (U.S.) in the world, the market for external power supplies will begin rapid transformation to higher efficiency.

Following the successful collaboration in establishing standards for external power supplies, China is now working with the interested international parties on the power use by the

[1] 29 households in Guangzhou were surveyed, and standby power load were measured for all consumer electronics devices in the house.

set-top-boxes, which is expected to needed soon when China starts to convert to digital TV ahead of 2008 Beijing Olympics.

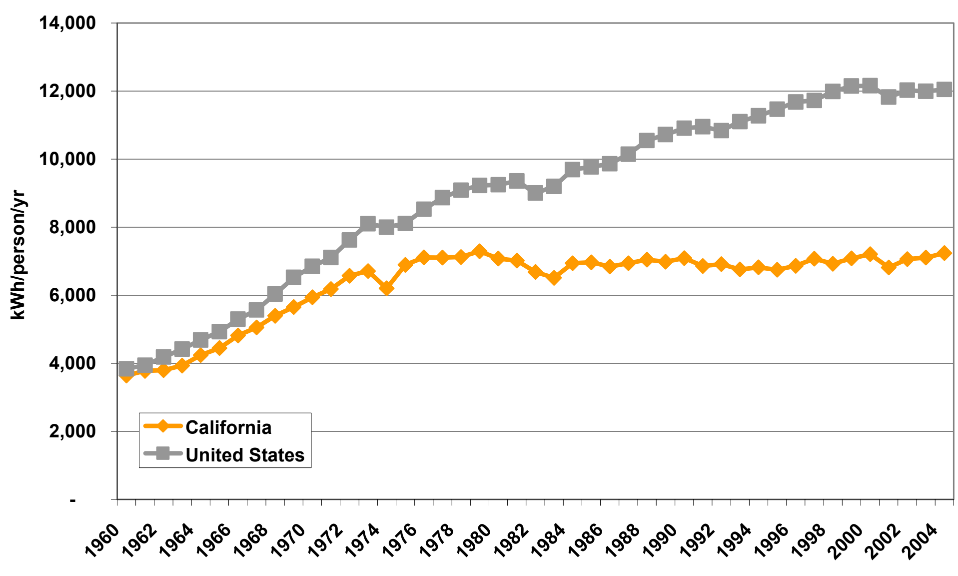
In 2005, China also issued a mandatory standard regulating the active power use of color televisions, becoming one of the first countries that regulate both the standby and active power use by consumer electronics products (AQSIQ, 2005).

In short, China has moved quickly in the last five years to address the growing standby power use, first through its voluntary labeling program and then through its mandatory standard program. Given that China is the production center for many types of consumer electronics products, its actions are likely to accelerate the global adoption of low standby power use policies.

Policy Initiatives and Energy Efficiency Programs Pertaining to Plug Loads in California

The per-capita electricity consumption in the U.S. has increased from 4,000 kWh/person/year in 1960 to 12,000 kWh/person/year in 2004. By contrast, since 1972 the per capita electricity consumption in California has remained about level at approximately 7,000 kWh/person/year. These savings are attributable to California's continuously rising codes and standards and aggressive utility energy efficiency programs. These trends are shown in Figure 4.

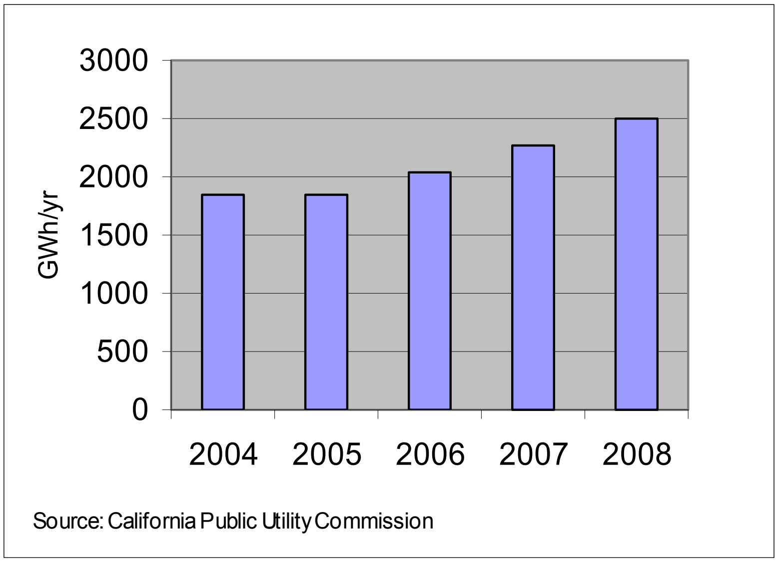
Figure 4. Per-Capita Electricity Consumption (kWh/person/year)



Source: CEC

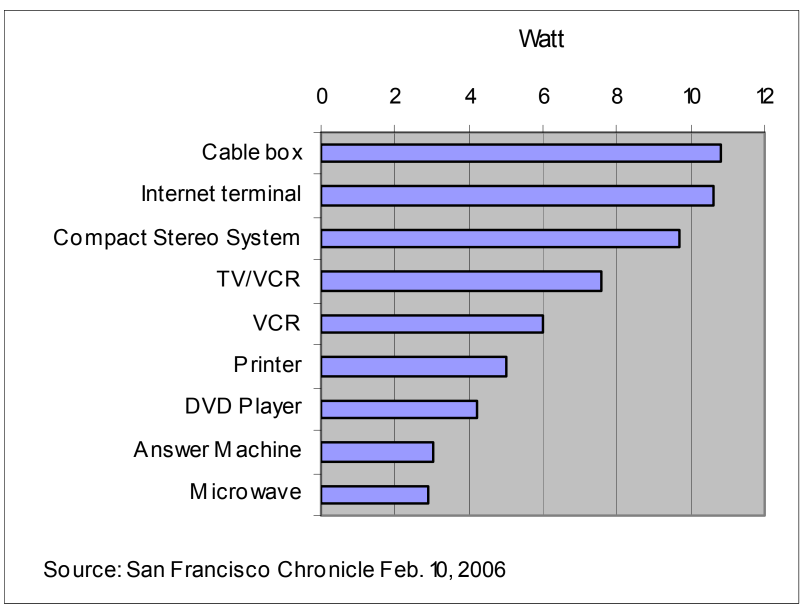
In 2005, the California Public Utility Commission (CPUC) approved the largest utility energy efficiency programs ever in the world–$2 billion for the state investor-owned utilities (IOUs) during 2006-2008. Accompanying this budget are very aggressive savings goals. In order to achieve these aggressive goals, the California IOUs have been searching for all possible ways to reach energy savings. Figure 5 shows these goals.

Figure 5. California IOU Goals (GWh/yr)



One of the fastest growing energy end uses is plug loads, both at home and at work. The standby load (or phantom load) portion of these plug loads is an area that has a great energy savings potential. Figure 6 shows the standby power use of typical household electronic equipment measured by the average energy they consume while on standby mode. These devices are usually plugged in 24 hours a day and 7 days a week. As can be seen, there are big savings opportunities for energy efficiency.

Figure 6. Average Standby Power Use (Watt)



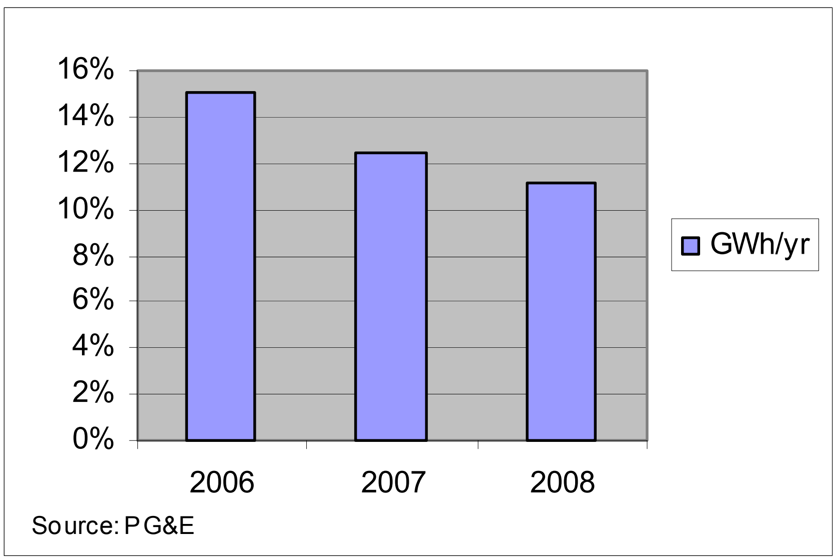
As one of the California IOUs, Pacific Gas and Electric Company (PG&E) is considering aggressively pursuing savings in the phantom load area. PG&E has a vested interest in understanding and influencing energy-efficiency among fast-developing electronics such as computers, TVs, set-top boxes and office equipment.

Comprehensive market research is under the way to assess the plug load market. A desk top computer CRT monitor replacement (by LCD) program is planned to reduce computer plug loads, especially for commercial buildings. Another program to reduce the plug load in desktop computers is the 80 PLUS program.

PG&E has undertaken participation in the national 80 PLUS effort to develop and accelerate to market higher-efficiency desktop computers and servers. The 80 PLUS program offers enormous potential for energy savings over the long run, with a very cost-effective short-term program.

The 80 PLUS program is built around a simple concept—recognize and reward any PC or desktop-derived server that contains a power supply meeting certain efficiency specifications: It offers a $5 manufacturer buy-down for each PC and a $10 manufacturer buy-down for each desktop-derived server containing a qualifying power supply that is sold in the service territory of a participating utility. PG&E aims to deliver over 285,000 such computers to its customers in 2006-2007 alone. Figure 7 shows the energy savings potential for PG&E from the 80 PLUS Program.

Figure 7. Energy Savings Potential from the 80 PLUS Program



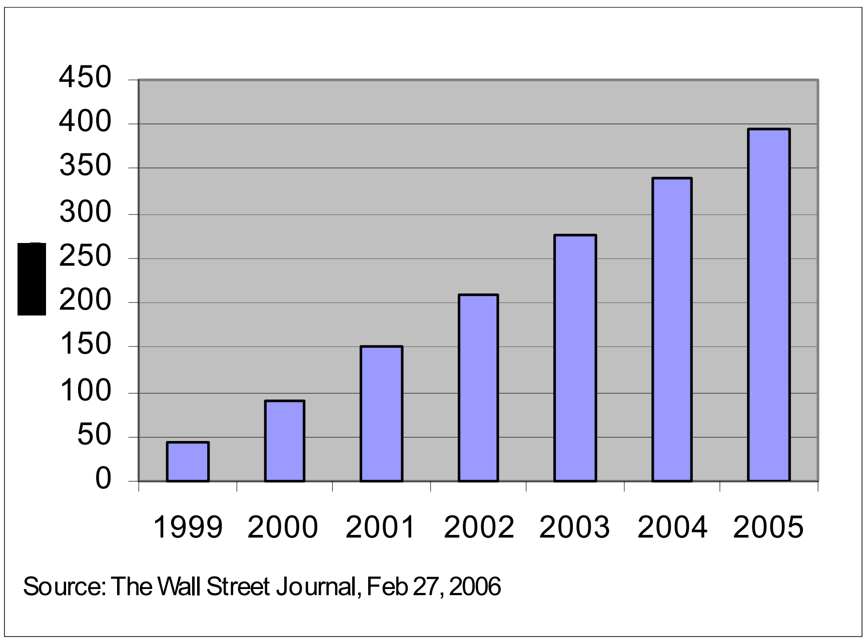
Additional programs underway or under consideration at PG&E include a market and technical study of the home electronics and small offices markets, and power management for PC networks. The market and technical study will include information on usage characteristics, product population, energy and demand information for end uses in homes and small offices, such as home entertainment systems, kitchen appliances, and broadband services. If undertaken the power management for PC networks project will review the energy and cost savings through the implementation of software that allows measurement, management, and reduction of a network's energy consumption.

How Are Plug Load Issues in the U.S. and China Linked?

Several examples of the link across the two countries can be found. China is set to spend billions on wireless upgrades (The Wall Street Journal, 2006). With 399 million mobile phone subscribers at the beginning of 2006, China has more subscribers than the entire population of the U.S. In 2005, China added about 59 million new wireless subscriptions, more than the entire population of Italy.

The total number of year-end mobile-phone accounts in China is rising rapidly as can be seen in Figure 8. China is the main producer of chargers in the world and the growth of its cell phone market at such a quick pace implies a huge market for its chargers. Leveraging of resources to incent the manufacturers in China to produce more energy efficient chargers will benefit the U.S., a major market for these chargers, since it will have access to more energy efficient chargers at lower costs.

Figure 8. Mobile Phone Accounts in China



Another example of the link across the two countries is the laptop PC market. With close to 70% of worldwide laptop production, China plays a very significant role as a manufacturer and supplier of laptop parts. The parts it supplies include hard-disk drives and virtually all power supplies (The Wall Street Journal, 6/9/05). For example, a laptop order placed in the United States is likely transmitted to a Taiwanese-owned plant in Shanghai. The laptop is assembled from parts made in China as well as all over the world. The assembled laptop is flown to the U.S. and shipped to American consumers from a U.S. distribution center.

As the examples above illustrate, it is clear that China’s capacity as a supplier creates a centralized point where power supply production can be influenced, thereby affecting power supplies and energy consumption in homes and offices worldwide.

Plug Loads in the Future

The fast-growing saturation of electronic equipment in the U.S. and China points to how crucial it is to monitor and control standby power. The link of efforts in the U.S. and China is likely the best strategy given the combination of the largest established market with the fastest-growing market and most important manufacturer of electronic equipment. These links for electronic equipment are likely to be good models for newer technologies with production in China and markets around the globe. Additional good efforts would include the European Union and other fast-growing markets such as India.

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