A Trickle Turns into a Flood: Standby Power Loss in China

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Introduction

Standby power use typically describes the power consumption of appliances when they are switched off or not providing their primary services but connected to the electric main. It has also acquired many colorful names such as leaking electricity and vampire power. The most common appliances with standby power use are televisions, VCRs, microwave ovens, and all devices with external power supplies (such as chargers for mobile telephones). Any appliance with a remote control, such as room air conditioner and many audio products, will also consume standby power. Standby power use is small for each appliance; however, when aggregated, it represents a significant portion of household energy consumption. Several studies (Rainer, Meier and Greenberg 1996; Nakagami et al. 1997; Sidler 2000; Harrington and Kleverlaan 2001; International Energy Agency 2001; Ross and Meier 2001; Vowles, Boardman and Lane 2001) have documented that standby power is about 20-60 W per home in developed nations, ranging from 4 – 10% of total residential electricity use.

Such electricity consumption also translates into a significant amount of global carbon emissions. It is estimated that standby power use of appliances is responsible for about 1% of total carbon emissions in OECD countries (Lebot, Meier and Anglade 2000; International Energy Agency 2001). Reducing standby power use has been recognized by a growing community of researchers and international agencies as one of best greenhouse gas mitigation strategies because standby power use can be substantially reduced at relatively low costs.

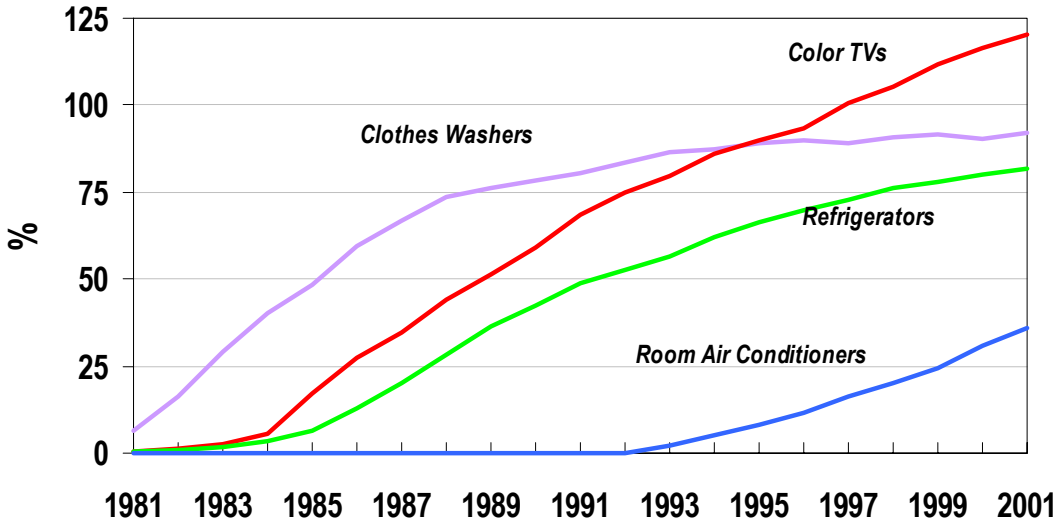
There is almost no information about standby power use in developing countries. Even if the levels of standby power draw for a particular appliance are similar to those found in developed countries, the ownership and usage patterns of those appliances will be different. This paper summarizes the findings from the first survey on standby power use in China.

1. Appliance Ownership in China

As a result of rapid economic growth in China, appliance sales and ownership have soared in China over the last twenty years (see Figure 1). In 1980, modern electric appliances were in ordinary Chinese homes. By 2001, China has become the largest appliance maker and market in the world, with high level of ownership of modern appliances. Clothes washers are present in over 92% of urban Chinese homes; color television sets are present in every urban household; and the ownership of refrigerators and room air-conditioners stand at 82% and 36%, respectively (National Bureau of

Statistics, 2001). Appliance ownership in rural households still lags behind that in urban households; however, the upward trend is similar.

Figure 1: Appliance Ownership in Urban China



2. Measurements of Standby Power Use in Urban Chinese Homes

Data presented in this paper were collected from an informal survey of 28 homes in Guangzhou, all belong to staff of CEPREI Guangzhou testing laboratory, in December 2000. This was not a representative sample of Chinese urban homes; however, the focus of this survey was to rapidly obtain first-hand information on measured standby power consumption.

The appliances in each home were inspected. If they had features generally associated with standby power use–remote control, digital displays, external power supplies, etc.–then their standby power use was measured. This initial survey focused on standby power use by larger appliances and ignored the smaller devices. For example, the surveyors did not measure cordless telephones, mobile telephones (or at least their chargers), and many types of computer equipment that may consume significant amounts of standby power. As a result, this survey may significantly underestimate the actual number of appliances with standby power use and the total standby power per home.

For this study, standby power use was considered to be the lowest power while connected to the electrical mains. Standby power draws are typically in the range of 1 – 10W. However, it is not unusual to find appliances with a standby loss in excess of 20 watts, as can be seen in the next table.

Table 1 summarizes the ownership and power consumption of major appliances with standby power features.

Table 1. Summary Statistics of Standby Power Measurement

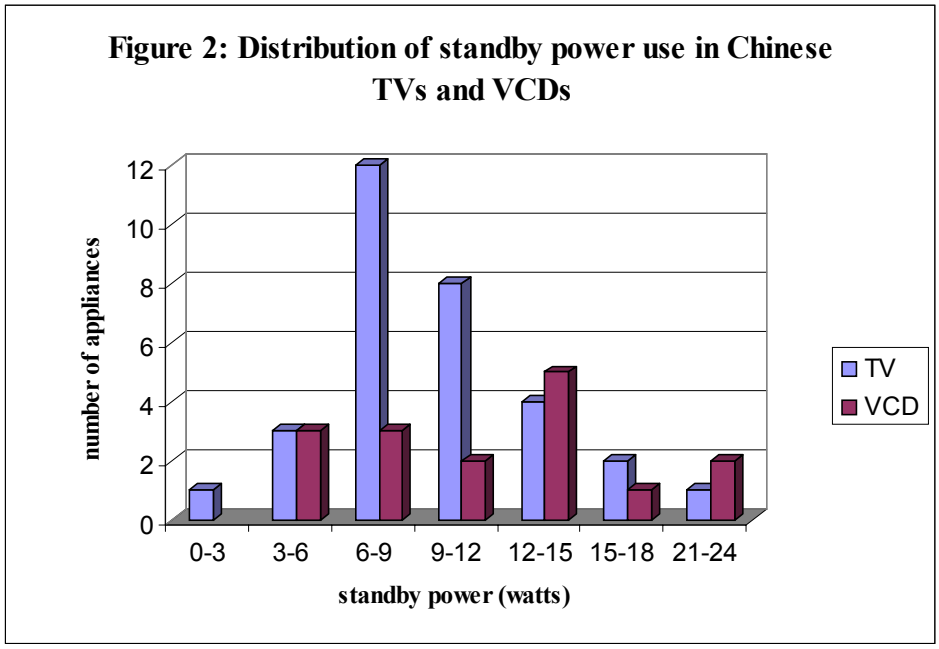
		Standby Power (W)		
Product	Count	Minimum	Average	Maximum
Air conditioner	32	1.0	3.1	9.3
Amplifier	2	19	31.7	45
Audio system	5	3.6	10.0	20
Cooking fan	1	1.2	1.2	1.2
Digital versatile disk (DVD) player	1	3.6	3.6	3.6
Microwave oven	5	0.5	2.9	3.7
Refrigerator	12	0.5	4.1	12
Rice cooker	1	5.2	5.2	5.2
Television (TV)	31	2.4	9.6	21
Video compact disk (VCD) player	16	3.4	12.9	22
Video cassette recorder (VCR)	1	13	12.8	13

Nearly all Chinese air conditioners have standby power use because they need to respond to remote controls. Many new refrigerators have microprocessor controls that cause energy use even when the compressor is not operating. Even modern rice cookers have clocks, displays, and other advanced controls.

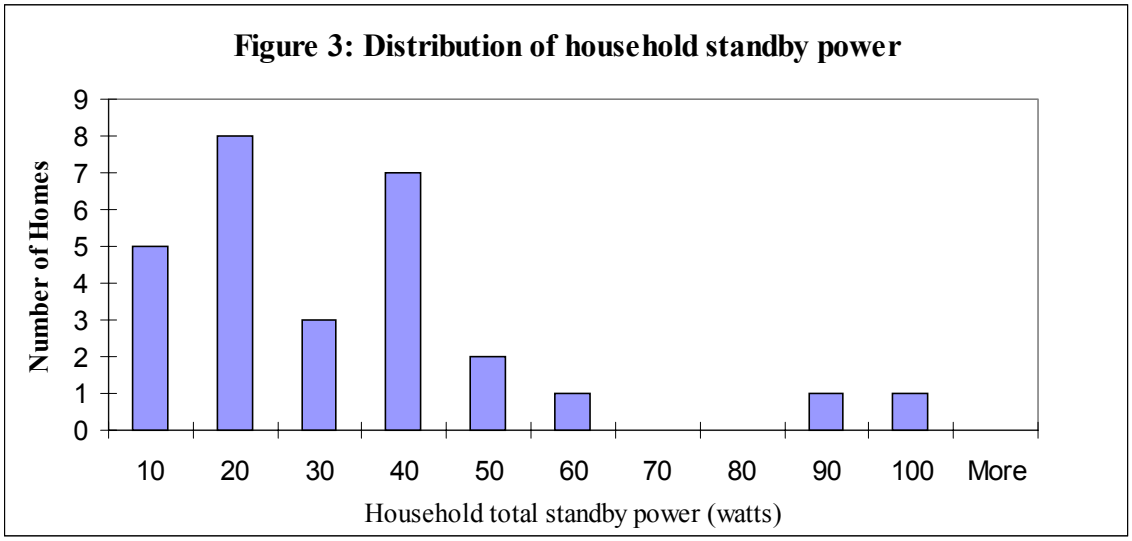
Television sets and air conditioners are the most popular appliances; every family has at least one on average. Roughly two thirds of the families own video players (VCD, DVD, or VCR). Over 40% of the families surveyed have refrigerators (this is lower than urban average, probably because a large proportion of the families in this survey are young). About 20% of the families have stereo systems and microwave ovens.

The highest standby power recorded are 45 W for amplifiers, 22 W for VCDs, 21 W for television sets, and 20 W for stereo systems. Due to their prevalence and high average standby power ratings, televisions and video players are the top two appliances that contribute to most of the standby power in these homes.

There is also considerable variation in the standby power in the measured Chinese appliances. For instance, the lowest standby power recorded for television sets is 2.4 W, low enough to qualify for the Energy Star label, while the highest is over 20 W. Figure 2 presents the distribution of TV and VCD standby power measured in this survey. Most of TVs and VCD players in this sample have 6 W or higher standby power use. It is interesting to note that most VCD players have higher standby power use than TVs.



The total household standby power measured in this survey is summarized in Figure 3. The average standby power per household is 29 W, and the highest is 100 W. The majority of the households in this sample have a standby power between 20 to 50 W, which is less than that observed in Europe, Japan, and North America.[1]



3. Estimates of Annual Standby Energy Use in China

[1] In a more recent survey covering over 400 households in Guangzhou and Beijing in the spring of 2001, we found that the average household standby power loss is about 37 watts.

Standby energy consumption depends not only on measured, instantaneous, standby power of all appliances, but also on how long each appliance spends in the standby mode. In most developed countries, these appliances are plugged in 24 hours per day, so the calculation of annual energy consumption is straightforward. Anecdotal evidence suggests that time spent in standby mode in China is less than the 24 hours per day because many Chinese families disconnect their TVs and other audio/video appliances by means of a switch on the power strip. In the past, this behavior was largely a safety measure to protect appliances against electric disruptions and voltage fluctuations. Power delivery is more reliable in Chinese cities today, so voltage spikes and potential damage to electrical equipment are much less of a concern today. Other appliances, such as cordless phones, are no doubt plugged in all day.

Anecdotal evidence suggests that the practice of unplugging appliances is clearly losing popularity, particularly among the younger generations of home owners. In the newly built homes, consideration of interior aesthetics might dictate the exclusion of visible presence of a power strip in the central entertainment station. And as their income level rise, Chinese home owners are simply less inclined to forego the convenience of their remote controls.

Given the uncertainty of time spent in standby mode, three scenarios were chosen to represent the range of possibilities: 5, 10, and 20 hours per day, respectively.

Table 2. Standby Energy Consumption Under Three Scenarios

Scenario (hours plugged in/day)	Annual Electricity Consumption Per Household (kWh/year)	National Electricity Use (TWh/year)
20	200	25
10	100	13
5	50	6

Based on such assumptions, estimates of average standby power consumption range from 50 - 200 kWh per month. This corresponds to 4 -16% of average household electricity consumption in Guangzhou during a winter month. (It would be less in the summer because of higher air conditioning electricity use.) We believe that the actual situation probably is more than ten hours per day, that is, our middle assumption probably underestimates the actual standby electricity consumption.

There are roughly 120 million households in urban China, so the total residential standby power consumption in China could range from 6 to 25 TWh per year. Even at the middle estimate, this power consumption is equivalent to the output of six 500 MW power plants. Rural households were not included in this estimate because we have no similar measurements. However, their contribution is probably much smaller than urban households because appliance ownership is much lower in rural China.

4. Potential Electricity Savings and Reductions in CO_2 Emissions

Much of the standby power consumption estimated above can be eliminated through simple design changes in the appliances. Meier and Lebot (Meier and Lebot 1999) described some of these technologies and even proposed that standby in all devices could be reduced to about 1W. In fact, many appliances available on market today have a standby power loss of 1 watt or less (www.energystar.gov).

The field measurements presented here suggest that Chinese appliances have on average higher standby power consumptions than similar products in Europe, Japan, or the United States. For example, Chinese television sets and video players consume on average 9.6 W and 13 W, respectively, while similar units in Japanese homes consumed roughly half as much (Nakagami, Tanaka et al. 1997).

Although power reduction per appliance is modest, the aggregate impact for China as a whole could be substantial. To estimate the total savings through reducing standby power of Chinese appliances, three scenarios are constructed: the China best, the 3 W, and the 1 W scenario. The 3 W and 1 W scenarios assume that standby power of Chinese appliances are limited to 3 W and 1 W[2], respectively, while the Best in China scenario takes the lowest observed standby power for each appliance product class as the target (Table 3). The choice of these three scenarios reflects the international practices and what China can realistically achieve in the near term. For example, the present Energy Star specification for televisions is 3 W (United States Environmental Protection Agency 2002), but is scheduled to be lowered to 1 W in 2002.

Table 3: Energy Savings Estimates (TWh)

Scenario (hours plugged in/day)	Scenario		
	Best Available in China	3 W	1 W
20	17	15	22
10	8.7	7.5	11
5	4.3	3.8	5.4

Based on these assumptions, the potential energy savings in China from reducing standby power use in its appliances could range from 3.8 to 22 TWh per year. Even achieving the modest target of 3 W of standby power per appliance could lead to reduction of electricity consumption by 3.8 to 15 TWh per year. Such electricity savings correspond to a reduction of CO_2 emissions of 5 to 19 million tons.

[2] The 1 watt scenario reflects the target set by IEA's One Watt Initiative, which aims to limit standby power loss under 1 watt by 2010.

5. Discussion

Data presented in this paper represent the first estimate of standby power use in China. The survey was not representative because it focused solely on urban households and used a sample of convenience. Furthermore, the survey concentrated on major appliances and ignored many smaller appliances that nevertheless have standby power use. Nevertheless, the results are meaningful, particularly the field measurements of standby loss of various major appliances used in Chinese homes. The total amount of standby power loss per household is likely to be under-estimated due to the omissions of small appliances and young demographics of the sample households which tend to have fewer number of appliances.

The greater uncertainty lies not in the biased sample but in the number of hours that the appliances are left plugged in after use and actually consuming standby power. We estimate that standby energy use is responsible for about ten percent of total electricity use in urban Chinese homes, based on our middle assumption of usage patterns. Thus, standby power consumption already ranks among the five largest end uses of electricity in urban Chinese homes. For urban China as a whole, this translates into roughly 13 TWh of electricity wasted, with a corresponding CO2 emissions of 16 million tons annually. Although rural households have fewer appliances with standby power loss, their sheer number means that a small "leak" could still have a large national impact.

There is strong evidence that standby power use in China will grow rapidly as consumers buy more appliances that consume standby power and as consumers keep the appliances plugged in more hours each day. These synergistic trends could cause standby power use to be the fastest growing end use of electricity in Chinese homes, whose electricity consumption is already growing at a stunning rate of 16% per year. This increasing electricity use translates directly into further investments in new electrical generating facilities and increasing CO_2 emissions. These estimates would be much higher if standby power use in office equipment is included.

Results from this survey also indicate that Chinese appliances may have higher standby power use than similar appliances in developed countries. This suggests that reductions in standby power will be easier–and cheaper–to achieve than in developed countries. More careful investigations of individual appliances will be needed to confirm the technical opportunities and costs of cutting standby power. Chinese manufacturers already build low-standby products for export, so the technical capability is already present.

This study has already had a significant impact on Chinese energy policy. The unexpectedly high levels of standby power observed in this survey caused the Chinese government to devote greater resource to further investigate the potential of reducing standby power loss and to collaborate with international institutions on this issue. In early 2001, China announced its first measurement of reducing standby power loss through its voluntary energy labeling program to reduce standby power in televisions.

Further actions are planned, including labeling program for consumer electronics and office equipment.

Our scenarios demonstrate that reductions in standby power can lead to enormous reductions in both electricity demand and CO_2 emissions. Further research is still needed both to identify technical solutions of reducing standby power loss in various appliances and to improve the initial estimates of reduction potentials of energy consumption and GHG emissions in China. In a country as big as China, no leak is too small.

6. References

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