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APPLIANCE EFFICIENCY STANDARDS AND LABELING PROGRAMS IN CHINA

Jiang Lin
Environmental Energy Technology Division, Lawrence Berkeley National Laboratory, 1 Cyclotron Road, MS 90-4000, Berkeley, California 94720; e-mail: j_lin@lbl.gov

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■ **Abstract** Since the late 1980s, China has developed an extensive program of energy efficiency standards and labeling for household appliances. This development closely traces the rapid growth of appliance ownership and the domestic appliance industry and is an integral part of China's comprehensive energy conservation policy. The implementation of energy efficiency standards and labels for household appliances has not only achieved significant reductions in energy consumption and therefore greenhouse gas emissions in China, but it has also been instrumental in stimulating one of the world's largest appliance markets. This article reviews the historical development of Chinese programs, summarizes the most recent activities, and documents to the extent possible their impact on appliance efficiency and energy consumption.

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INTRODUCTION

China currently has one of the most comprehensive appliance standards and labeling programs in the developing world. The program includes minimum energy efficiency standards (MEES), 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 13 types of appliances, lighting, and industrial products. The information label is under development and is likely to be implemented as a pilot program in 2002.

Although quite comprehensive, the programs were initiated fairly recently. The first set of Chinese standards was published in 1989 (1). This is not surprising, given that appliance production and ownership in China was miniscule in the early 1980s when China started its economic reform.

In 1980, the total output of household refrigerators in China was less than 50,000 units per year. Annual production of color television sets, clothes washers, and air conditioners was approximately 300,000, 250,000, and 13,000 units, respectively (Figure 1). Very few households had modern electric appliances except radio receivers.

The next decade witnessed tremendous growth in China's economy, rising personal incomes, and a rapidly expanding domestic appliance industry that was eager to serve the growing demand for modern appliances. Many international and Chinese manufacturers set up production facilities in the 1980s, and production increased rapidly to meet the needs of the large Chinese market.

By 1989, the production of color television sets was approaching 10 million units, and production of clothes washers and refrigerators had reached 8.3 and 6.7 million units (2), respectively, which represented a growth of 33-fold and 136-fold over one decade. The increases in appliance ownership led to rapid growth in household energy consumption—16% annually since 1980 (Figure 2); this energy use placed an ever-increasing burden on China's electric supply systems, which have been forced to add an average of 15 GW of new capacity each year.

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 (SBTS) issued the first set of standards related to energy efficiency. They included minimum efficiency standards for eight types of products: refrigerators, room air conditioners, clothes washers, television sets, automatic rice cookers, radio receivers, electric fans, and electric irons (4–11).

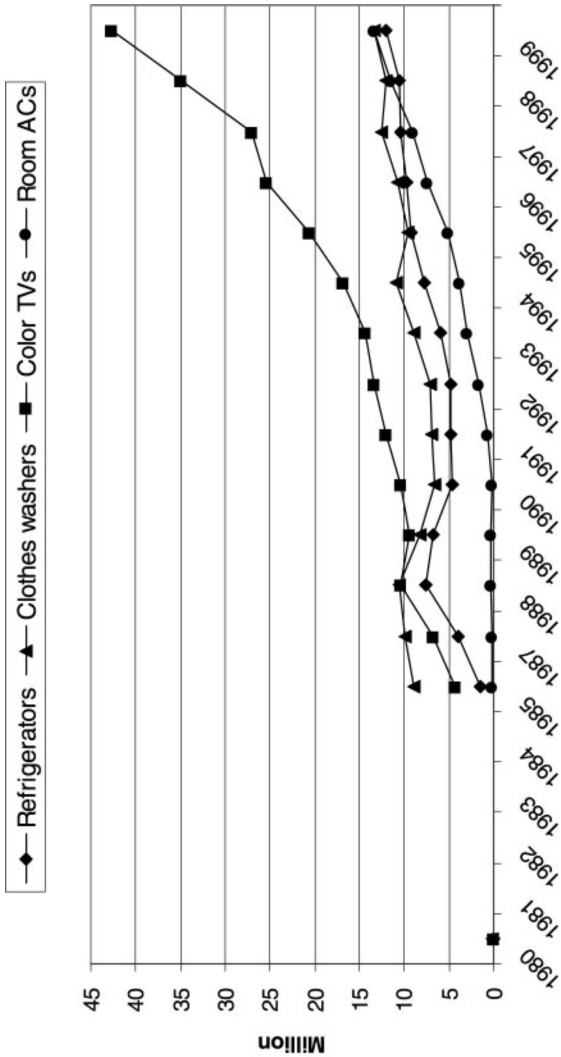

Figure 1 Appliance production in China from 1980–1999, *China Statistical Yearbook 2000* (2).

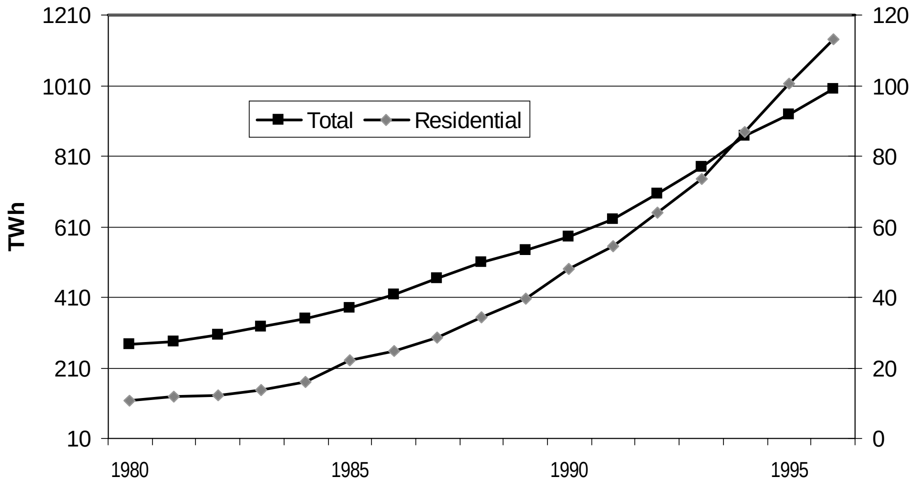

Figure 2 Electricity consumption in China from 1980–1999, *China Energy Databook, Version 5.0* (3).

INSTITUTIONS INVOLVED IN STANDARDS AND LABELS DEVELOPMENT IN CHINA

China's State Economic and Trade Commission (SETC) is responsible for the overall management of China's economy. The SETC's Department of Resource Conservation and Comprehensive Utilization is charged with setting national energy conservation policy and implementing China's Energy Conservation Law (ECL), and it has been responsible for supervising the development of energy efficiency standards and labels in China.

China's State Bureau of Technical Supervision (SBTS) is the government agency authorized to issue all standards except for those related to environmental safety and selected petroleum products. Minimum energy efficiency standards (MEES) are only a small part of SBTS's total project portfolio. The agency has recently been restructured and renamed the State General Administration for Quality Supervision, Inspection, and Quarantine (AQSIQ), which reflects its elevated ranking within the Chinese bureaucracy.

The China National Institute of Standardization (CNIS) is a research institution under the supervision of AQSIQ. CNIS provides technical support to AQSIQ in the development of mandatory minimum energy efficiency standards including data collection and analysis. CNIS is also responsible for the development of China's energy information labeling program under the supervision of SETC and AQSIQ (12).

The China National Technical Committee for Energy Basics and Management Standards, under CNIS, is responsible for the coordination of technical research and the review of standards. The committee is comprised of researchers, academics, and policy makers, as well as representatives from manufacturing companies (1).

The China Certification Center for Energy Conservation Products (CECP) is an independent certification agency that was established in 1998 to administer a voluntary endorsement energy labeling program. CECP follows policy guidance from the State Economic and Trade Commission (SETC) and AQSIQ and is affiliated administratively with CNIS.

Despite the multiple program components—including MEES, information, and endorsement labels—the management of China's appliance standards and labeling programs remains fairly centralized: SETC and AQSIQ set the national agenda, while CNIS and CECP develop and implement relevant program components. Given that CECP is still administratively under CNIS's supervision, there have been healthy exchanges among the technical staff and good collaborations between CNIS (MEES) and CECP for endorsement labels. Over the last few years, CNIS and CECP have synchronized the development and introduction of the MEES and the endorsement label performance requirement for common products[1] (13, 14). Such close coordination, which is highly recommended (15), has been mutually beneficial. However, the proposed energy information label has introduced new complexities in the coordination of China's standards and labeling programs.

ASCENDANCE OF STANDARDS AND LABELING PROGRAMS IN CHINA'S ENERGY CONSERVATION POLICIES

The publication of China's first set of standards had only a modest impact on the energy efficiency of Chinese appliances due to lax enforcement and easy-to-meet performance requirements (1). However, establishing these standards helped to define clear roles and responsibilities for the institutions involved and set in motion a procedure for creating and revising energy efficiency standards for an expanding list of products in the future.

In the 1990s, the appliance market in China experienced a dramatic transformation, characterized by soaring appliance sales, industry consolidation, and an extremely competitive appliance market. Appliance sales and ownership both skyrocketed. By 1999, the production of refrigerators, room air conditioners, and clothes washers had each reached approximately 13 million units, and the production of color television sets had topped 40 million units (Figure 1), which made China the largest appliance producer in the world.

In 1980, few Chinese families owned a major appliance. However, by 1999 ownership of major appliances in urban Chinese households[2] had risen to 112% for color television sets, 91% for clothes washers, 78% for refrigerators, and 24% for room air conditioners (Figure 3). Such a rapid rise in appliance ownership drove

[1]Energy efficiency specifications are developed by the same team of technical professionals and are announced at the same time, for example, for fluorescent ballasts, refrigerators, and room air conditioners.

[2]Urban areas cover large cities and townships (small urban centers in rural areas). In 1998, urban population was about 30% of China's total population.

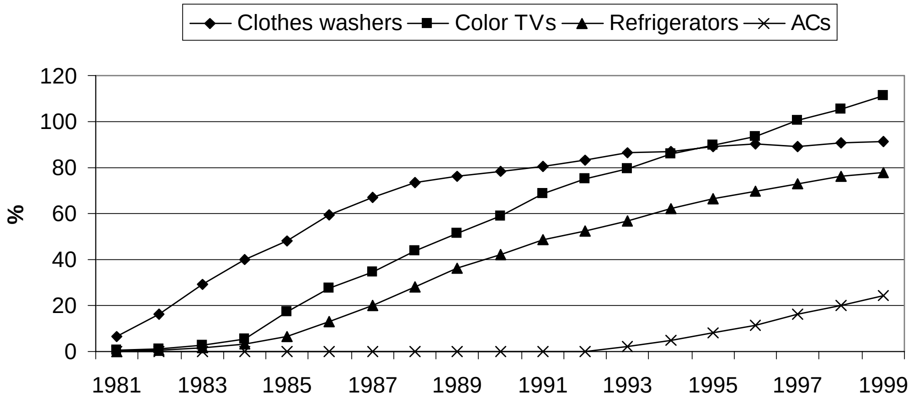

Figure 3 Appliance ownership in urban Chinese households from 1981–1999, *China Statistical Yearbook 2000*.

residential electricity usage to grow at an average annual rate of 16% beginning in 1980, which was double the rate for total electricity usage growth during this time period in China.

The rapid growth in appliance ownership and the resultant residential electricity consumption helped highlight the critical role that appliance efficiency standards and labels could play in China's overall energy conservation policies. Meanwhile, the fierce competition in the appliance industry had helped to spur technical innovations that demonstrated the potential of energy savings in household appliances. All of these factors helped to put energy efficiency standards and labels at the forefront of China's effort at reshaping its energy conservation policy portfolio for a more market-oriented economy.

China has had a very successful energy conservation program under its traditional centrally planned economy (16). Ever since China started its transition toward a more market-based economy, many of the traditional mechanisms of promoting energy conservation began losing their relevance. In 1997, China passed the Energy Conservation Law (ECL), which focused renewed attention on end-use energy efficiency, standards, and labeling programs.[3] As a result, the development of energy efficiency standards and labels has been accelerated.

The development of China's energy efficiency standards and labeling program has also benefitted from active collaborations with several foreign and international institutions, including the U.S. Environmental Protection Agency (U.S. EPA), Lawrence Berkeley National Laboratory (LBNL), the Energy Foundation (EF), and the Collaborative Labeling and Appliance Standards Program (CLASP). Today,

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

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.

Minimum Energy Efficiency Standards

The minimum energy efficiency standards (MEES) program is one of the most mature of China's standard and labeling programs. In addition to the first set of standards that was issued for eight types of products in 1989, China has since enacted three more new product standards or revisions of existing standards, with several more under review and development.

In 1995, SBTS sought technical assistance from LBNL as it started to consider the revision of its first refrigerator standard. In the summer of 1996, LBNL hosted a training seminar on the use of the U.S. EPA's Refrigerator Analysis software (ERA) for three researchers from SBTS, CNIS, and the Beijing Energy Efficiency Center (Becon). ERA is an engineering simulation tool used to evaluate technical options and their impacts on refrigerator energy use. This exercise allowed the Chinese researchers to gain greater understanding of the technical path to improving refrigerator energy efficiency and facilitated the revision of China's refrigerator standard, which was finalized in 1999 (13).

The success of the initial collaboration between SBTS and LBNL led to a series of collaborative projects that helped build the foundation for China's current standards program. In 1999, SBTS issued an efficiency standard for fluorescent lamp ballasts (14) and in 2000 issued the revised efficiency standard for room air conditioners, both after extensive collaboration with LBNL and the U.S. EPA.

Since the passage of the Energy Conservation Law in China in 1997, the pace of standard development has accelerated. Currently, minimum efficiency standards for linear and compact fluorescent lamps and small and medium motors have been drafted and are undergoing a stakeholder review. Work on a standard for clothes washers has begun. The development of standards for televisions, central air conditioners, water heaters, cooking and other gas appliances, and the revision of the existing refrigerator standards are planned over the next two years.

Voluntary Endorsement Label

Following its establishment in 1998, 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.[4] In 1999, CECP granted its energy conservation label

[4]Tailored to China's appliance market conditions, both a stringent requirement for quality assurance for manufacturers that is similar to internationally compatible standards (such as ISO 9000) and a product efficiency specification, as part of its certification requirement, have been added by CECP.

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 nonlabeled products (1).

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 nonlabeled products (1).

The CECP voluntary certification program has achieved considerable success during a relatively brief period through aggressive engagement of the manufacturers and a publicity campaign in both broadcast and print media. Considerable collaborative marketing has occurred between CECP and the manufacturers at the launching of the certification program for each product. Not surprisingly, many manufacturers wanted the exclusive right to obtain the CECP label first, which CECP rightfully declined to offer. However, such overtures from manufacturers indirectly validate the value of CECP's labeling program.

In addition to those for refrigerators and air conditioners, CECP has recently developed certification specifications for 11 other products including fluorescent lamp ballasts, electric water heaters, microwave ovens, and small and medium electric motors (17). Similar technical specifications are under development for linear and compact fluorescent lamps.

Most recently, CECP has been closely following international developments in reducing standby power losses. CECP is currently undertaking the first analysis of standby power losses in China with LBNL, and it is in the process of evaluating various policy options for reducing standby power consumption (18). Among the policy options being considered is the initial curtailment of standby power losses in televisions and other consumer electronics through the CECP labeling program.[5]

Despite its initial success, CECP faces considerable challenges in keeping up with a rapidly evolving appliance market in China. A market assessment mission, conducted jointly by CECP, U.S. EPA, ICF, and LBNL through interviews with leading refrigerator manufacturers and retailers in China, finds that consumer and sale staff awareness of the CECP label remains insufficient. The efficiency requirement for label qualification needs to be raised as the average refrigerator efficiency improves, and the label design needs to provide more information to consumers (19). CECP is currently working with the U.S. EPA to design a more focused promotion effort for labeled refrigerators.

Energy Information Label

Starting in 2000, SETC authorized CNIS to undertake a feasibility study of establishing a mandatory energy information labeling program with assistance from the Energy Foundation and CLASP. CNIS has developed a draft regulatory

[5]CECP has expressed interest in harmonizing technical specifications with the U.S. EPA's Energy Star program, and televisions are likely to be the first test case.

framework for the proposed information labeling program and is considering a pilot project that would apply the proposed information label to refrigerators (20).

IMPACT OF CHINA'S APPLIANCE STANDARDS AND LABELING PROGRAMS

Although China's appliance standard and labeling programs were started in the late 1980s, their impacts have not been well documented. Various reports on China's appliance standard and labeling programs have been written, but few have been prepared for scholarly publications. In this section, a preliminary assessment of the impact of China's standards and labeling programs is offered, based on the efficiency standards and labels that have been developed since the mid-1990s. This assessment relies extensively on internal technical reports produced by CNIS, CECP, and their collaborators. Due to the lack of historical appliance efficiency data, it is difficult to estimate the impact of the first appliance standards that were issued in 1989. In addition, there have been significant changes in the product mix and in appliance technologies since the late 1980s; therefore these first standards are less relevant today.

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 (13). 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 for energy consumption by the actual volume of the refrigerator (4).

Given that China and Europe use the same testing procedure and their refrigerator products are similar in size, CNIS adopted the formula used in the European labeling scheme for refrigerators. However, there is a significant difference: Although 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

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

in which E_{max} is the daily electricity consumption limit, $kW \cdot h/24h$; M and N are coefficients (see the values listed in Table 1); and V_{adj} is the adjusted volume in liters (3).

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

TABLE 1 Values of *M* and *N* in China's 1999 refrigerator efficiency standard

Type	Description	*M*	*N*
1	Refrigerator, no-star compartment[a]	0.233	245
2	Refrigerator, one-star compartment	0.643	191
3	Refrigerator, two-star compartment	0.450	245
4	Refrigerator, three-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

[a]Stars refer to the temperature settings in the freezer compartment. Most home refrigerators have three-star freezer compartments.

standard reduced the maximum daily allowance for the most popular refrigerator products by 10% to 15%. The impact of this revision on national energy savings has not been fully documented. However, a recent estimate from CNIS (20) suggests that the refrigerator standard—assuming further revisions in the coming decade—could reduce China's electricity consumption by 87 billion kWh over the next 10 years.

Fluorescent Lamp Ballast Standard

In the development of a ballast efficiency standard, CNIS adopted the ballast efficacy factor (BEF) as the measurement of energy efficiency. BEF is defined as the ratio of ballast factor (BF) over input power to the ballast, and it has been used in the U.S. Department of Energy (U.S. DOE) 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 in Table 2.

TABLE 2 China's minimum energy efficiency standard for fluorescent ballasts using BEF measurements

Type	18 W	20 W	22 W	30 W	32 W	36 W	40 W
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 (21, 22). For the most widely used ballasts—those in the 40-watt category—the Chinese standard is slightly more stringent than the current U.S. standard. However, the U.S. DOE has announced a newly revised standard for fluorescent ballasts (effective in 2005), which would phase out magnetic ballasts in most applications (23).

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 (22).

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.

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 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 on both technical and economic grounds (24). The results of the CNIS and LBNL joint analysis, based on the engineering simulation and life-cycle cost analysis, are summarized in Table 4 below.

If an EER of 2.9 is adopted as the revised Chinese minimum efficiency standard for air conditioners, it is estimated that China could reduce its air-conditioning energy consumption by 16.7 billion kWh from 2001 to 2010, with a corresponding

TABLE 3 China's minimum standards for room air conditioners

Type	Rated cooling capacity (CC) Watt (W)	EER W/W	
		Cooling only	Heat pump
Single-package	$CC \leq 4500$	2.20	2.15
	$CC > 4500$	—	—
Split	$CC \leq 2500$	2.50	2.40
	$2500 < CC \leq 4500$	2.45	2.35
	$4500 < CC \leq 7100$	2.40	2.30
	$CC > 7100$	2.30	2.25

TABLE 4 Life-cycle cost analysis results for baseline unit (split system heat pump type, 2500 W < capacity < 4500 W)

				Life-cycle cost		
No.	**Design option**	**Capacity Watts**	**EER W/W**	**2% Yuan**	**6% Yuan**	**15% Yuan**
0	New baseline	3102	2.27	7247	6648	5852
1	0 + Evaporator slit fins	3316	2.37	7146	6572	5808
2	1 + Condenser groove tube	3388	2.53	7015	6477	5762
3	2 + Evaporator groove tube	3560	2.62	6958	6438	5747
4	3 + 3.0 EER compressor	3556	2.89	6820	6349	5722
5	4 + Condenser slit fins	3572	2.92	6820	6354	5733
6	5 + 3.16 EER compressor	3574	3.06	6868	6423	5831
7	6 + Condenser fan motor +10%	3574	3.08	6884	6442	5854
8	7 + Evaporator fan motor +10%	3577	3.09	6907	6467	5881

reduction in CO_2 emissions of 4.5 million tons of carbon over the same period (24). However, the study assumed constant domestic sales of these products 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, because 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 MEES for fluorescent lamps is currently undergoing a stakeholder review. However, a draft report from CNIS (25) 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 savings 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 choose to increase lighting levels by maintaining the number of lamps per room, then the savings from the standard would be lower than indicated above.

CECP Endorsement Labels for Refrigerators and Room Air Conditioners

No study to date has attempted to evaluate the market penetration of CECP's endorsement label among various appliance products in China. Findings from a CECP study indicate that labeled refrigerators and air conditioners consume on average 18% and 10% less electricity, respectively, than their nonlabeled counterparts, and a great majority of refrigerator and air-conditioner manufacturers have at least one labeled model on the market. However, the study offered no data on the sales-weighted market share of labeled refrigerators and air conditioners (1). Interviews with several top refrigerator manufacturers in China by CECP, LBNL, and ICF indicated that most of their products met the CECP label specifications (19). An assessment of the potential impact of the labeling program in China finds that if CECP's labeling program achieved a market penetration similar to that of the U.S. 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 CO_2 emissions would be 7.9 and 4.3 million tons of carbon (26).

These numbers suggest that existing Chinese standards and labeling requirements for refrigerators and room air conditioners are already having a substantial impact on slowing the growth of residential electricity demand. As China accelerates the development of standards and labels for an expanding list of consumer appliances (including clothes washers and televisions for which standards are currently planned), energy savings due to these programs are likely to increase as well.

However, the energy savings estimates reviewed above are hard to evaluate and aggregate owing to inconsistent methodologies and incomplete data. In order to assess the aggregate impact of appliance standard and labeling programs on China's residential electricity consumption, a simplified model based on future appliance sales and unit energy savings was developed to calculate electricity savings for refrigerators, room air conditioners, clothes washers, and color televisions (see Appendix A for a detailed description of assumptions used)[6]. The estimated aggregate savings are summarized below (Figure 4) in the context of future residential electricity consumption in China.

These estimates indicate that, by the 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 usage in 2010.[7] Such a savings would also result

[6]Savings due to fluorescent lamp and ballast standards are not included in the current estimate because most fluorescent lighting equipment is installed in commercial and industrial sectors.

[7]Residential electricity usage from 1980–1998 is from the *China Statistical Yearbook 2000*, and figures after 1999 are forecasted based on the assumption of an annual growth rate of 8%.

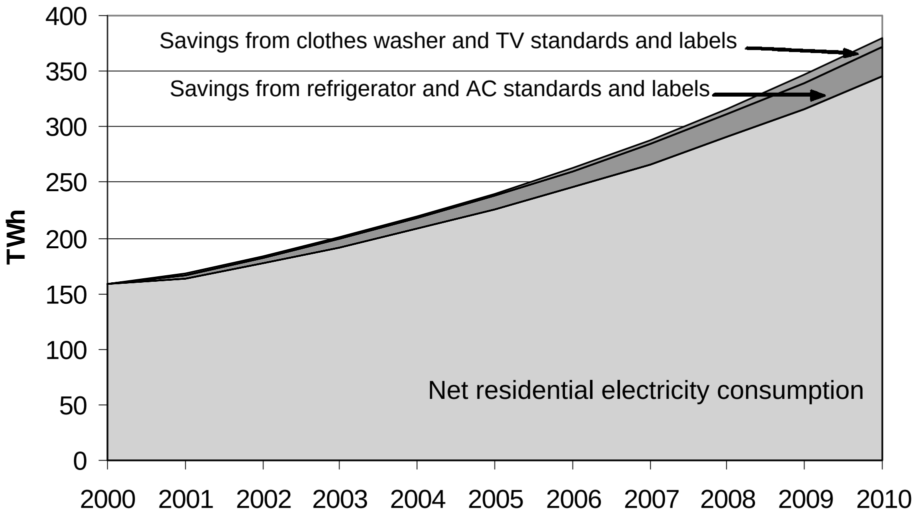

Figure 4 Impact of China's appliance standard and labeling program (AC, air conditioners).

in a CO_2 emissions reduction of 11.3 million tons of carbon in China. Also by 2010, the cumulative electricity savings would add up to 164 TWh, equivalent to a reduction of China's CO_2 emissions by 56 million tons of carbon.

These savings estimates, if they materialize, represent a remarkable achievement for the Chinese 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 CO_2 emissions in the U.S. residential sector (27). Therefore, China in a few years has put into effect a program that will catch up—in terms of greenhouse gas (GHG) emission reductions–with the world's best program by 2010. As China expands its program to cover more products, this may happen even earlier.

OUTLOOK FOR THE FUTURE

China's appliance standards and labeling programs have made tremendous progress in recent years. The Chinese government has developed a well-coordinated management program for various standards and labeling programs in support of its Energy Conservation Law. The standards development process is fairly open, with active participation from industry and academy. Chinese policy makers and technical professionals have built a strong domestic analytical capacity in support of standards research. And the standards and labels that have been enacted or that will be issued in the next two years could lead to substantial reductions in residential electricity consumption and in China's CO_2 emissions.

Yet, in order to reach their full potential, China's appliance standards and labeling programs still have much to improve. Technically, there are still significant efficiency gaps between appliances made in China and those made in the developed nations. To narrow such gaps, China needs to develop a more aggressive approach toward setting minimum efficiency standards. Instead of simply eliminating the least efficient 10% to 15% of the products as it does now, China should choose a standard level that is technically feasible and economically justified. Such an approach, supported by careful engineering and economic analyses, could lead to more stringent standards and would have a greater impact in reducing China's energy consumption and GHG emissions. At the same time, these standards would bring tremendous benefits to both Chinese consumers and the economy: Consumers would benefit from the lower costs of operating appliances, and the economy would benefit from reduced investment in power plants that could be used for more productive purposes.

Currently, when Chinese standards are issued they become effective almost immediately, which leaves manufacturers little time to make necessary adjustments in order to comply with the standards. When a product design cycle is short and the increase in minimum efficiency is modest, such a short lead time does not present a major challenge. However, when the increase in minimum efficiency is substantial, a longer lead time is essential so that manufacturers can redesign their products to meet the new standard. A longer lead time also encourages better compliance with the standard. Therefore, to facilitate the development of more stringent minimum efficiency standards, China should allow longer lead time in setting the effective dates of new standards.

At the present time, standard and label development agendas are set by CNIS and CECP in consultation with SETC and AQSIQ. Other stakeholders are notified only after the standard development is well under way. In the future, a clear time line 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.

China has coordinated its minimum efficiency standards and voluntary labeling programs fairly well in the past. With the recent introduction of an energy information label, a consistent methodology is needed to link the requirements of endorsement and information labels, and possibly the minimum efficiency standards. Because both labeling programs target consumers, they need consistent as well as distinctive messages to promote the respective programs. The development of such messages should be based on extensive consumer research.

With China's accession to the World Trade Organization, its 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. 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 electronics market toward higher energy efficiency.

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APPENDIX A: ASSUMPTIONS USED TO CALCULATE ENERGY SAVINGS FROM CHINA'S STANDARDS AND LABELING PROGRAMS FOR HOUSEHOLD APPLIANCES

MODEL FOR ESTIMATING ENERGY SAVINGS Annual energy savings are calculated as the product of *stock* of the affected appliance and unit energy savings (UES). Stock is the cumulative sum of appliance sales in the previous years within the accounting framework, 2000–2010, in this analysis. Given that new refrigerators, air conditioners, and clothes washers made today have a lifetime of over 10 years, the retirement of appliances from the stock is not considered here.

To estimate the impact of standards, UES is taken as the difference between old and new standards for refrigerators and air conditioners, and it is estimated for clothes washers. Considering the multitude of refrigerators and air conditioners, UES is calculated using consumption of the most typical products—a 220-liter refrigerator and an air conditioner with a cooling capacity of 3500 watts (in the middle of 2500–4500 watt range).

To estimate the impact of labels, UES is computed using a percentage saving on the new baseline consumption that meets the new standard. This accounts for the additional savings due to labels on top of the improvement due to new standards. The relative savings of 16% for refrigerators and 15% for air conditioners are taken from an evaluation of U.S. EPA's Energy Star program (28). In addition, penetration of the labeled refrigerators and air conditioners are assumed to be 25% for refrigerators and 20% for air conditioners. These rates are also taken from the study of the U.S. EPA Energy Star program (28) and are likely to be quite conservative in light of a recent market assessment of labeled refrigerators in China (19).

APPLIANCE SALES FORECAST Production of refrigerators, air conditioners, clothes washers, and color televisions are forecasted for the period 2000–2010 (Table 5). The implied growth rates are much lower than those observed over the last two decades. To the extent such conservative assumptions underestimate appliance

TABLE 5 Key assumptions

	Production	
	2000	**2010**
Refrigerators	16 million	32 million
Room air conditioners	13 million	26 million
Clothes washers	13 million	26 million
Color televisions	30 million	40 million

stock affected by the new standards and labels, the energy saving impact would be underestimated as well. In addition, domestic sales are assumed to be roughly 90% of local production.

RESIDENTIAL ELECTRICITY FORECAST Residential electricity consumption is forecasted up to 2010, assuming an annual growth rate of 8%. This is much lower than the observed rate over the last two decades, but it is similar to China's overall electricity growth rate.

ENERGY SAVINGS ESTIMATES Table 6 summarizes the savings estimates, both annual and cumulative, for appliance standards and labels for refrigerators, air conditioners, clothes washers, and color televisions.

TABLE 6 Impact of China's appliance standards and labeling programs

	Electricity savings		**CO_2 emission reductions**			**Percentage savings in residential electricity**
	Annual TWh	**Cumulative TWh**	**Annual $MMTCO_2$**	**Annual MMTC**	**Cumulative MMTC**	
2000	1.2	1.2	1.5	0.4	0.4	1%
2001	3.1	4.3	3.9	1.1	1.5	2%
2002	5.3	9.7	6.6	1.8	3.3	3%
2003	7.8	17.4	9.6	2.6	5.9	4%
2004	10.4	27.8	12.9	3.5	9.4	5%
2005	13.4	41.2	16.6	4.5	13.9	6%
2006	16.8	58.0	20.8	5.7	19.6	6%
2007	20.7	78.7	25.6	7.0	26.6	7%
2008	24.8	103.5	30.8	8.4	35.0	8%
2009	29.3	132.8	36.3	9.9	44.9	8%
2010	34.0	166.7	42.1	11.5	56.4	9%

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