# Made *for* China: Energy Efficiency Standards and Labels for Household Appliances

**Jiang Lin**
**Environmental Energy Technology Division**
**Lawrence Berkeley National Laboratory**
**Berkeley, California 94720**
**Email: J_Lin@lbl.gov**

## Introduction

Since introduced in the 1960's, energy efficiency standards and labels have been widely adopted in the world as one of the most effective policies to raise end-use energy efficiency. These policies have gained increasing popularity among government agencies because not only they are effective tools in achieving energy saving and climate change goals, but also they can bring substantial economic benefits to consumers and the national economy in terms of reduced energy costs and avoided investment in generating capacities (Wiel and McMahon, 2001).

By focusing on manufacturers, energy efficiency standards can effectively remove most inefficient energy consuming products from the market place while guide the market competition toward higher energy efficiency. By providing energy performance information, energy efficiency labels help consumers make informed choices in their purchasing decision on appliances. Standards and labels can be either mandatory or voluntary, and are often complementary. The most successful examples of these policies include the minimum energy performance standards in the United States, the "Top Runner" program in Japan, the comparative energy labels in Europe and Australia, and the endorsement energy label Energy Star in the United States.

Since 1989, China has developed one of the most comprehensive appliance standards and labeling programs in the developing world. The program includes minimum energy efficiency standards, a voluntary endorsement label, and a proposed information label. The minimum energy efficiency standards are mandatory and have been issued for 9 types of appliance and lighting products. The voluntary endorsement label has been issued for 15 types of appliances, lighting, and industrial products. The information label is under development and is likely to be implemented as a pilot program in 2003 (Lin, 2002).

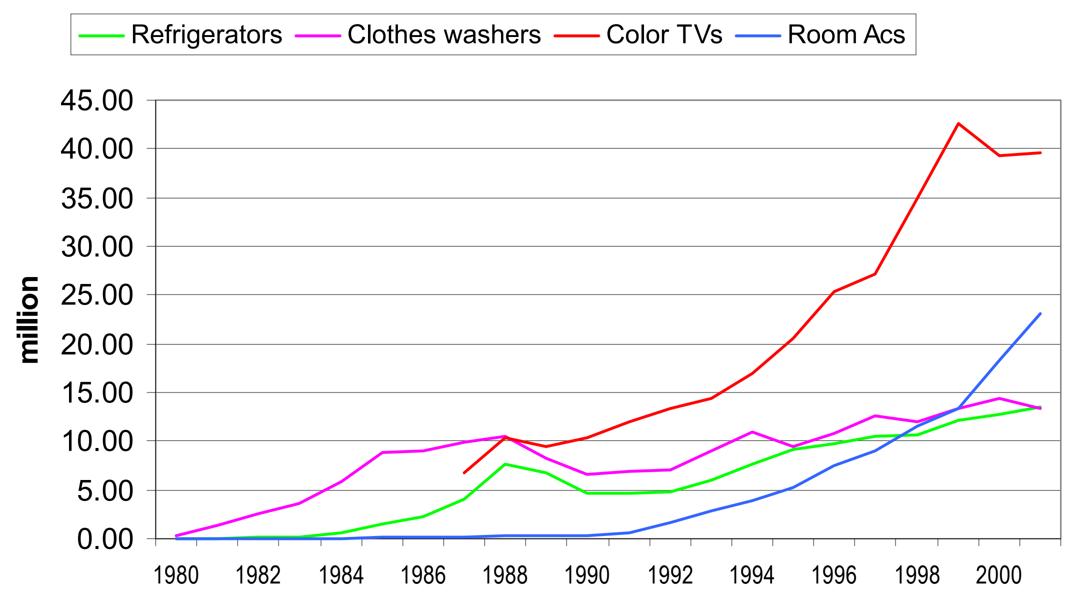
## Appliance Market in China

Over the last twenty years, the growth of the Chinese economy has generated tremendous demand for consumer appliance. To meet such a demand, appliance industry in China has grown with a stunning speed. From a very low production base in the early 1980's, China's appliance industry has become one of the largest in the world, with sales topping U.S. $14.4 billion in 2000 (*Appliance* 2001).

In 1980, the total output of household refrigerators in China was less than 50,000 units per year. Annual production of television sets, clothes washers, and air conditioners was approximately 2.5 million, 250,000, and 13,000 units, respectively.

By 2001, the output of refrigerators and clothes washers in China had each reached approximately 13 million units; production of room air-conditioners had risen to 23 million; and the output of color television sets had increased to approximately 40 million units (NBS 2002). China has become the largest appliance producer in the world by volume, and many multinational firms have shifted their production facilities to China.

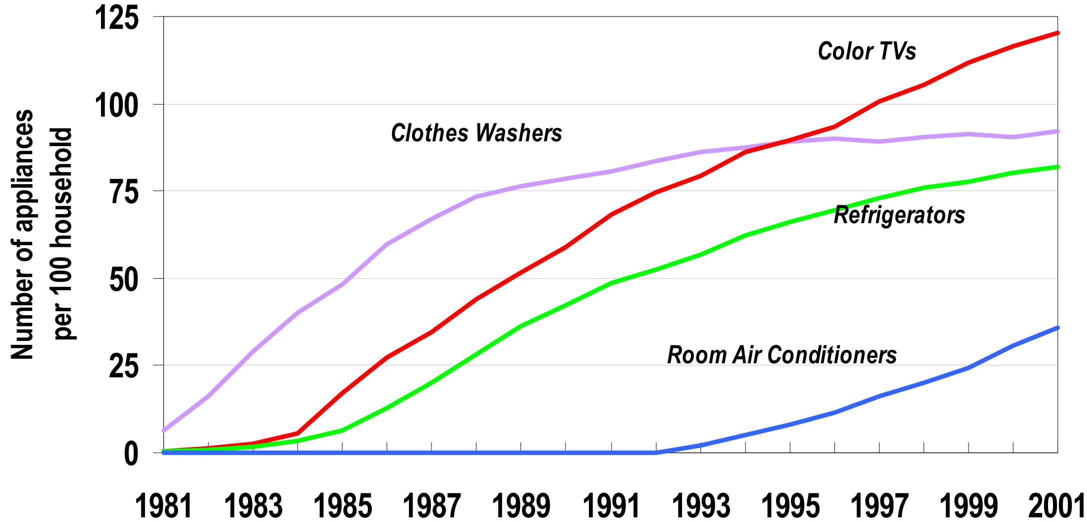
**Figure 1: Appliance Production in China**




Appliance ownership has risen rapidly as well, particularly in urban China. In early 1980s, it is rare to find major electric appliance in Chinese households. By 2001, penetration of color TVs had reached 121 unit per 100 urban Chinese household (i.e., homes having on average more than one television set). Penetration levels have reached 92 for clothes washers, 82 for refrigerators, and 36 for room air-conditioners, respectively, for every hundred urban homes (NBS, 2002).

Such a rapid rise in appliance ownership has contributed significantly to the growth of China's electricity use. Between 1980 and 1996, Chinese electricity consumption grew from 276 TWh to 1000 TWh, with an average annual growth rate of 8 percent, while residential electricity use grew from 10 to 113 TWh, averaging 15 percent growth per year (nearly twice as fast as overall electricity consumption). To meet such rapidly increasing demand, China has added 15 GW of new generation capacity every year since 1980. Most of these new power plants are powered by coal, with high impact on the environment (NBS, 2001).

**Figure 2: Appliance Ownership in Urban China**




**China's Appliance Efficiency Standards and Labeling Programs**

It was against this backdrop of supply/demand imbalance and fast-growing appliance ownership that China started to consider the adoption of energy efficiency standards for appliances. In 1989, China's State Bureau of Technical Supervision issued the first set of standards related to energy efficiency. They included minimum efficiency standards for 8 types of products: refrigerators, room air conditioners, clothes washers, television sets, automatic rice cookers, radio receivers, electric fans, and electric irons.

Given the strong role of government in Chinese economy, mandatory energy efficiency standards are particularly appealing to Chinese policy makers. China has had a very successful energy conservation program under its traditional centrally planned economy (Sinton et al, 1998). Ever since China started its transition toward a more market-based economy, many of the traditional mechanisms of promoting energy conservation have lost their relevance. Appliance standards and labels have thus become a critical component in China's new portfolio of energy efficiency policies. In fact, China's recently enacted Energy Conservation Law highlighted the importance of end-use energy efficiency and standards and label programs[1]. As a result, the development of energy efficiency standards and labels has been accelerated in recent years. Today, China has developed an active and comprehensive energy efficiency standard and labeling program that includes minimum energy efficiency standards, a voluntary energy label, and a proposed energy information label. In the section below, China's most current standards and labels are reviewed.

[1] Several articles of ECL encourage setting limits on energy-intensive products, eliminating most inefficient energy-consuming products, and implementing energy conservation certification programs.

*Minimum Energy Efficiency Standards*

Since the publication of the first set of standards for 8 types of appliance products in 1989, China has enacted 3 more new product standards or revisions of existing standards, with several more under review and development. The standard for fluorescent lamp ballasts was enacted in 1999. Standard revision for household refrigerators and room air conditioners was completed in 1999 and 2000, respectively. Standards for compact and linear fluorescent lamps and clothes washers are in the final review process and should be published soon.

*Refrigerator standard*. The most significant feature of the revised 1999 Chinese refrigerator standard is the inclusion of adjusted volume in the calculation of the energy consumption of the allowed daily maximum (SBTS, 1999a). The adjusted volume takes into account the fact that freezers consume more energy than refrigerators of the same volume. In contrast, the 1989 refrigerator standard set daily maximum by the actual volume of the refrigerator (SBTS, 1989a).

Given that China and Europe use the same testing procedure and their refrigerator products are similar in size, China National Institute of Standardization (CNIS), the research group in charge of developing energy efficiency standards, adopted the formula used in the European labeling scheme for refrigerators. However, there is a significant difference: while the formula is used in Europe as a benchmark to determine the relative ranking of a refrigerator (A-F categories), it is used in China to set the maximum allowable energy consumption. Details of China's 1999 refrigerator standard are summarized below:

Daily electricity consumption limit is calculated according to the formula

$$E_{max} = (M \times V_{adj} + N)/365 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..$$

in which: $E_{max}$—daily electricity consumption limit, kW•h/24h
M, N—coefficients, values listed in Table 1.
$V_{adj}$—adjusted volume in liters

**Table 1. Values of M and N in China's 1999 Refrigerator Efficiency Standard**

| Type | Description | M | N |
|---|---|---|---|
| 1 | Refrigerator, no-star compartment | 0.233 | 245 |
| 2 | Refrigerator, 1-star compartment | 0.643 | 191 |
| 3 | Refrigerator, 2-star compartment | 0.450 | 245 |
| 4 | Refrigerator, 3-star compartment | 0.657 | 235 |
| 5 | Refrigerator/Freezer | 0.777 | 303 |
| 6 | Chest frozen food cooler | 0.558 | 200 |
| 7 | Chest food freezer | 0.597 | 216 |
| 8 | Upright frozen food cooler | 0.624 | 223 |
| 9 | Upright food freezer | 0.519 | 315 |

Note: Stars refer to the temperature settings in the freezer compartment.[2]

[2] Most home refrigerators have 3-star freezer compartments.

The difference in the calculation of the daily maximum electricity consumption between China's 1989 and 1999 refrigerator standards makes it difficult to measure the relative efficiency gains of the new standard. A rough estimate, based on the two popular models (222 and 268 liters), indicates that the revised 1999 standard reduced the maximum daily allowance for the most popular refrigerator products by 10 to 15% (Lin, 2002). The impact of this revision on national energy savings has not been fully documented. However, a recent estimate from CNIS (Li and Cheng, 2001) suggests that China's refrigerator standard -- assuming further revisions in the coming decade -- could reduce China's electricity consumption by 87 billion kWh over the next ten years.

*Fluorescent lamp ballast standard*. In the development of ballast efficiency standard, CNIS adopted the ballast efficacy factor as the measurement of energy efficiency (BEF). BEF is defined as the ratio of ballast factor (BF) over input power to the ballast, and has been used in the US Department of Energy (USDOE) standard for fluorescent ballasts. BEF is a more accurate measurement of ballast efficiency than ballast power loss, because it measures the relative light output per unit of power input. Minimum energy efficiency requirements for Chinese ballasts are summarized Table 2 (SBTS, 1999b).

**Table 2: China's Minimum Energy Efficiency Standard for Fluorescent Lamp Ballasts (BEF)**

| Type | 18W | 20W | 22W | 30W | 32W | 36W | 40W |
|---|---|---|---|---|---|---|---|
| Magnetic | 3.154 | 2.952 | 2.770 | 2.232 | 2.146 | 2.030 | 1.992 |
| Electronic | 4.778 | 4.370 | 3.998 | 2.870 | 2.678 | 2.402 | 2.270 |

The Chinese standard set efficiency requirements for magnetic and electronic ballasts separately. The current requirements would eliminate the most inefficient magnetic and electronic ballasts, but would allow energy-efficient magnetic ballasts to be sold (Zhao, 2000; Lin and Zhao, 2000). For the most widely used ballasts -- those in the 40-watt category -- the Chinese standard is slightly more stringent than the current US standard. However, US DOE has announced a newly revised standard for fluorescent ballasts (effective starting in 2005), which would phase out magnetic ballasts in most applications (Turiel et al, 2000).

Despite the modest efficiency requirements in the Chinese ballast standard, once implemented, it is likely to lead to a reduction in Chinese lighting electricity consumption of 5 to 12 billion kWh over ten years. The corresponding reduction in $CO_2$ emissions is likely to be 1.35 to 3.2 million metric tons of carbon (Lin and Zhao, 2000).

*Room air-conditioner standard*. The revised Chinese minimum energy efficiency standard for room air-conditioners became effective in 2001. Table 3 summarizes the efficiency requirements by product categories.

**Table 3: China Room Air Conditioner Minimum Standard**

| Type | Rated Cooling (CC) W | EER W/W | |
|---|---|---|---|
| | | Cooling Only | Heat Pump |
| Single-Package | CC ≤4500 | 2.20 | 2.15 |
| | CC >4500 | - | - |
| Split | CC ≤2500 | 2.50 | 2.40 |
| | 2500<CC≤4500 | 2.45 | 2.35 |
| | 4500<CC≤7100 | 2.40 | 2.30 |
| | CC >7100 | 2.30 | 2.25 |

For the most popular product category with a cooling capacity between 2500 to 4500 watts, the revised standard raised the minimum EER from 2.26 to 2.45, a gain of 8%. This is a very modest improvement. An analysis conducted jointly by CNIS and LBNL has indicated that if a combination of available technical options, such as more efficient compressors and improved fin and tube design for the heat exchangers, had been adopted, a minimum EER of 2.9 could have been justified both on technical and economic grounds (Fridley et al, 2001).

If an EER of 2.9 were adopted as the revised Chinese minimum efficiency standard for air-conditioners in China, it is estimated that China could reduce its air-conditioning energy consumption by 16.7 billion kWh from 2001 to 2010, with a corresponding reduction in CO2 emissions of 4.5 million tons of carbon over the same period (Fridley et al, 2001). However, the study assumed constant domestic sales in China after 1999, which is likely to underestimate the impact of the standard (with a minimum EER at 2.9). On the other hand, since China adopted a less stringent standard based on other social and political factors, the savings due to this revision of the air-conditioner standard could be lower than indicated above.

*Fluorescent lamp standard*. The proposed minimum energy efficiency standard for fluorescent lamps is currently undergoing a final review. However, a draft report from CNIS (CNIS, 2001) indicates that the cumulative savings from the implementation of the fluorescent lamp standard could reduce Chinese lighting consumption by almost 80 billion kWh over the next 10 years, by accelerating the switch from T12 lamps to more efficient T8 lamps. A closer look at the analysis indicates that the saving estimate is based on the assumption that a given space will need fewer T8 lamps than T12 lamps because T8 lamps are slightly brighter on average. Whether such an assumption would hold true in the coming decade remains debatable, given that lighting levels in China are typically lower than those observed in the developed nations and could rise as income level rises in China. If people chose to increase lighting levels by maintaining the number of lamps per room, then the savings from the standard would be lower than indicated above.

*Voluntary Endorsement Labeling*

Following its establishment in 1998, China Certification Center for Energy Conservation Products (CECP) formalized a comprehensive system of certification requirements and procedures, under which an endorsement label would be granted to products that meet both the *quality assurance* and *energy performance specifications*[3]. In 1999, CECP granted its energy conservation label to 103 models of refrigerators from 9 major manufacturers. At the end of 2000, there were a total of 203 different models of labeled refrigerators from 20 manufacturers. According to a CECP analysis, labeled refrigerators consume an average of 18% less electricity than non-labeled products (CNIS 2000).

In 2000, CECP granted its energy conservation label to 67 models of air-conditioners from 10 manufacturers. According to CECP estimates, labeled air-conditioners consume 10% less electricity on average than non-labeled products (CNIS, 2000).

No study to date has attempted to evaluate the market penetration of CECP's endorsement label among various appliance products in China. Interviews with several top refrigerator manufacturers in China by CECP, US EPA, LBNL, and ICF indicated that most of their products met the CECP label specifications (ICF, 2001). An assessment of the potential impact of the labeling program in China finds that if CECP's labeling program achieved a similar market penetration target as the US Energy Star program, refrigerator and air-conditioner labels could reduce China's electricity consumption by 23.5 and 12.8 billion kWh, respectively, over the next 10 years. And the corresponding reduction in CO2 emissions would be 7.9 and 4.3 million tons of carbon, respectively (Lin and Fridley, 2001).

In addition to refrigerators and air-conditioners, CECP has recently developed certification specifications for 13 other products including fluorescent lamp ballasts, electric water heaters, microwave ovens, and small and medium electric motors (CECP, 2002). Similar technical specifications are under development for linear and compact fluorescent lamps. However, impact on energy savings from these programs is unknown at present.

In January 2002, CECP launched a program to reduce standby power loss in home appliance and consumer electronics. The first specification for color television sets requires qualified television sets to have a standby loss under 3 watts. By 2011, the TV program alone would lead to an electricity reduction of 2.7 billon kWh by 2011. Such a reduction would translate into a reduction of CO2 emission of .93 million tons of carbon

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[3] Tailored to China's appliance market conditions, CECP has added stringent requirement for quality assurance for manufacturers that is similar to internationally compatible standards (such as ISO 9000), in addition to product efficiency specification, as part of its certification requirement.

per year by 2011. CECP is planning to extend this program to cover other consumer electronics and office equipment in the next few years.

*Energy Information Labels*

Starting in 2000, CNIS has undertaken a feasibility study of establishing an energy information labeling program. A draft regulatory framework has been developed. Draft label designs are being tested in the field. A pilot information label program is likely to be launched in 2003 for one or two appliance products.

**Discussion**

Although China's appliance standard and labeling programs were started in the late 1980s, their impacts have not been well documented. There are various working reports on China's appliance standard and labeling programs, but few have been made to scholarly publications. A recent review (Lin, 2002) finds, however, that existing Chinese standards and labeling requirements for appliances are already having a substantial impact on slowing the growth of residential electricity demand.

According to Lin, by end of this decade, existing standards and labels in China for the most common appliances are likely to reduce residential electricity consumption by 33.5 TWh annually, or by approximately 9% of the forecasted residential electricity in 2010 (Lin 2002). Such a savings would also result in a CO2 emissions reduction of 11.3 million tons of carbon in China. And by 2010, the cumulative electricity savings would add up to 164 TWh, equivalent to a reduction of China's CO2 emissions by 56 million tons of carbon.

These savings estimates, if they materialize, represent a remarkable achievement for China's appliance efficiency programs. The American appliance standards program, which started much earlier, covers more products, and is the most successful in the world to date, projects an annual reduction of 13.6 million tons of carbon by 2010 -- roughly 5.4% of the total CO2 emissions in the residential sector (McMahon et al, 2000). Therefore, China in a few years has put into effect a program that will catch up -- in terms of GHG emission reductions with the world's best program by 2010.

Despite the significant gains that China has made in raising appliance efficiency, there is still substantial energy reduction potential in the appliance sector. Technically, there are still significant efficiency gaps between appliances sold in China and those sold in the developed nations. To narrow such gaps, China needs to develop a more forward looking approach towards setting minimum efficiency standards. In the US, for example, standard levels are determined through a careful examination of all available technical options that are economically justified. Such an approach often results in greater energy savings than simply looking at the distribution of appliances currently on the market. The results are more stringent standards, sometimes referred as "reach" standards. The effective dates of such standards are typically set a few years after the announcement of the standards to allow sufficient time for the manufacturers to meet the new standards.

Currently, standard levels in China are set to eliminate the least efficient 10 to 15% of the products. China should pursue such a "reach" standard approach in the future to capture the full energy saving potential and bring greater economic and environmental benefits to the Chinese consumers. Of course, the "reach" standard approach demands more in-depth engineering and economic analyses which require more analytical resources. Given the large economic and environmental benefits that appliance standards could bring, China should devote more resources to develop such analytical capabilities and enforcement mechanisms.

Currently, the development agenda for standards and labels is set by CNIS and CECP in consultation with leading government agencies (such as the State Economic and Trade Commission and State Administration on Standards). Other stakeholders are notified only after the standard development is well under way. In the future, a clear timeline for standard and label development and revision would reduce the uncertainties that manufacturers face and thus make it easier to comply with the standard and label requirements.

With China's accession to WTO, China's appliance market will be further integrated with the world market. Therefore, China needs to better coordinate the development of its standards and labels with international programs in the interest of reducing trade barriers and promoting export. Particularly in the consumer electronics sector where China is one of the largest producers and consumers, coordination and possibly harmonization with international standard and labeling requirements could be mutually beneficial in both increasing trade volume and increasing effectiveness of standards and labeling programs. China, if willing, could play a leadership role in transforming the global consumer appliance market towards high energy efficiency.

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