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Impacts of China's Current Appliance Standards and Labeling Program to 2020

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THE COLLABORATIVE LABELING AND APPLIANCE STANDARDS PROGRAM

Impacts of China's Current Appliance Standards and Labeling Program to 2020

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Contents

Executive Summary 1

1 Background and Introduction 3

1.1 Background to the project 3
1.1.1 Selection of Products and Data Collection 4
1.1.2 Modeling 5
1.1.3 Analysis of Results 6

1.2 Introduction 8

2 Micro Energy Impacts 14

2.1 Refrigerators 14
Efficiency 16

2.2 Room Air Conditioners 19
Efficiency 21

2.3 Televisions 23
Efficiency 25

2.4 Clothes Washers 27
Efficiency 29

2.5 Computers and Printers 30
Efficiency 32

2.6 DVD and VCD Players 33
Efficiency 34

2.7 Case of lighting & gas water heaters 35
2.7.1 Lighting (Fluorescent Lamps and CFLs) 35
2.7.2 Gas Water Heaters 39

3 National Energy Savings Analysis 42

3.1 Refrigerators 45

3.2 Air Conditioners 47

3.3 Televisions 49

3.4 Clothes Washers 51

3.5 VCD/DVD Players 53

3.6 Computers 55

3.7 Printers 57

3.8 National Summary 59

4 Economic and Environmental Impacts 62

4.1 Financial Savings ... *62*
4.2 Greenhouse Gas and Other Emissions Reductions ... *63*

5 Conclusions ... 68
5.1 Overall Summary of Results ... *68*
5.2 Implications for China's Current Energy Policy and Suggested Next Steps ... *69*

6 Selected References ... 72

7 Appendix: Description of the Model ... 73
7.1 Sectoral Modeling Approaches ... *73*
7.1.1 Stock Turnover ... 74
7.1.2 Energy Intensity ... 75
7.1.3 Energy Consumption ... 75
7.2 Demographic Assumptions ... *75*

Executive Summary

With international assistance China has implemented a series of minimum energy performance standards (MEPS) and has expanded the coverage of its voluntary energy efficiency label to over 40 products, including residential, commercial and selected industrial products. Further, since 2005, household refrigerators and air-conditioners are required to display a mandatory, information label with the expectation that clothes washers will be added to the program soon. To date, however, the impact of the first phase of the S&L program (1999-2005) has not been evaluated on a consistent basis. In this report, CLASP, with the support of the Ministry of Economy, Trade, and Industry (METI), has undertaken such a study, focusing on key products subject to China's S&L program.

Eleven products in China's S&L program were chosen for inclusion into this analysis ranging from large consumer appliances such as refrigerators and air conditioners to consumer electronics such as DVD players and computers. The products were chosen primarily on the basis of their energy consumption and ownership rates (penetration) in households and the commercial sector. To determine impacts of the standards and voluntary labeling programs, the report compares unit and aggregate energy consumption for each product against a trajectory to 2020 in which efficiency is frozen at the average level at the time of the implementation of the first standard. In the case of the voluntary energy efficiency label, savings generated by appliances that had already achieved the efficiency labeling criteria were deducted from the total in order to focus on the impact of the labeling program alone. The saving analysis covers the period 2000 to 2020.

By way of background, the report summarizes the history and nature of China's standards and labeling program in the Introduction in Section 1. Trends in domestic production, exports, penetration rates, unit energy consumption and the history of S&L technical levels by product are discussed in great detail in Section 2. The national energy impacts analysis found in Section 3 concludes that overall China's standards and labeling programs reduce total electricity consumption in 2020 by an annual 106 TWh, or 16% of what would otherwise been expected in that year in the absence of standards and labeling programs.

In total, the report concludes that the S&L programs currently in place in China are expected to save a cumulative 1143 TWh by 2020, or 9% of the cumulative consumption of residential electricity to that year. In 2020 alone, annual savings are expected to be equivalent to 11% of residential electricity use. In average generation terms, this is equivalent to 27 1-GW coal fired plants that would have required around 75 million tonnes of coal to operate. In comparison, savings from the US appliance standards program alone is expected to save 10% of residential electricity consumption in 2020.

The report further concludes that between 2000 and 2020, improved efficiency among electric appliances and gas water heaters will reduce carbon dioxide emissions by more than 300 million tons carbon equivalent. These reductions are calculated assuming thermal marginal power generation and future improvements in generation efficiency, as well as diminishing losses in electricity transmission and distribution. From 2000 to 2020 cumulative sulfur dioxide emission reductions are expected to reach 6.8 million tons. Between 2000 and 2020, cumulative NO_X emission reductions are expected to reach 4.8 million tons. Between 2000 and 2020, program-derived cumulative particulate emission reductions are expected to reach 29 million tons.

The report also finds that the payback of these S&L programs to China's economy is high. Compared to expenditures, **Chinese consumers in 2005 alone enjoyed over 10 billion RMB in savings (about 161 billion Yen) from conserved electricity from S&L.**

This report is primarily an analysis of the impact of China's *existing* standards and voluntary labeling program with respect to its key products and *does not* try to predict what future specifications will be and neither does it assess the technical potential for savings for each product. However, the analysis shows that within China's suite of energy efficiency standards and voluntary labels, there are several clear opportunities by product for further savings. Specifically:

- In the case of clothes washers, the standard appears to be too low, as already the market average efficiency of vertical washers is higher than the minimum standard.
- In the case of refrigerators, although refrigerators were among the first appliances subject to standards, and are projected to provide a substantial portion of the projected savings to 2020, the absolute level of the standard is far lower than more stringent international standards in use in the US, Australia, or Japan. This is demonstrated as well in the high proportion (65%) of refrigerators that meet the CSC voluntary label criteria, which requires energy consumption at 75% or lower than the minimum standard.
- In the case of televisions, further savings are to be largely derived from application of a minimum standard for active mode power to the flat screen televisions (LCD and plasma), which promise to rapidly supplant CRT televisions over the next decade. Indeed, China is reportedly already working on such a standard.
- For products subject only to voluntary labeling, the high degree of "already efficient" products in the market—which serves to reduce the amount of applicable savings from the labeling program—is largely a function of global homogenization of design and style. Printers, computers, monitors and other office equipment vary little between China and other countries. Given this high rate of "already efficient" products in the market, it appears timely to consider further revision of these specifications and to consider criteria for active mode power consumption as well.
- In the case of room air conditioners, the tier-2 standard to come into effect in 2009 will bring the requirements for China's mainstream split room air conditioners up to international levels, though still behind Japanese averages.

The basis for the analysis performed for this report is a customized model of all of the selected products developed using the "Long Range Energy Alternatives Planning" (LEAP) accounting model (details of the underlying model equations can be found in Appendix 1). This report relies on a wide range of materials and information from primary, Chinese sources. To the extent possible, it has cross-checked data from multiple sources in cases where a single source stood in conflict with others. When Chinese data alone were insufficient, international data sets have been referenced.

1 Background and Introduction

1.1 BACKGROUND TO THE PROJECT

The Collaborative Labeling and Appliance Standards Program (CLASP) has collaborated over the years with several Chinese institutions in order to: promote energy efficiency in China; enhance the capabilities of Chinese institutions that promote energy efficiency; and understand the dynamics of energy use in China. CLASP, with Lawrence Berkeley National Laboratory (LBNL) as a primary partner, has helped China implement a robust energy efficiency standards and labeling program (S&L) that includes: minimum energy performance standards; mandatory, information labeling; voluntary, endorsement labeling; and a residential energy consumption survey. China's S&L program has transformed several product markets while improving the nation's economic efficiency and contributed to China's greenhouse gas (GHG) mitigation efforts.

In the years of collaboration, China has, with international assistance, implemented a series of minimum energy performance standards (MEPS), including mandatory standards for all of the major appliances. At the same time, it has expanded the coverage of its voluntary energy efficiency label to over 40 products, including residential, commercial and selected industrial products. And, since 2005, household refrigerators and air-conditioners are subject to the use of mandatory, information labels as well with the expectation that clothes washers will be added to the program soon.

As China's capacity for S&L implementation has grown, the nature of CLASP's support has shifted from technical training and capacity-building for the domestic program to assistance in extending market transformation effects internationally through harmonization of efficiency specifications. Most notably, in 2005, China, Australia, and the US adopted a harmonized set of efficiency specifications for external power supplies, based on a single testing standard. Current efforts support both the application of China's S&L programs into new market transformation programs domestically (such as government procurement) as well as the expansion of China's outreach internationally in additional harmonization efforts.

The essence of CLASP's work in China has been technology transfer, transferring to China the last 20 years of experience and toolkits that have been developed around the world to support S&L programs. The success relies heavily on cooperation with a wide range of organizations and groups and training of Chinese counterparts. For example, LBNL alone provided 196 person-weeks of training for 90 officials from five agencies, split roughly evenly between training at LBNL and training inside China.

S&L has become a prominent element in China's increasing emphasis on more sustainable energy development and its recently announced goal to reduce energy intensity of the economy by 20% by 2010. Without question, expansion and strengthening of the energy standards requirements and labeling criteria are an important policy option to assist China in achieving this target. On an individual product basis, comparisons of certain Chinese S&L levels with those in use international have demonstrated that there is room for further improvement and a large potential for additional energy savings from the program.

To date, however, the impact of the first phase of the S&L program (1999-2005) has not been evaluated on a consistent basis. Such an evaluation is timely, since it can provide policymakers and other energy analysts with details of the successes and shortcomings of the program as well as a guide to targets for further strengthening of the program.

CLASP, with the support of the Ministry of Economy, Trade, and Industry (METI), is now undertaking such a study, focusing on key products subject to China's S&L program. The work is divided into three main tasks: selection of products and data collection; modeling; and analysis of results.

1.1.1 Selection of Products and Data Collection

Eleven products in China's S&L program were chosen for inclusion into the analysis. These products range from large consumer appliances such as refrigerators and air conditioners to consumer electronics in widespread use such as DVD players and computers (See Table 1).

Table 1: China Appliance Efficiency Standards and Voluntary Labels Covered in this Report

	Product	Type	Standard No.	Year of Implementation
1.	refrigerators	MEPS & Label[1]	GB12021.2-2003	1999; 2003
2.	room air conditioners	MEPS & Label	GB19577-2004	2000; 2005
3.	TVs	MEPS & Label	GB 12021.7-2005; T17—2002	2002, 2006
4.	clothes washers	MEPS & Label	GB 12021.4-2004	2004
5.	computers	Label	T22-2003	2004
6.	printers	Label	T18-2003	2003
7	DVD/VCD players	Label	T25-2003	2004
8.	linear fluorescent lamps	MEPS & Label	GB 19043-2003	2003, 2006
9.	CFLs	MEPS & Label	GB 19044-2003	2003
10.	gas water heaters	MEPS & Label		2007

These products were chosen primarily on the basis of their energy consumption and ownership rates (penetration) in households and the commercial sector. In many cases, China is a major global producer and exporter of the product.

Unlike in markets such as Japan or the US, data on production, trade, sales, efficiency distribution, ownership, usage patterns and other technical details of each product are much more challenging to acquire and compile in China. The study relies on a wide range of materials and information sources including: the National Bureau of Statistics; China Customs; industry yearbooks; commercially produced reports; association web pages; testing laboratory data; and other sources to provide the necessary data for the model. In some cases, such as for market sales, Chinese data are contradictory and may vary widely from source to source. To the extent possible, this study has attempted to cross-check data from multiple sources in cases where a single source stands in conflict with others. When Chinese data alone are insufficient (such as for the active mode power of typical flat-screen—LCD and plasma—televisions), international data sets have been referenced.

The projected electricity consumption in China in 2020 is taken from previous modeling work based on the development assumptions of the *Research on National Energy Comprehensive Strategy and Policy of China*. This document, prepared by the Development Research Committee of China's State Council, is the most comprehensive expression of China's medium- and long-term development plan to-date.

1.1.2 Modeling

The basis for the analysis performed for this report is a customized model of all of the selected products developed using the "Long Range Energy Alternatives Planning"

[1] "Label" in this table refers to China's voluntary endorsement label. Although China has implemented a mandatory energy information label starting in 2005 for refrigerators and air conditioners, no data exists from which market impact analysis could be undertaken.

(LEAP) accounting model.[2] The strength of this approach is its bottom-up orientation and strong focus on technology that allows detailed characterization of energy intensity (unit energy consumption); saturation; sectoral usage differences, vintaging; energy source; and other details of each product. In this model, these elements are compiled for each product, and further subdivided among urban and rural households. In the case of lighting (fluorescent lamps and CFLs) and gas water heaters, data challenges do not permit the development of a full vintaging approach to modeling in the same manner as the other products, so they have been modeled differently. For lighting, lighting intensity per unit area has been substituted for stock and vintaging analysis. For gas water heaters, owing to a poor characterization of the domestic market, a standard unit efficiency gain and sales projection analysis has been done. The results for these products will be described separately in the final report.

Other demographic data are included in the model, including: population and number of households, which are further broken down into urban and rural households. Demographic data rely on UN population statistics and China's survey of households.

Such a model can be extended in use to analyze other issues, such as the impact of different policy scenarios of standards implementation and standards levels and to provide estimated savings from the development of standards for new products.

Details of the underlying model equations can be found in Appendix 1.

1.1.3 Analysis of Results

This report is an analysis of the impact of China's *existing* standards and voluntary labeling program with respect to its key products. As such, the analysis does not try to predict what future specifications will be and neither does it assess the technical potential for savings for each product. In some cases, such as refrigerators, an examination of Chinese standards and those in effect elsewhere internationally implies that Chinese standards could still be strengthened substantially; in other cases, such as air conditioners, upcoming standards will bring China nearly to world levels of efficiency.

The analysis here covers only those standards or voluntary labeling efficiency criteria that have already been implemented, or, in the case of the "reach" standards (i.e. two-tiered standards, for air conditioners, refrigerators, televisions, lighting), those standards that will go into effect when the second tier of the standard is reached[3]. For example, the na-

[2] Further information on the software and its use can be found at the developer's webpage http://forums.seib.org/leap/default.asp?action=47. LEAP is licensed by the Stockholm Environment Institute-Boston.

[3] Historically, China's minimum efficiency standards were implemented within 6 months of promulgation, giving manufacturers little lead time to meet the new target standards. Typically, this approach resulted in only small incremental improvements in energy efficiency. In recognition of the long lead times for product design and production line modification, China in 2003 introduced a new approach, termed a "reach" standard, which added a second tier of standards with a 3 to 4 year lead time. Under this new approach, the first tier is still implemented within 6 months of promulgation and represents a modest increase in efficiency, while the second tier is a much more aggressive efficiency level.

tional television standard was implemented in 2006, with the second tier going into effect in 2009. In this case, the analysis includes both the impact of the 2006 standard and the 2009 standard (the only exception in this analysis to a focus on existing standards is the energy efficiency criteria for tier 2 of a reach standard, in which the energy efficiency criteria are not specified. It is assumed in each case that the tier 2 energy efficiency criteria are the same ratio to the standard as in tier 1.). Prior to development of reach standards, Chinese standards were single-period, in effect for three or four years before revision. The last standard developed as a single-period standard was clothes washers, implemented in 2004. In this case, the analysis looks only at the impact of the 2004 standard and does not try to predict the next standard level.

Computers, printers, and VCD/DVD players are not subject to mandatory standards and have only voluntary energy efficiency criteria for labeling. The analysis includes only the savings from this program, based on projections by the China Standards Certification Center (CSC) of the expected market share of the product after 10 years of the program. Further, it excludes savings from those products that had already reached the CSC level of energy efficiency at the time of the launch of the program for each product, since the energy savings related to those products were not the result of the labeling program and thus should not be counted as part of the impact of the labeling program. In some cases, this significantly reduces the savings estimates from the labeling program.

In China, the national standards document now includes an "evaluation value for energy efficiency" (节能评价值), which sets the level of the voluntary energy efficiency label. As such, for the most part, the minimum standard and the energy efficiency criteria are in effect for the same period and change in tandem. For products with only energy efficiency criteria and no corresponding mandatory standard, the criteria are in effect for an unspecified amount of time, with revisions occurring based on the changing nature of the market for that product. Through the end of 2006, however, only one set of criteria has been established for computers, printers, and VCD/DVD players, although future criteria revisions are expected.

The saving analysis covers the period 2000 to 2020. To determine impacts of the standards and voluntary labeling programs, the unit and aggregate energy consumption for each product is compared against a trajectory to 2020 in which efficiency is frozen at the average level at the time of the implementation of the first standard. In the case of refrigerators, for example, the average energy consumption through 1999 was examined, and this number provided the baseline energy consumption through 2020 against which the standards case—including the 2000, 2005, and 2008 standards—was assessed.

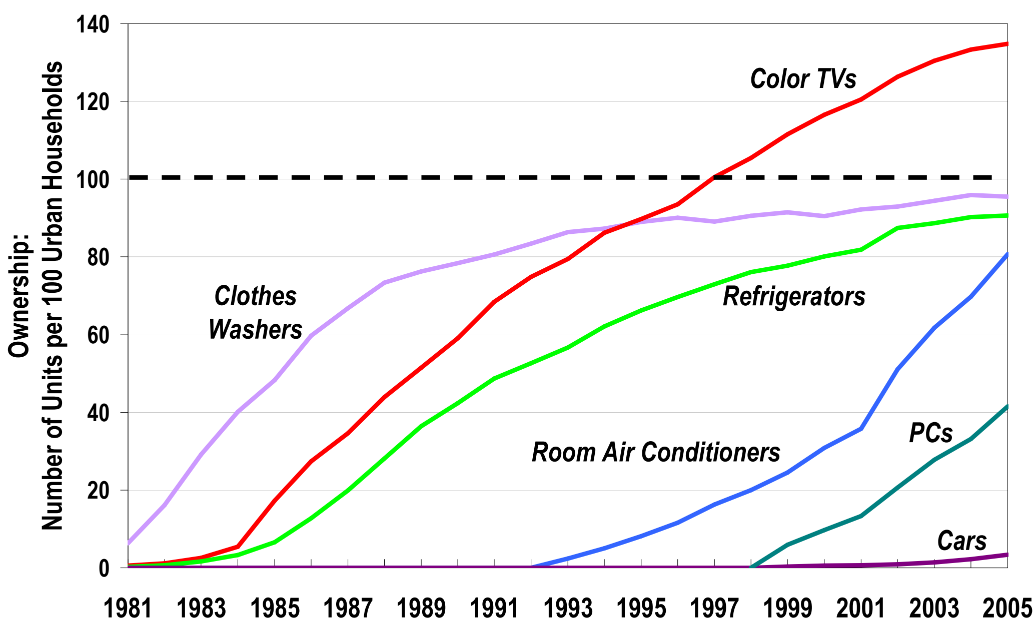
Unlike a number of other studies that focus on sales projections for a product without consideration of the impact of retirement, stock and household saturation rates, this study uses these parameters explicitly. For the 2020 projections, forecasted saturation rates for each product were developed, based both on China's own projections (where available) and the historical experience in other countries such as Korea, Japan, and the US. This avoids the problem of forecasting sales growth and the potential for overstating ownership rates, because the target saturation rates are then "backcasted" into implied sales figures, accounting for retirement of a percentage of the stock in each year.

The report provides the related details of the unit energy consumption and aggregate (national) energy consumption for each product, including the savings accrued from the existing standards compared to the base case. For all products except gas water heaters, the savings are in electricity.

1.2 Introduction

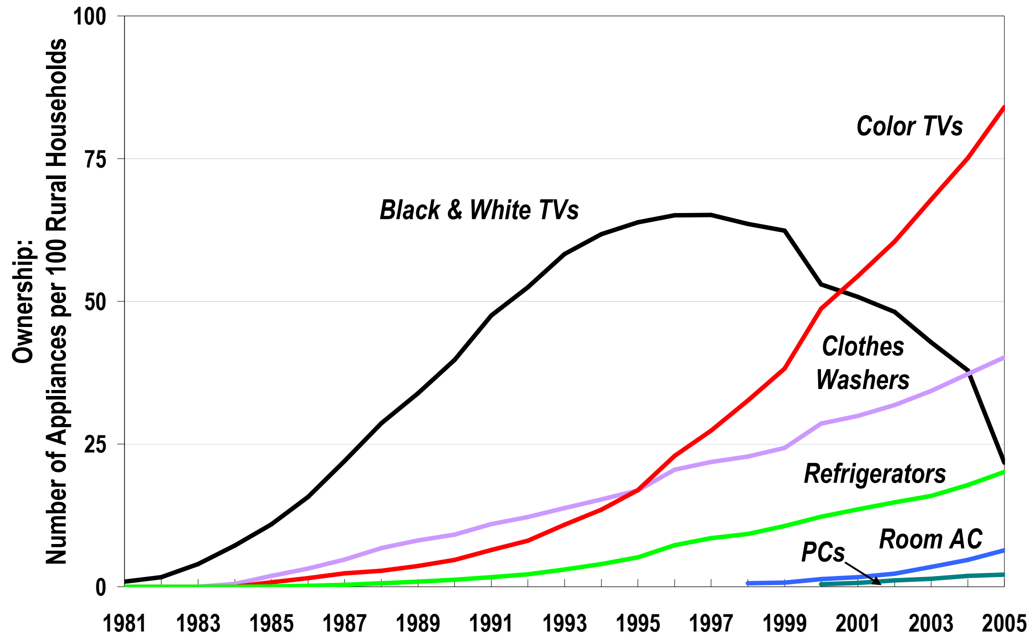
China is now one of the world's largest producers and consumers of household appliances, lighting, and other residential and commercial equipment. This transformation from a relatively equipment-poor and low-energy-service country has taken place very rapidly, with the bulk of the growth in the last 10 years. In 1981, shortly after China's economic reforms began, ownership of appliances was extremely limited and even televisions were an uncommon commodity. In contrast, by 2005, each of China's nearly 190 million urban households had on average 1.3 color televisions, and nearly all owned a clothes washer, refrigerator, and air conditioner. In just 7 years, personal computer ownership rates jumped from zero to over 40% (Figure 1). Ownership rates in rural households lag urban areas by 15 to 20 years owing to a combination of income disparities, higher electricity rates, and varying degrees of electrification (Figure 2).

Figure 1: Urban Ownership of Major Appliances



Source: National Bureau of Statistics

Figure 2: Rural Ownership of Major Appliances



Source: National Bureau of Statistics

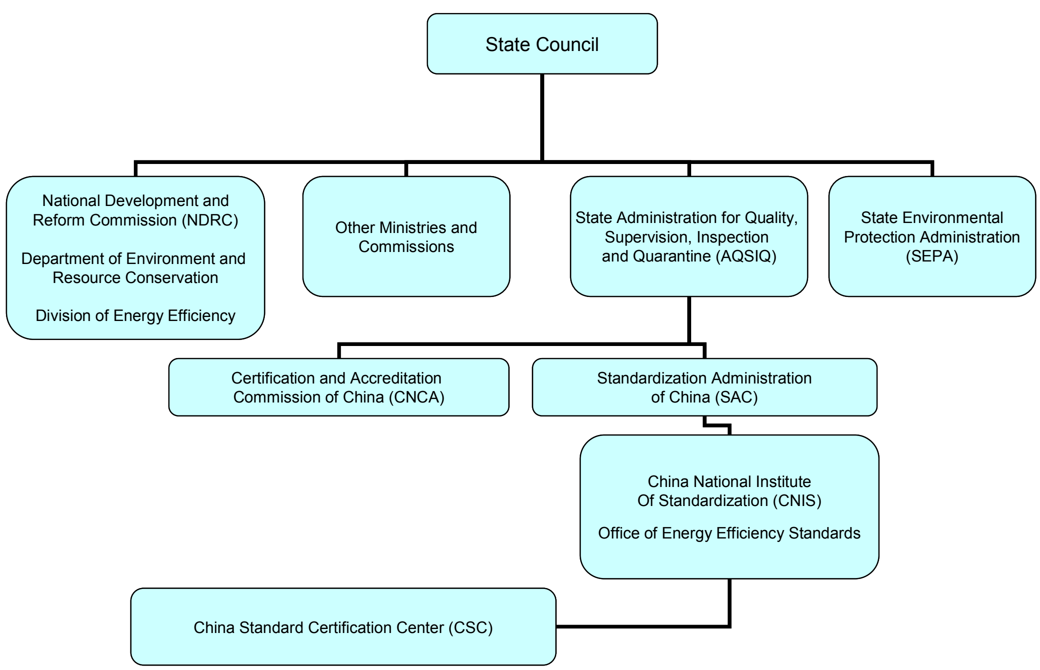
The rapid uptake of appliances and electronics into Chinese households has driven a sustained increase in residential electricity use with an average of 14% per year between 1980 and 2004. The impact of this growth spurred the government to initiate China's first program on equipment standards which was established in 1990 covering equipment then expected to be the most common in Chinese households: refrigerators; air conditioners; clothes washers; electric irons; electric rice cookers; televisions; radios; and electric fans. In general, these first standards were not particularly effective and some manufacturers ignored their guidelines. Moreover, the standards were in general not consistent with international standards, and thus the energy standards described are difficult to compare with those in place elsewhere at that time. For example, the first refrigerator standard of 1990 stipulated an absolute daily consumption figure (e.g., 1.3 kWh/day) based on the nominal capacity of the refrigerator. In contrast, the standards in Japan, the US, and EU all use "adjusted volume" considering the size and temperature of the freezer compartment.

By the mid-1990s, increasing emphasis on energy conservation and on the harmonization of Chinese domestic standards with international norms led to the initiation of a program to "modernize" China's standard system. Further impetus was provided by the Energy Conservation Law of 1998, which placed specific emphasis on both minimum efficiency standards and energy efficiency labeling. By 1999, the foundations of the new system for standards and labeling were in place when revised standards and new voluntary labeling criteria were released for refrigerators and air conditioners.

China's standards system—including energy efficiency, safety, classification, and other areas—is currently under the authority of AQSIQ (State Administration of Quality, Supervision, Inspection, and Quarantine), formerly known as the State Bureau of Technical Supervision (SBTS). Although directly under the State Council, AQSIQ holds a vice-ministerial rank. This is lower than other ministries such as the Ministry of Construction (Figure 3). The administrative functions of AQSIQ relative to standardization are exercised by the Standardization Administration of China (SAC), which is responsible for review and approval of new energy standards. Technical development work on energy standards has been delegated to the China National Institute of Standardization (CNIS), Office of Energy Efficiency Standards. In 1998, China established the China Certification Center for Energy Conservation Products (CECP, now the China Standards Certification Center or CSC) to implement a voluntary energy efficiency labeling program.

Overall energy efficiency policy, however, is developed and managed by the powerful National Development and Reform Commission (NDRC), based on the framework of energy conservation laid out in the National Energy Conservation Law of 1998. Though administratively separate, CNIS and CSC both provide technical support to NDRC and are responsive to new policy directions developed by NDRC.

Figure 3: Basic Structure of China's Standards and Labeling Organizations

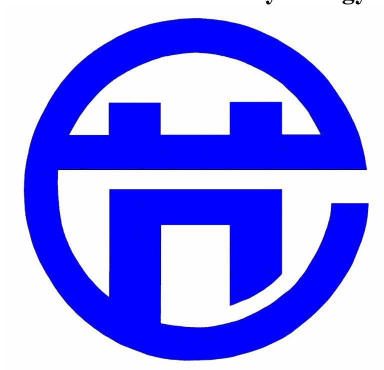


Currently, China has four major programs related to standards and labeling:

1. Mandatory minimum efficiency standards. Developed by CNIS, mandatory energy efficiency standards now cover most residential and commercial appliances, lighting and heating and cooling equipment, and total 22 or more. Beginning in 1999, CNIS developed a series of new single-period standards based upon international practice, and in 2003 began development of "reach" standards, or two-period, two-tiered standards. Though the standards are mandatory, conformity varies widely. Enforcement is now a major policy focus in the area of mandatory standards.

2. Voluntary energy efficiency labeling. The voluntary energy efficiency endorsement labeling program (Figure 4), analogous to the US Energy Star program with which it cooperates closely, has been administered by CSC since 1998. Currently, the program labels 50 products from over 300 participating manufacturers including: home appliances; consumer electronics; office equipment; lighting; and selected industrial equipment. The program requires manufacturers to: submit to an on-site audit of production facilities; undertake third-party testing in certified laboratories; and to accord with ISO 9000 standards. Audits are repeated annually.

Figure 4: China's Voluntary Energy Efficiency Label



3. Mandatory energy information labeling. In 2005, China launched a categorical mandatory energy information label, adapted from the EU categorical energy label (Figure 5). Including five categories of efficiency, from 100% (meeting the minimum standard) to 55% of the minimum standard, the label is applied now only to refrigerators and room air conditioners, although it is expected to be expanded to other product categories. CNIS is responsible for managing this program. Unlike both the mandatory standard and the voluntary energy efficiency label, manufacturers are able to self-report the energy consumption of each model.

Figure 5: China's Mandatory Energy Information Label

4. Government energy efficiency procurement. As part of a drive to increase the efficiency of the government sector, NDRC and the Ministry of Finance implemented a new program of government energy efficiency procurement in 2005. The program established a list of nine products including: air conditioners; refrigerators; fluorescent lamps (linear and CFLs); TVs; computers; printers; faucets; and toilets. China's centralized procurement system must "preferentially procure" only those models that are on this list and have achieved certification under the CSC energy efficiency labeling program. The program was first launched at central government organs in Beijing and the provincial capitals; in 2006 it was extended to other provincial cities; and in 2007 it will be expanded nationwide. In 2006, the catalog of products subject to mandatory procurement was expanded to 19 in total.

Significant overlap exists between the list of products subject to minimum energy efficiency standards and those certified for voluntary labeling (Figure 6). For products subject to the minimum efficiency standard, such as refrigerators and air conditioners, voluntary labeling criteria are developed simultaneously with the same timeframe of implementation and revision. Other products, such as printers, computers, DVD players, and other consumer electronics, are generally not subject to minimum efficiency standards and are covered only by the voluntary labeling program. In these cases, the timeline for revisions is subject to market and technical developments.

Figure 6: Timeline of Standards and Labeling in China (Selected Products)

Minimum Efficiency Standards

	1990		1999	2000	2001	2002	2003	2004	2005	2006
Domestic refrigerators/freezers*	◆		◆				◆			
Room air conditioners*	◆			◆					◆	
Clothes washers	◆						◆			
Electric irons	◆									
Automatic rice cookers	◆									
Televisions	◆									◆
Radio receivers and recorders	◆									
Electric fans	◆									
Fluorescent lamp ballasts				◆						
Small electric motors						◆				○
Compact fluorescent lamps							◆			
Linear fluorescent lamps							◆			
HPS lamps								◆		
HPS lamp ballasts								◆		
Instantaneous gas water Heaters										○
External power supplies										○
Commercial packaged AC									◆	

Endorsement Labeling

	1990	1993	1999	2000	2001	2002	2003	2004	2005	2006
Domestic refrigerators/freezers*			◆				◆			
Room air conditioners*				◆					◆	
Fluorescent lamp ballasts				◆						
Automatic rice cookers					◆					
Hot water bottle					◆					
Small electric motors					◆					
Microwave ovens					◆					
Electric water heaters					◆					
Televisions						◆				◆
Compact Fluorescent lamps							◆			
Linear Fluorescent lamps							◆			
Clothes washers							◆			
Printers							◆			
Computers								◆		
Monitors								◆		
Fax machines								◆		
DVD players								◆		
Copiers								◆		
External power supplies									◆	
Set-Top-Box										◆

◆ Implemention of standard/label or of standard/label revision

○ Currently under revision, development, or awaiting implementation

*Products subject to mandatory energy information labeling.

Economic policies encouraging “domestication” of production and extensive investment by foreign companies, combined with a rapid increase in household wealth and demand for energy services, have underpinned the growth of China’s appliance industry. Although in the early years of the industry, production was aimed primarily at the domestic market, China’s rapid absorption of more advanced technologies and quality production skills shifted the focus to the international market. Ten years ago, over three-fourths of production was sold domestically. Today, over three-fourths of televisions, for example, produced in China are exported (Table 2).

Table 2: Production and Export of Selected Appliances (*million units)*

	Washing Machines			Refrigerators			Room Air Conditioners			Televisions		
	Production	*Exports*	*E/P*	*Production*	*Exports*	*E/P*	*Production*	*Exports*	*E/P*	*Production*	*Exports*	*E/P*
1995	9.5	0.5	5%	9.2	1.0	11%	6.8	0.3	5%	20.6	5.7	28%
1996	10.7	0.6	5%	9.8	1.0	10%	7.9	0.3	3%	25.4	5.3	21%
1997	12.5	0.7	6%	10.4	1.2	12%	9.7	0.7	7%	27.1	4.1	15%
1998	12.1	0.5	4%	10.6	1.5	14%	11.6	1.1	9%	35.0	4.3	12%
1999	13.4	0.6	5%	12.1	2.1	18%	13.4	1.8	13%	42.6	5.7	13%
2000	14.4	1.0	7%	12.8	3.5	28%	18.3	3.2	18%	39.4	10.3	26%
2001	13.4	1.6	12%	13.5	4.5	33%	23.3	5.6	24%	40.9	11.6	28%
2002	16.0	2.2	14%	16.0	6.1	38%	31.4	9.2	29%	51.6	18.8	37%
2003	19.6	3.7	19%	22.4	8.8	39%	48.2	18.9	39%	65.4	31.3	48%
2004	25.3	6.3	25%	30.1	12.9	43%	63.9	26.7	42%	74.3	44.1	59%
2005	30.4	9.5	31%	29.9	13.8	46%	67.6	28.3	42%	82.8	64.1	77%

Source: China Statistical Yearbook; China Customs. E/P: ratio of exports to production

One potential impact, therefore, that is not captured in this study is the “spillover” effect of the high level of Chinese exports. Because manufacturers generally prefer to have single production lines for any single model, it is unlikely that Chinese manufactures will develop and produce less efficient models for export compared to what they sell domestically, in cases where the trading partner would allow a lower efficiency. As a result, as China’s standards become increasingly stringent, this may translate into additional savings accruing to China’s trading partners.

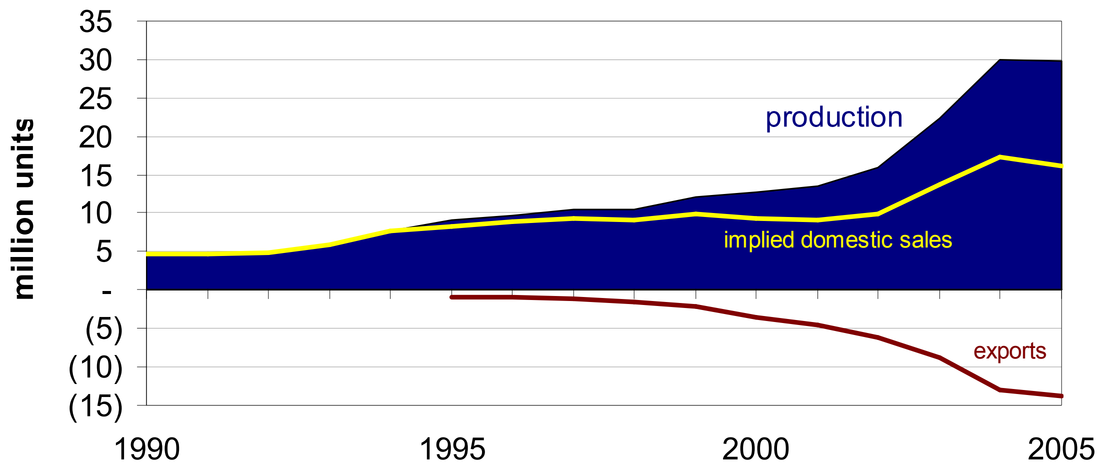
The remainder of this report provides the details of the unit efficiency gains by equipment type and the aggregate national impact of the standards and labeling program, along with aggregate national emissions impacts and financial savings.

2 Micro Energy Impacts

2.1 Refrigerators

In 1999, China surpassed the United States to become the largest refrigerator manufacturer: production surged from 1.4 million units in 1985 to 29.9 million units in 2005 (Figure 7). Among the appliances under consideration in this study, refrigerators are the largest energy consumers, accounting for 40% of total the total in 2005. Given their energy intensiveness and the expectation that urban household saturation will reach 97% by 2020, refrigerators are a key product for energy efficiency standards and labels in China.

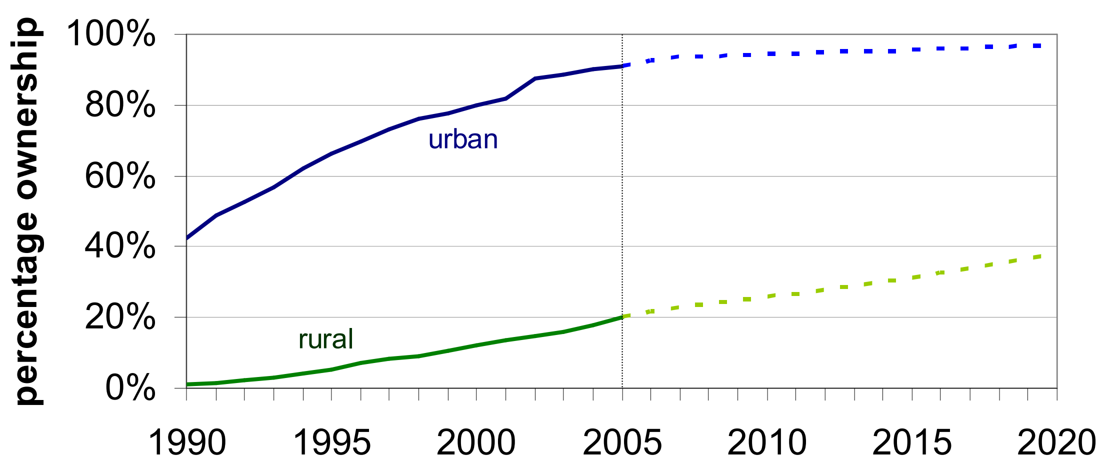
Figure 7: Annual Refrigerator Production, Sales, and Trade, 1990-2005



Source: NBS 2006; China Customs Data.

China's official refrigerator trade is externally-oriented: exports surged to 14 million units (46% of total production) in 2005, while reported imports have not exceeded 100,000 units per year since 1996. Insofar as standards and labels shape all Chinese production practices, strong export markets can amplify the impacts of improved refrigerator efficiency.

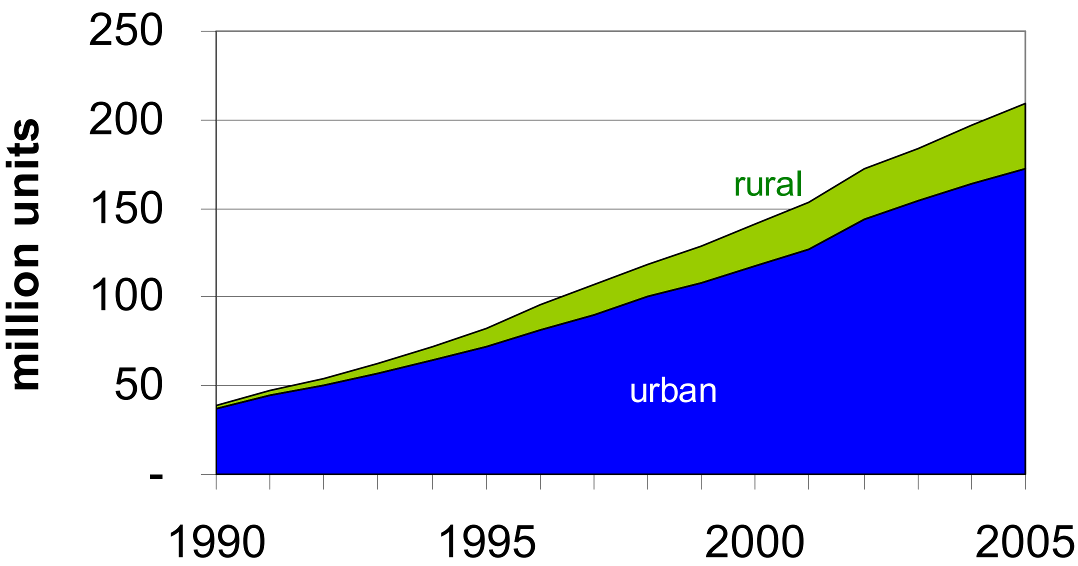
Figure 8: Historical and Forecast China Refrigerator Ownership, 1990-2020



Source: NBS, 2006.

China's refrigerator market has grown dramatically since 1990. Urban household penetration more than doubled—from 42% to 91% between 1990 and 2005—and rural ownership took off from 1% to 20% over the same period (Figure 8). Given that 99.9% of all American households owned a refrigerator in 2000, China's ownership rates are likely to continue to rise with per-capita GDP.

Figure 9: Cumulative Urban and Rural Refrigerator Stocks, 1990-2005



Source: NBS 2006.

Urbanization, diminishing household size and per-capita GDP growth are the underpinnings of the growth in China's refrigerator stocks (Figure 9). According to the National Bureau of Statistics, urban-owned refrigerators accounted for 82% of China's 209 million refrigerators in 2005.

Efficiency

China's current national minimum energy performance standard (MEPS) for refrigerators is called "The maximum allowable values of the energy consumption and energy efficiency grade for household refrigerators" (GB12021.2-2003). This standard updated an earlier version from 2000. The MEPS provides: maximum allowable values of energy consumption; "energy efficiency grades" (threshold values for the information label categories); "energy conservation evaluation values" (energy efficiency specifications for the voluntary endorsement label); energy consumption test methods; and inspection regulations for household refrigerators. China's current MEPS covers refrigerators with a volume of up to 500 liters. This standard includes required specifications for implementation in 2003, as well as higher efficiency "reach" standards for implementation in 2007.

The MEPS calculates maximum allowable energy consumption values according to the following formula:

$$E_{\max} = (MV_{adj} + N)/365 \qquad (1)$$

where E_{max} is the maximum allowable energy consumption (kWh/day), *M* (kWh/L) and *N* (kWh) are coefficients (Table 4), and V_{adj} is the adjusted volume in liters.

Table 3: Coefficient Values for China Refrigerator 2000 MEPS

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

The juxtaposition of Table 3 and Table 4 illustrates the improvement of refrigerator efficiency between 2000 and 2003. The *M* and *N* coefficient values decreased by 10% for Type 5 refrigerator/freezers and by 5% for all other categories; equations and methodology remained constant between the 2000 and 2003 revisions.

Table 4: Coefficient Values for China Refrigerator 2003 MEPS

Type	Description	*M*	*N*
1	Refrigerator, no-star compartment	0.221	233
2	Refrigerator, 1-star compartment	0.611	181
3	Refrigerator, 2-star compartment	0.428	233
4	Refrigerator, 3-star compartment	0.624	223
5	Refrigerator/Freezer	0.697	272
6	Chest frozen food cooler	0.530	190
7	Chest food freezer	0.567	205

This standard determines energy efficiency grades according to index values calculated with the following formula:

$$\eta = E_t \,/\, E_{max} \tag{2}$$

where η is the energy efficiency index and E_t represents the tested value of energy consumption (kWh/day).

Table 5: Energy Efficiency Grades for Household Refrigerators

Energy Efficiency Index	Energy-Efficiency Grade**
$\eta < 55\%$	A *
$55\% \leq \eta < 65\%$	B *
$65\% \leq \eta < 80\%$	C
$80\% \leq \eta < 90\%$	D
$90\% \leq \eta \leq 100\%$	E

* denotes "energy-conserving product" category eligible for the voluntary endorsement label..
** at the time the refrigerator standard was issued, the final design of the mandatory informational label was not yet completed; in the final version, the efficiency grades (thresholds) are numbered 1 to 5 instead of using letters.

The China Standards Certification Center certifies energy-efficient products meeting the requirements of grades A and B (1 and 2) and awards endorsement labels. As shown in Table 5, endorsement labels can be awarded for refrigerators that are at least 35% more efficient than the minimum standard per category.

Table 6: Modeled Refrigerator Unit Energy Consumption Values (kWh/year)

Volume (liters)	Efficiency Level*	Year of Implementation		
		1999	2003	2007
170	MEPS	489	372	336
	Labeled	367	242	218
220	MEPS	545	489	440
	Labeled	409	318	286
270	MEPS	608	545	491
	Labeled	456	354	319

*"MEPS" indicates the average model that complies with the minimum standard; "Labeled" indicates the average model that has achieved the energy efficiency specifications for labeling.

The unit energy consumption (UEC) values in Table 6 illustrate the range and progress of energy efficiency performance among China's residential refrigerators based on the most typical sizes in the Chinese market. Within each size category, endorsement labels are awarded for units that were at least 25% more efficient than the minimum standard in 2000, and 35% thereafter.[4] UEC values for endorsement labeling decreased between 22% and 34% between 2000 and 2003, and all MEPS and label UEC values decrease by 10% between 2003 and 2007. Regarding the distribution between volume categories, refrigerators are expected to continue growing larger: between 2000 and 2020, the share of 170-liter refrigerators will drop from about 8% of households to virtually nothing, while the 270-liter refrigerators will grow from 8% to 93% of households over the same period. The shift to larger volume refrigerators moderates efficiency improvements insofar as consumers are essentially moving from the upper left toward the bottom right corner of

[4] Japan's Top Runner Program provides a point of reference for China's appliance efficiency standards. Within Japan's 2006 Revised Edition, the target energy consumption value for a 220 liter 3-star natural-convection type refrigerator freezer with 33% freezer volume is 300 kWh per year (vs. 440 kWh/year MEPS and 286 kWh/year reach values for comparable Chinese refrigerators in 2007).

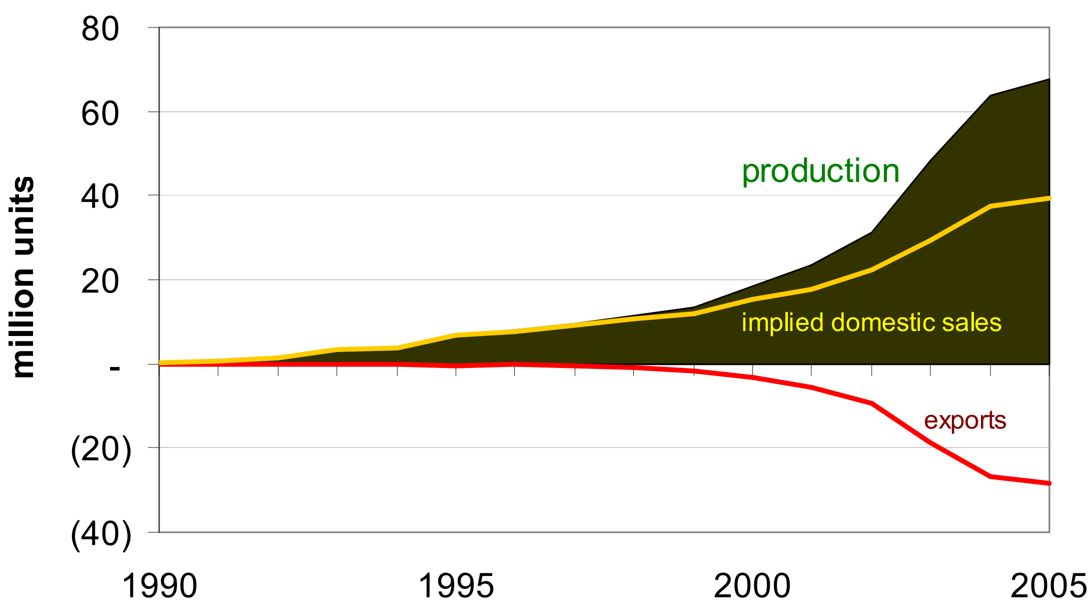
Table 6. This study used an average assumed lifetime of eleven years for all refrigerator categories.

2.2 Room Air Conditioners

Space cooling with room air conditioners consumes the third largest amount of residential electricity, after refrigerators and televisions. The proliferation of room air conditioners has helped to drive China's residential electricity consumption growth, particularly peak electricity demand. In 2005, room air conditioners accounted for 16% of the electricity use of all the appliances under consideration in this study.

Whereas refrigerator production grew from 5 to 30 million units between 1990 and 2005, the room air conditioner market has exploded over the same period—from 240,000 units to 68 million units in fifteen years (Figure 10).

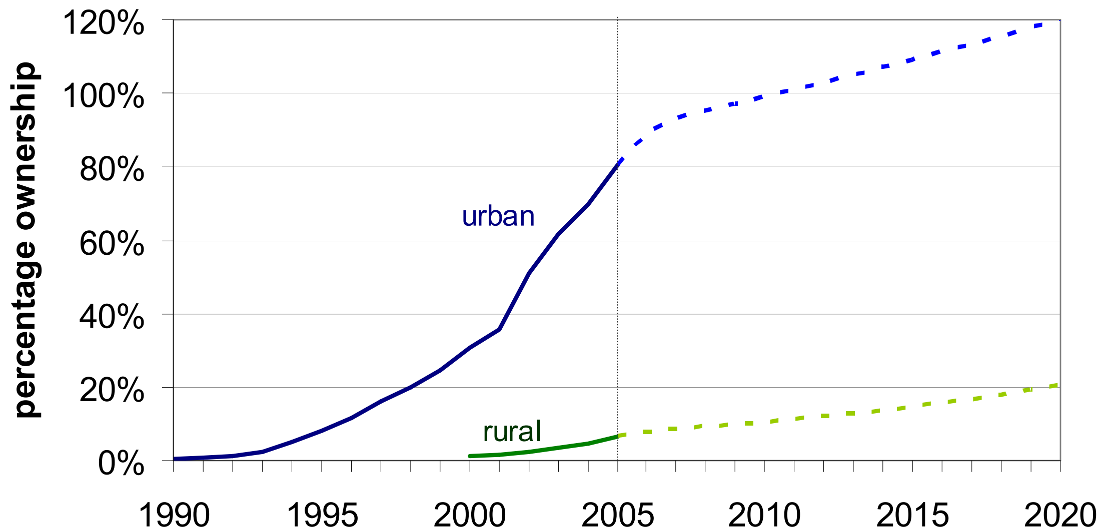
Figure 10: Annual Room Air Conditioner Production, Sales, and Trade, 1990-2005



Sources: NBS, 2006; China Customs Data.

Between 1995 and 2005, room air conditioner production grew at an average annual rate of 26%. In 2005, 42% of room air conditioner production was exported (28 million units)—export markets increasingly serve as a large driver for Chinese room air conditioner production. Imports have not exceeded 200,000 units per year since 1995.

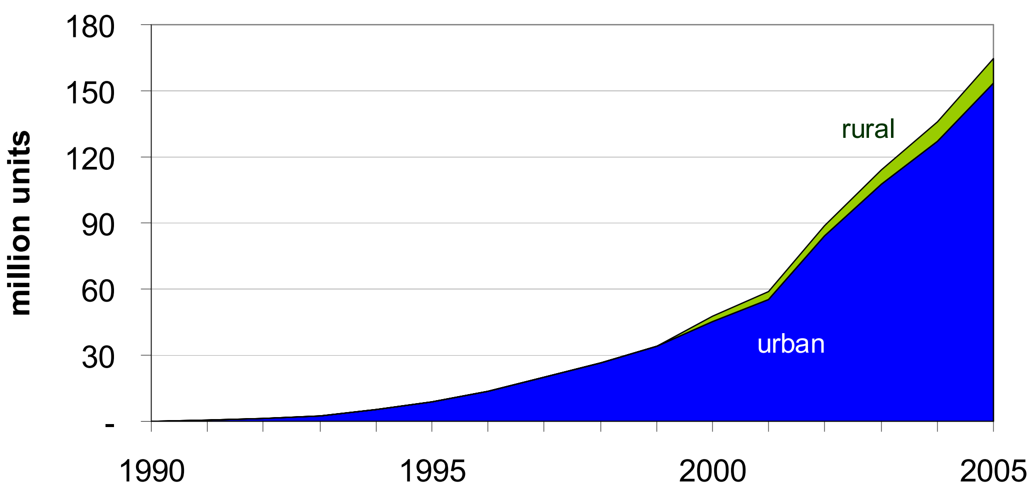
Figure 11: Historical and Forecast Household Room Air Conditioner Penetration, 1990-2020



Source: NBS, 2006.

Rising per-capita GDP and a concomitant demand for comfort have led to unprecedented growth in urban household air conditioner ownership (Figure 11). Whereas 76% of urban U.S. households used air conditioners in 2000, 81% of China's urban households owned room air conditioning units in 2005. Between 2005 and 2020, rural household ownership is forecast to grow from 6% to 20%.

Figure 12: Cumulative Urban and Rural Residential Room Air Conditioner Stocks, 1990-2005



Source: NBS, 2006.

Although only 43% of China's population lived in urban areas, 93% of air conditioning units were used in urban areas in 2005. Urbanization has served as a major driver for room air conditioner consumption. Aggregate room air conditioner stocks reached 165 million units in 2005, and, given ongoing urbanization, are projected to reach 350 million units in 2020.

Efficiency

China's national MEPS for air conditioners is called "The minimum allowable values of the energy efficiency and energy efficiency grades for room air conditioners" (GB12021.3-2004), which updated the previous standard in use since 2000. The MEPS provides: maximum allowable values of energy consumption; energy efficiency grades (mandatory energy information label category thresholds); evaluation value for energy conservation (voluntary energy efficiency label specifications) energy consumption test methods; and inspection regulations for room air conditioners with a cooling capacity less than or equal to 14,000 Watts. The standard includes UEC values for 2005 implementation of standards and labels, as well as "reach" values for 2009 implementation.

The former MEPS implemented in 2000 are shown in Table 7 (cooling only) and the 2005 MEPS in Table 8. The 2005 standard, however, reorganized the capacity categories with the main focus being on the 2500-4500 W split air conditioner—the most common in the China market today. The 2005 MEPS represented only an incremental increase in minimum efficiency of about 6% over 2000.

Table 7 Room Air Conditioner 2000 MEPS

Category	Rated Cooling Capacity (CC) (Watts)	Energy Efficiency Ratio (EER) (W/W)
Single-package	CC ≤4500	2.20
	CC >4500	-
Split unit	CC ≤2500	2.50
	2500<CC≤4500	2.45
	4500<CC≤7100	2.40
	CC >7100	2.30

Table 8: Room Air Conditioner 2005 MEPS

Category	Rated Cooling Capacity (CC) (Watts)	Energy Efficiency Ratio (EER) (W/W)
Single-package	CC ≤ 14,000	2.30
Split unit	CC ≤ 4,500	2.60
	4,500 <CC≤ 7,100	2.50
	7,100 < CC ≤ 14,000	2.40

On 1 January 2009, the reach standard will go into effect, raising the minimum standard as shown in Table 9.

Table 9: Room Air Conditioner 2009 MEPS

Category	Rated Cooling Capacity (CC) (Watts)	Energy Efficiency Ratio (EER) (W/W)
Single-package	CC ≤ 14,000	2.90
Split unit	CC ≤ 4,500	3.20
	4,500 <CC≤ 7,100	3.10
	7,100 < CC ≤ 14,000	3.00

A comparison of Table 9 with Table 8 illustrates an overall energy efficiency ratio improvement of approximately 25% between 2005 and 2009. The reach standard does not specify the energy efficiency grades or the energy efficiency specification to go into effect at that time.

Refrigerators and room air conditioners are the only products currently subject to mandatory energy information labeling. The 2005 MEPS defines the 5 efficiency grades as shown in Table 10.[5] The grades represent the same percentage bins as defined in Table 5. Room air conditioners that achieve grades 1 and 2 are eligible for energy efficiency labeling.

[5] Within Japan's 2006 Top Runner Program Revised Edition, the target EER values for the three categories of split-unit air conditioners described in Table 10 are 3.23 (up to 4 kW), 3.23 (4-7 kW), and 2.47 (above 7 kW).

Table 10: Room Air Conditioner 2005 Energy Efficiency Grade Specification

Category	Rated Cooling Capacity (Watts)	Energy Efficiency Grade (EER)				
		5	4	3	2	1
Single-package	CC ≤ 14,000	2.30	2.50	2.70	2.90	3.10
Split unit	CC ≤ 4,500	2.60	2.80	3.00	3.20	3.40
	4,500 <CC≤ 7,100	2.50	2.70	2.90	3.10	3.30
	7,100 < CC ≤ 14,000	2.40	2.60	2.80	3.00	3.20

The UEC values for room air conditioner energy consumption used in the model are those shown in Table 11. These values are derived from the EER of the standard in consideration of average usage patterns. In this exercise, it was assumed that usage would not change over the period of study, but if higher income leads to higher hours of usage, then the UEC figures in this table for 2009 and beyond would need to be revised upwards, and savings would be correspondingly smaller.

Table 11: Modeled Room Air Conditioner Unit Energy Consumption Values (kWh/year)

	Efficiency Level*	Year of Implementation		
		2000	2005	2009
Room AC	MEPS	395	372	302
	Labeled	358	302	285

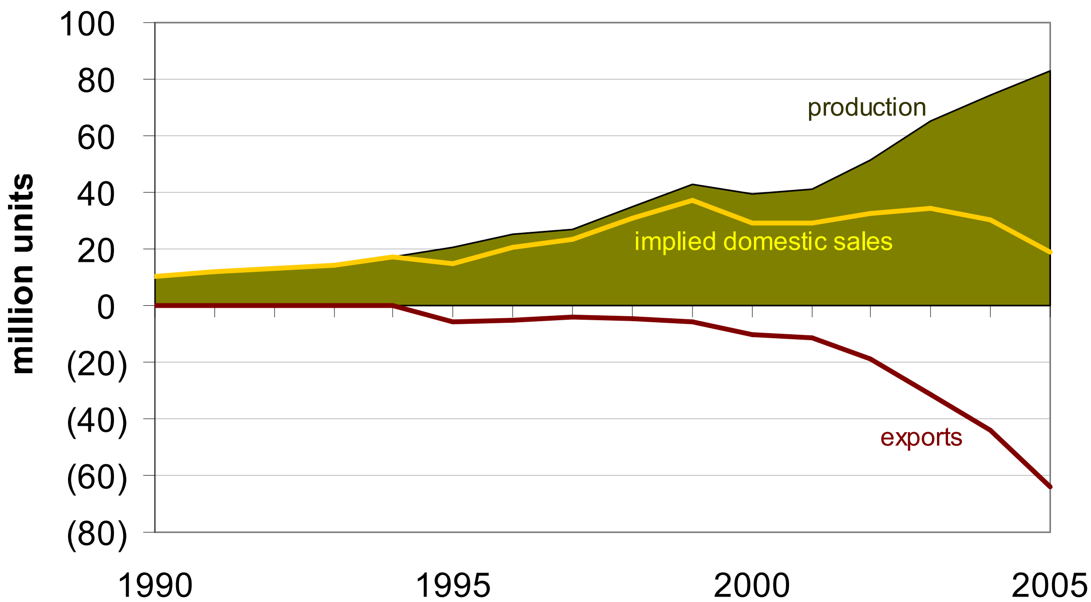
*"MEPS" indicates the average model that complies with the minimum standard; "Labeled" indicates the average model that has achieved the energy efficiency specifications for labeling.

This study used an average assumed lifetime of ten years for all room air conditioner units.

2.3 TELEVISIONS

As illustrated in Figure 2, early and sustained market growth has led to high household television saturation. In 2005 television usage accounted for 30% of total electricity consumption by appliances under consideration in this study.

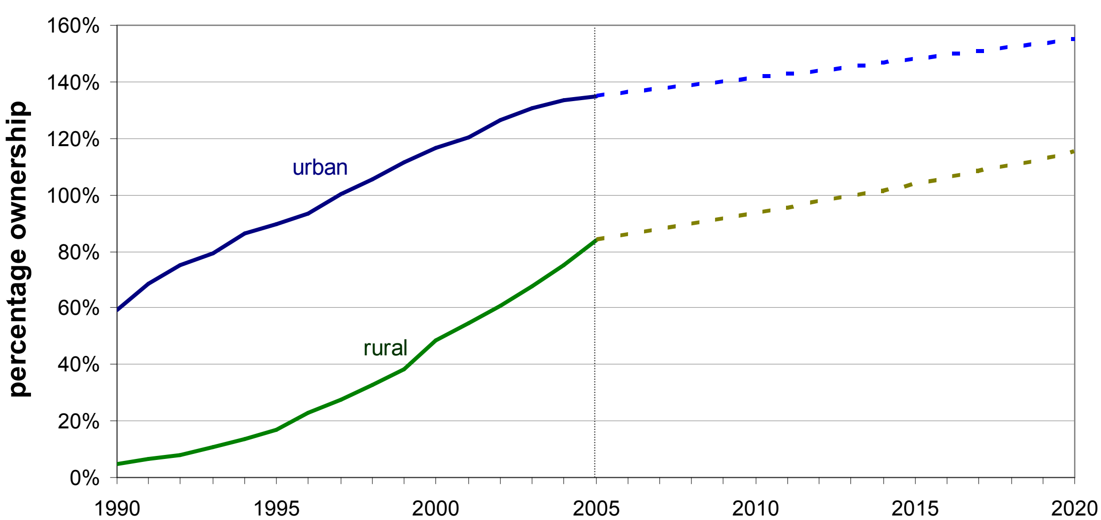
Figure 13: China Television Production, Sales, and Trade, 1990-2005



Sources: NBS, 2006; China Customs Data.

China TV production reached 83 million units in 2005, and is forecast to reach 160 million units by 2020. Television exports surged to 64 million units (77% of production) in 2005; imports have amounted to less than 400,000 per year since 1995 (Figure 13).

Figure 14: Actual and Forecast TV Ownership, 1990-2020

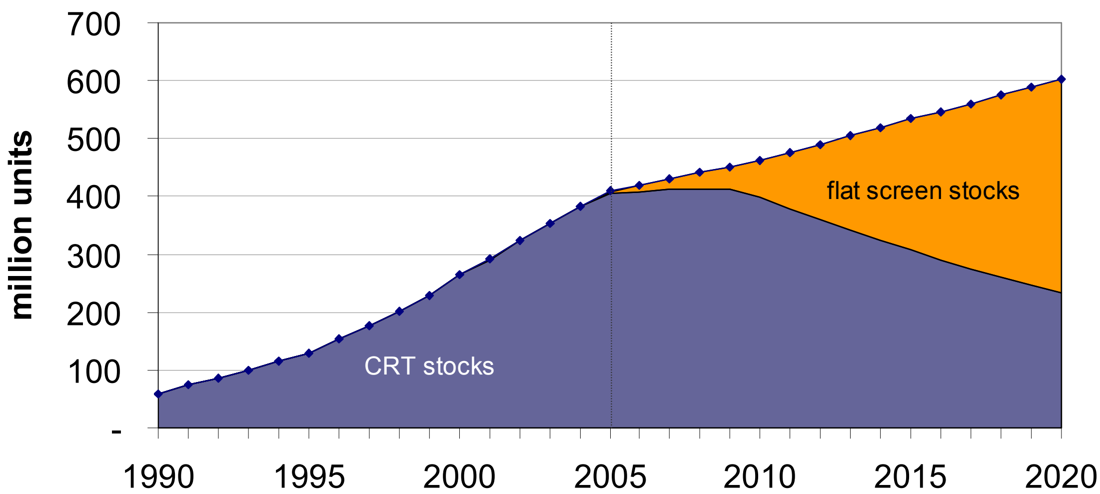


Source: NBS, 2006.

In contrast with the room air conditioner market, China's urban television market was already fairly mature in 1990, when nearly 60% of households owned a color television.

Urban household penetration increased at an annual average growth rate of 6%, from 59% to 130% ownership between 1990 and 2005, and rural household penetration grew at an average 21% per year to reach 84% ownership in 2005 (Figure 14).

Figure 15: Actual and Forecast Cumulative Television Stocks by Type, 1990-2020



Source: NBS, 2006; United Nations Population Data.

As plasma and LCD technology becomes cheaper, the television market is shifting from cathode ray tube (CRT) to flat-screen technologies, and this process is already well underway in China. Based on this trend and industry predictions, Figure 15 illustrates the growth of flat screen televisions in China's total television stock, rising from 3.8 million units in 2005 to an estimated 369 million flat-screen units (61% of total TV stocks) in 2020.

Efficiency

China's national energy performance standard for televisions is called "The minimum allowable values of energy efficiency and energy conservation labeling values for color television broadcasting receivers" (GB12021.7-2005). The MEPS provides: maximum allowable values of energy consumption; energy efficiency grades (thresholds for the mandatory energy information label categories); energy conservation evaluation values (voluntary energy efficiency labeling specifications); energy consumption test methods; and inspection regulations for color televisions. The standard includes minimum energy values and energy efficiency criteria for 2006 implementation of standards and labels, as well as "reach" values for 2009 implementation.

Prior to GB12021.7-2005, the China Standard Certification Center (CSC) voluntary energy efficiency labeling specification went into effect in 2002. It specified a maximum of 3W in standby mode for color CRT televisions with no constraints on active mode power use and excluded LCD, plasma, or rear projection technologies. GB12021.7-2005 was issued on 18 July 2005 and came into effect on 1 March 2006. This MEPS applies to all screen types (CRT, rear projection, LCD, plasma), but the active mode requirement only to color CRTs while flat-screen technology is subject only to standby power limits. Given the market shift illustrated in Figure 15, this omission of active mode consideration for flat-screen technology is likely to result in an increasingly large amount of foregone energy savings.

The MEPS level requires passive standby no greater than 9W, and an energy efficiency index of 1.5 (the television energy efficiency index is calculated as the ratio of actual energy consumption in a standard laboratory test measuring on-mode energy consumption to a "baseline" index that considered graphics, sound level, processing, power supply, and usage patterns—the lower the figure, the higher the efficiency) (Table 12).

Table 12: Television MEPS and Energy Efficiency Criteria, 2006 and 2009

MEPS	2006		2009	
	Energy Efficiency Index	**Standby Power**	**Energy Efficiency Index**	**Standby Power**
CRT	1.5	9W	1.1	5W
Plasma, LCD, rear projection	n/a	9W	n/a	5W
Energy Efficiency Labeling Criteria				
CRT	1.1	3W	n/a	n/a
Plasma, LCD, rear projection	n/a	3W	n/a	n/a

Translating the energy efficiency index and standby power usage into an annual unit energy consumption requires assumptions about average daily television viewing habit. The analysis uses the assumptions developed for the Energy Resource Institute LEAP model of China of 4 hours daily, rising to 5 hours by 2020. This translates in the UEC values shown in Table 13.

Table 13: Modeled Television Unit Energy Consumption Values (kWh/year)

TV Type	Efficiency Level*	Year of Observation/Implementation		
		2000*	**2006**	**2009**
CRT	MEPS	214	208	137
	Labeled	142	143	98
Flat	MEPS	345	345	345
	Labeled	333	333	333

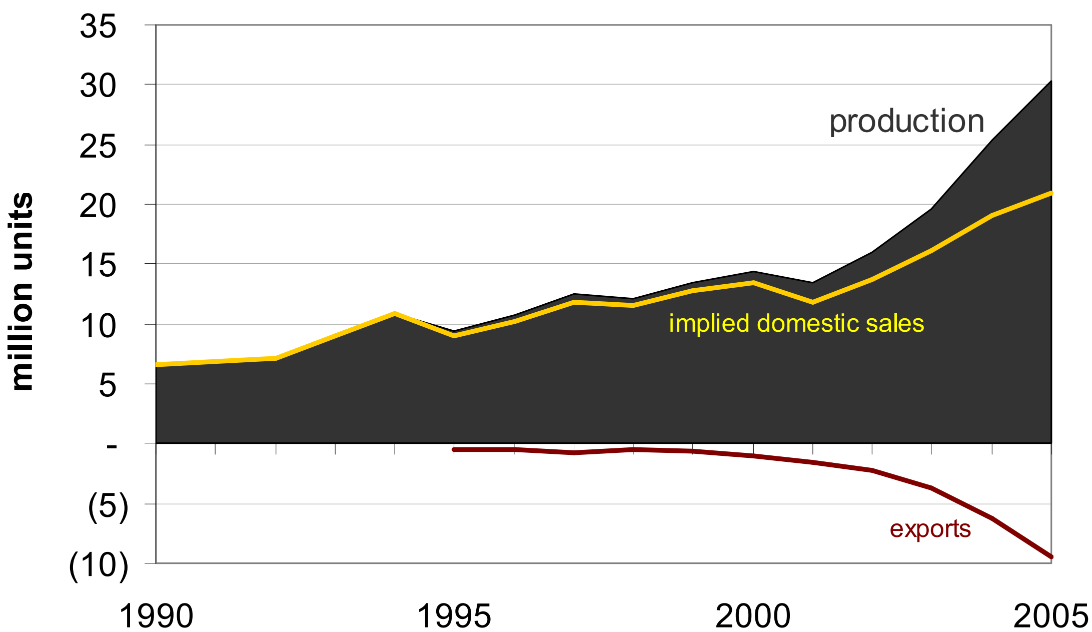
*"MEPS" indicates the average model that complies with the minimum standard; "Labeled" indicates the average model that has achieved the energy efficiency specifications for labeling.

This study used an average assumed lifetime of ten years for all television types.

2.4 Clothes Washers

Clothes washer ownership levels are high in China, divided between the dominant vertical (impeller) and horizontal types of clothes washer. Horizontal (drum) washers are becoming more prevalent, but still account for a small percent of the market. In 2005, clothes washers accounted for about 8% of electricity consumption by appliances under consideration here.

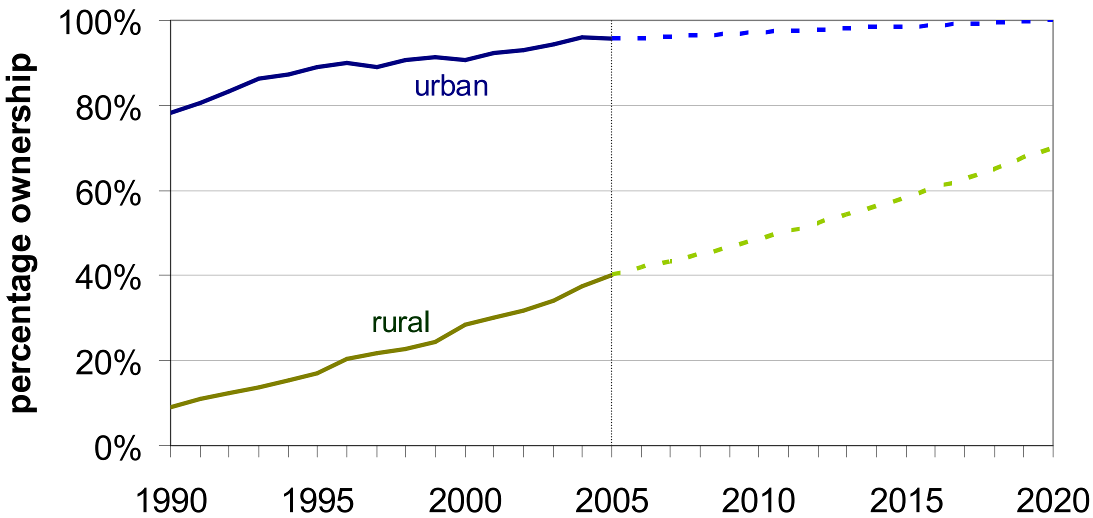
Figure 16: Annual Clothes Washer Production, Sales, and Trade, 1990-2005



Sources: NBS, 2006; China Customs Data.

Clothes washer production has grown from 7 million units in 1990 to 30 million in 2005. Exports surged to 9.5 million units (32% of production) in 2005, while imports have not exceeded 100,000 units per year since 1995 (Figure 16).

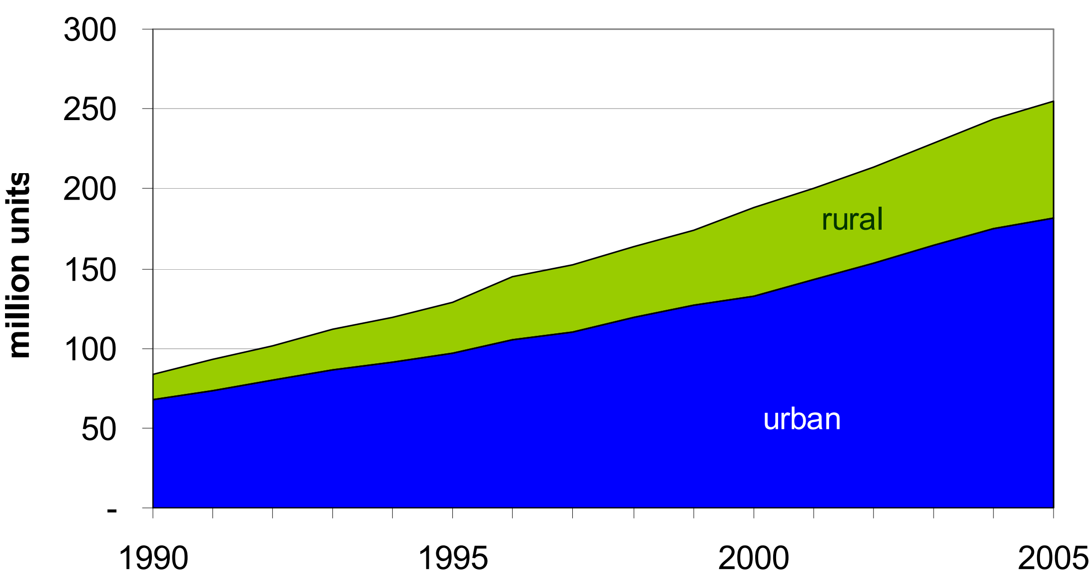
Figure 17: Actual and Forecast Clothes Washer Ownership, 1990-2020



Source: NBS, 2006.

Household ownership data indicate that clothes washers are the next-most sought after appliance after televisions. Although clothes washer penetration growth has not been as rapid as TV ownership growth, more households owned clothes washers than televisions in 1990. Urban penetration rates expanded from 78% to 96% between 1990 and 2005, and rural ownership grew from 9% to 40% over the same period (Figure 17).

Figure 18: Cumulative Urban and Rural Clothes Washer Stocks, 1990-2005



Source: NBS, 2006.

Clothes washer stocks grew consistently between 1990 and 2005, from 84 million units in 1990 to 255 million units in 2005, of which 181 million units (71%) were used in urban households (Figure 18).

Efficiency

China's national minimum energy performance standard (MEPS) for televisions is called "The minimum allowable values of the energy efficiency and energy efficiency grades for household electric washing machines" (GB 12021.4-2004). The MEPS provides: maximum allowable values of energy consumption; energy efficiency grades (thresholds for the mandatory energy information label categories); energy conservation evaluation values (voluntary energy efficiency labeling specifications);maximum allowable values for water consumption; energy consumption test methods; and inspection regulations for clothes washing machines. This is the last standard developed that does not contain a tier-two "reach" standard.

Table 14: Clothes Washing Machine MEPS and Energy Efficiency Criteria 2004

Washing Machine Type	Efficiency Level	Unit Energy Consumption (kWh/cycle/kg)	Unit Water Consumption (liters/cycle/kg)
Vertical/Impeller	MEPS	≤0.032	≤36
	Energy Efficient	≤0.017	≤24
Horizontal/Drum	MEPS	≤0.350	≤20
	Energy Efficient	≤0.23	≤14

Table 14 data illustrate the energy-water tradeoff between washing machine types: vertical, top-loading units are energy-efficient, but more-highly water consuming, and horizontal, drum units are more energy consumptive, but water efficient. Both energy and water are serious conservation topics in China today.[6]

Table 15 provides the details of the 5-grade efficiency categories. These categories are those on which the mandatory information label is based, but the label has not yet been applied to clothes washers. Those washers meeting grades 1 and 2 meet the voluntary endorsement labeling criteria.

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[6] Per-capita water availability in China is among the lowest in the world, and water resources are unevenly distributed. The northern part of the country, for example, contains 63% of China's land but possesses only 19% of the water resources. Water quality, declining water tables, and insufficient water for agriculture are additional challenges China's face. CSC, which runs China's voluntary energy efficiency labeling program, also run China's water efficiency labeling program.

Table 15: China Clothes Washer 2004 Energy Efficiency Grade Specifications

Energy Efficiency Grade	Vertical Clothes Washers		Horizontal Clothes Washers	
	UEC (kWh/cycle/kg)	UWC (L/cycle/kg)	UEC (kWh/cycle/kg)	UWC (L/cycle/kg)
1	≤0.012	≤20	≤0.19	≤12
2	≤0.017	≤24	≤0.23	≤14
3	≤0.022	≤28	≤0.27	≤16
4	≤0.027	≤32	≤0.31	≤18
5	≤0.032	≤36	≤0.35	≤20

Table 14 shows that clothes washers must be 35% to 65% more efficient than the MEPS to be eligible for voluntary endorsement labeling. However, testing data show that prior to the implementation of the MEPS in 2004, the market average efficiency of the predominant vertical washers already surpassed the MEPS requirement for both the minimum standard and the voluntary endorsement label. As a result, the savings from this standard accrue from the increased average efficiency of the horizontal washers (Table 16). The share of vertical clothes washers is forecast to decline from 85% of stock to 2005 to 63% in 2020, while horizontal washer market share is expected to increase from 15% to 37% over the same period.

Table 16: Modeled Clothes Washer Unit Energy Consumption Values (kWh/year)

Clothes Washer Type	Efficiency Level	Year of Observation/Implementation	
		2000*	**2004**
Vertical	MEPS	38	42
	Labeled	16	22
Horizontal	MEPS	540	455
	Labeled	182	299

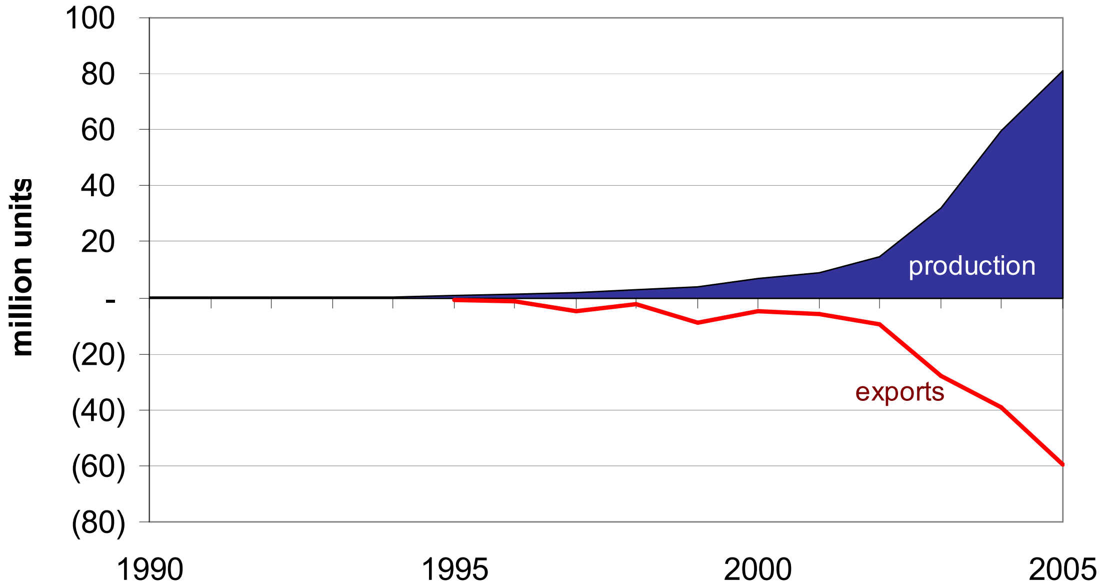
*"MEPS" indicates the average model that complies with the minimum standard; "Labeled" indicates the average model that has achieved the energy efficiency specifications for labeling.

This study used an average assumed lifetime of ten years for all clothes washer types.

2.5 Computers and Printers

Most of the growth in China's computer market has occurred since 2000. Domestic production was only 80,000 units in 1990. In 2002, production began its current growth phase, with total 2005 production at 81 million units. Export data appear to include domestic assembly of internally-produced components. In 2005, exports were recorded at 60 million units. Computer imports amounted to 3 million units in 2005.

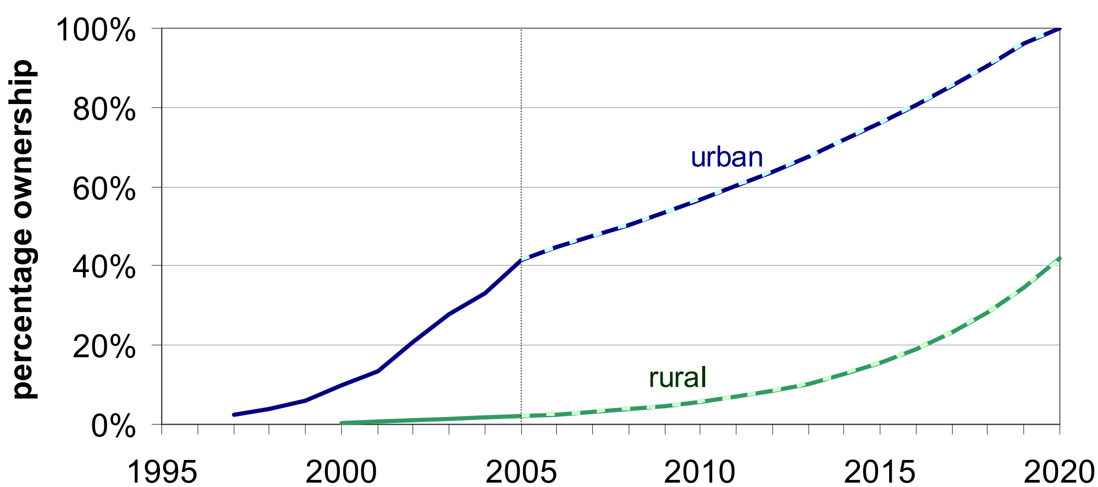
Figure 19: Annual Computer Production and Trade, 1990-2005



Source: NBS, 2006; China Customs Data.
Note: exports presumably include domestic assembly of internationally-produced components.

Urban computer ownership grew from 3% in 1997 to 42% in 2005; rural ownership reached 2% in 2005. In 2003, aggregate US ownership of computers reached 62%; as shown in Figure 20, it is assumed that China will reach 100% urban by 2020 based on the increasing affordability and ubiquity of the computer.

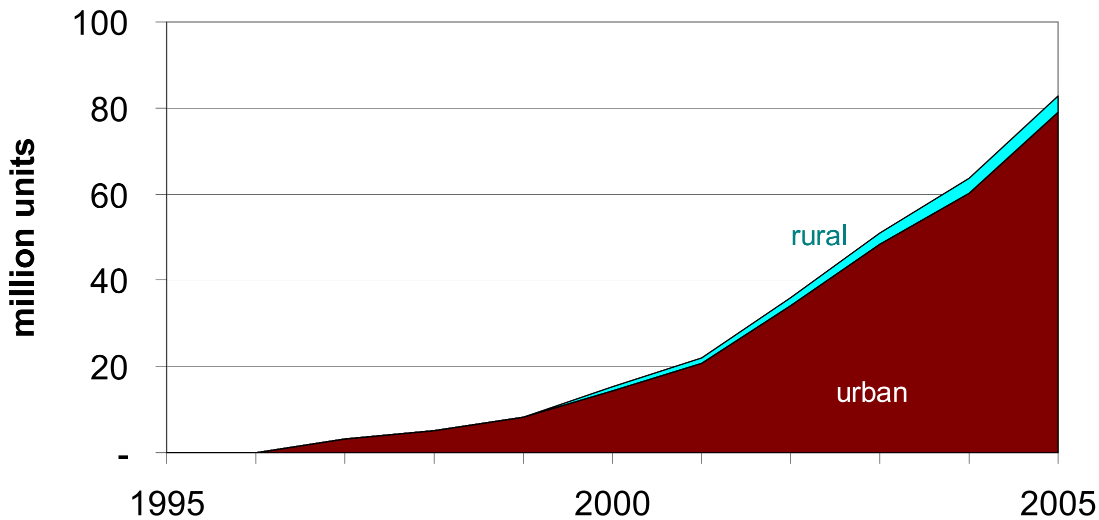
Figure 20: Historical and Forecast Residential Computer Ownership, 1995-2020



Source: NBS, 2006.

Urban computer stocks comprised more than 95% of total national stocks (83 million units) in 2005. Given China's demographic and household ownership projections, total 2020 computer stocks are forecast to reach 330 million units (Figure 21). Printer ownership and stock data are estimated on the basis of computer data, with an average 1 printer for every 10 computers. This figure accords with recent sales trends.

Figure 21: Cumulative Urban and Rural Residential Computer Stocks, 1995-2005



Source: NBS, 2006.

Efficiency

China's national energy efficiency specification for computers is called "Technical specifications for energy conservation product certification for computers" (T22—2003). The specification provides: energy conservation target values; energy consumption test methods; and inspection regulations for computer energy efficiency labels. The national energy efficiency specification for printers is called the "Technical specifications for energy conservation product certification for printers and printer-fax combinations" (T-18—2003). The energy efficiency specifications apply only to standby power usage as shown in Table 17.

Table 17 Computer and Printer Energy Efficiency Specifications

Product	Standby Power Consumption
Computer	≤3W
Printer	≤3W

Because most of the energy use of these products is in their active mode, the standby energy requirement does not significantly reduce that annual consumption of electricity per unit.[7] However, because of the very large and growing market for these products, substantial savings are possible through an increase in the market share of the efficient labeled models (Table 18).

Table 18: Modeled Computer and Printer Unit Energy Consumption and Market Share Values

Product	Efficiency Level	UEC (kWh/year)	Initial Market Share	Ultimate Market Share
Computers	Ordinary (2002 average)	78	90%	9%
	Efficient	75	10%	91%
Printers	Ordinary (2002 average)	102	41%	0
	Efficient	88	59%	100%

Note: Ultimate market share levels are attained in 2008 for computers and 2012 for computers.

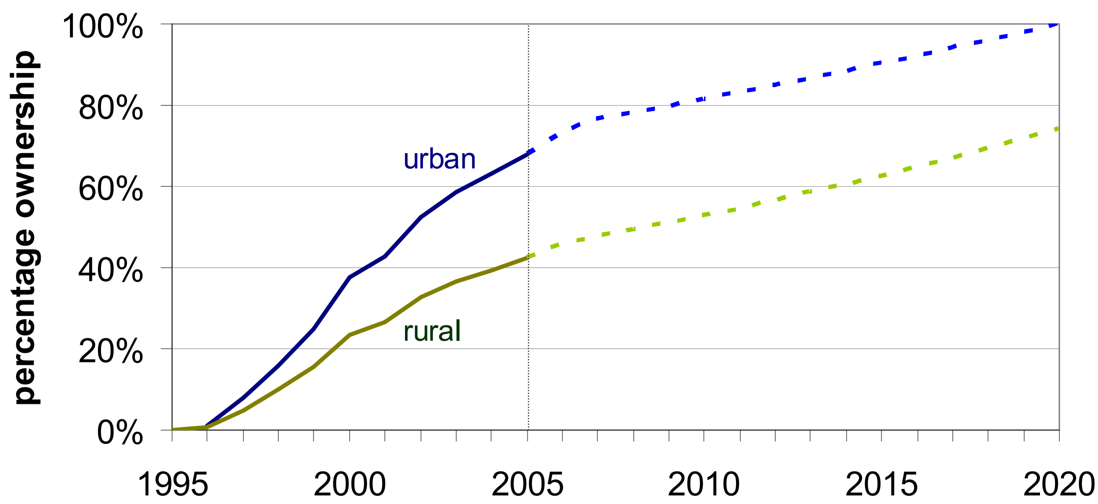
This study used an average assumed lifetime of five years for all modeled computers and printers.

2.6 DVD AND VCD PLAYERS

DVD and VCD (video CD) player ownership has grown rapidly since 1996. In 2005, 68% of urban households owned a DVD or VCD player, while 42% of rural households owned one. Household ownership is projected to reach 100% of urban households and 74% of rural households in 2020 (Figure 22).

[7] Within Japan's 2006 Top Runner Program Revised Edition, the target energy consumption efficiency values for client-side computers with less than 2 input/output transmission channels and an average memory capacity of less than 1 GB is 0.043 W of average power consumption per duration of theoretical operation (MTOPS). This process-oriented standard captures active-mode savings while not penalizing more sophisticated equipment.

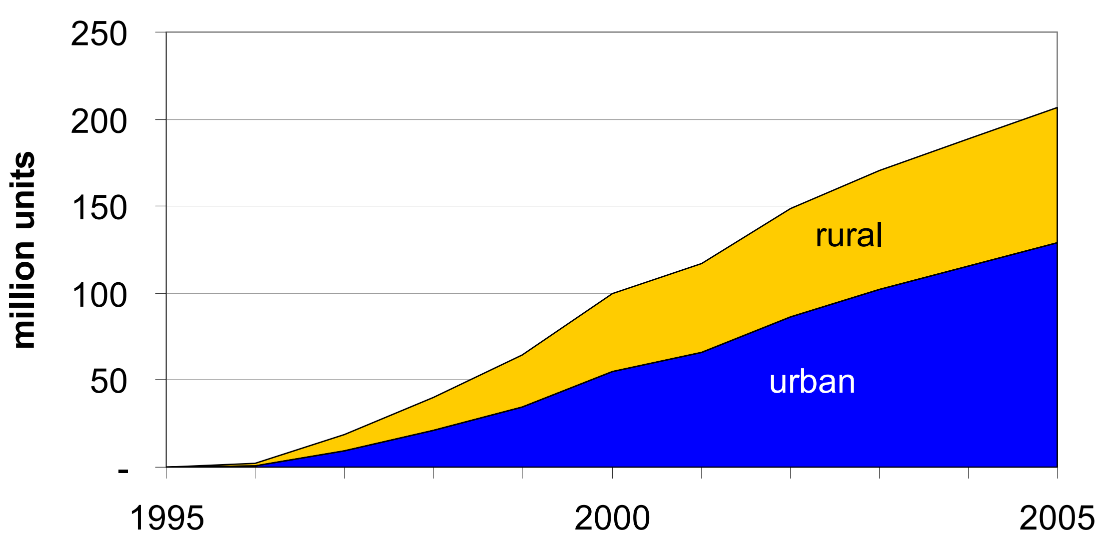
Figure 22: Historical and Forecast Ownership of DVD/VCD Players, 1995-2020



Source: NBS, 2006.

DVD and VCD player stocks reached a total of 207 million units in 2005, of which a relatively high 38% were owned by rural households (Figure 23).

Figure 23: Cumulative Stocks of Urban and Rural DVD/VCD Players, 1995-2005



Source: NBS, 2006.

Efficiency

China's national energy efficiency specification for DVD and VCD players is called the "Technical specifications for energy conservation product certification for DVD/VCD"

(T25—2003). The specification provides energy conservation target values, energy consumption test methods, and inspection regulations for DVD and VCD player energy efficiency labels. As in the case of computers and printers, the energy efficiency specifications apply only to standby energy use, as shown in Table 19.

Table 19: DVD/VCD Energy Efficiency Specifications

Product	Standby Power Consumption
DVD	≤3W
VCD	≤3W

Similarly, annual energy consumption of these products is dominated by their active mode usage. Reducing standby energy use, on average, saves about 7 kWh per unit per year, but given widespread ownership and a projected increasing market share of efficient units, the savings are considerable.

Table 20: Modeled DVD & VCD Player Unit Energy Consumption and Market Share Values

Appliance	Efficiency Level	UEC (kWh/year)	Initial Market Share	Ultimate Market Share
DVD/VCD Players	Ordinary (2002 average)	58	98%	10%
	Efficient	51	2%	90%

This study used an average assumed lifetime of five years for all DVD- and VCD-players.

2.7 Case of Lighting & Gas Water Heaters

2.7.1 Lighting (Fluorescent Lamps and CFLs)

China currently has both minimum efficiency standards and voluntary efficiency criteria for linear fluorescent lamps and self-ballasted fluorescents, or compact fluorescent lamps (CFLs). In the case of linear fluorescent lamps, the latest standard was adopted in 2003, and contained a second-tier "reach" standard to go into effect in 2006 (Table 21). The 2003 standard required linear fluorescent lamps to achieve a minimum of grade 3, while the voluntary efficiency specification was set at grade 2. In 2006, however, the minimum standard was raised to grade 2, but there was no corresponding increase in the voluntary efficiency specification. In essence, the two levels were collapsed into one.

Table 21: Linear Fluorescent 2003 MEPS and Efficiency Specifications

Rated Wattage	Efficacy (lm/W)								
	Efficiency Grade (color: RR, RZ)			**Efficiency Grade** (color: RL, RB)			**Efficiency Grade** (color: RN, RD)		
	1	2	3	1	2	3	1	2	3
14~21	75	53	44	81	62	51	81	64	53
22~35	84	57	53	88	68	62	88	70	64
36~65	75	67	55	82	74	60	85	77	63

Note: the two-letter codes denote color temperature. RR-6500K, RZ-5000K, RL-4000K, RB-3500K, RN-3000K, RD-2700K.

CFL standards were adopted in 2003, without a second-tier reach standard. The CFL standard also uses the same 3 grades as linear fluorescents, with grade 2 being the specification for the voluntary energy efficiency label (Table 22).

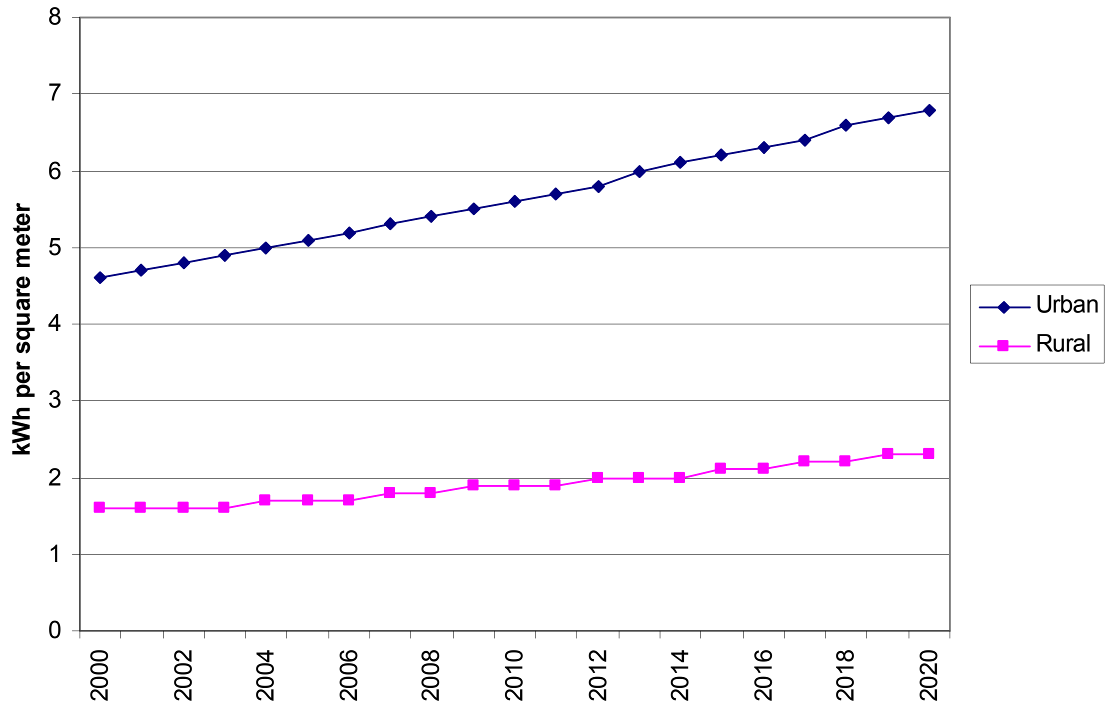
Table 22: CFL 2003 MEPS and Efficiency Specifications

Rated Wattage (W)	**Initial value of luminous flux** (lm/W)					
	Grade (RR, RZ)			Grade (RL, RB, RN, RD)		
	1	2	3	1	2	3
5~8	54	46	36	58	50	40
9~14	62	54	44	66	58	48
15~24	69	61	51	73	65	55
25~60	75	67	57	78	70	60

Note: the two-letter codes denote color temperature. RR-6500K, RZ-5000K, RL-4000K, RB-3500K, RN-3000K, RD-2700K.

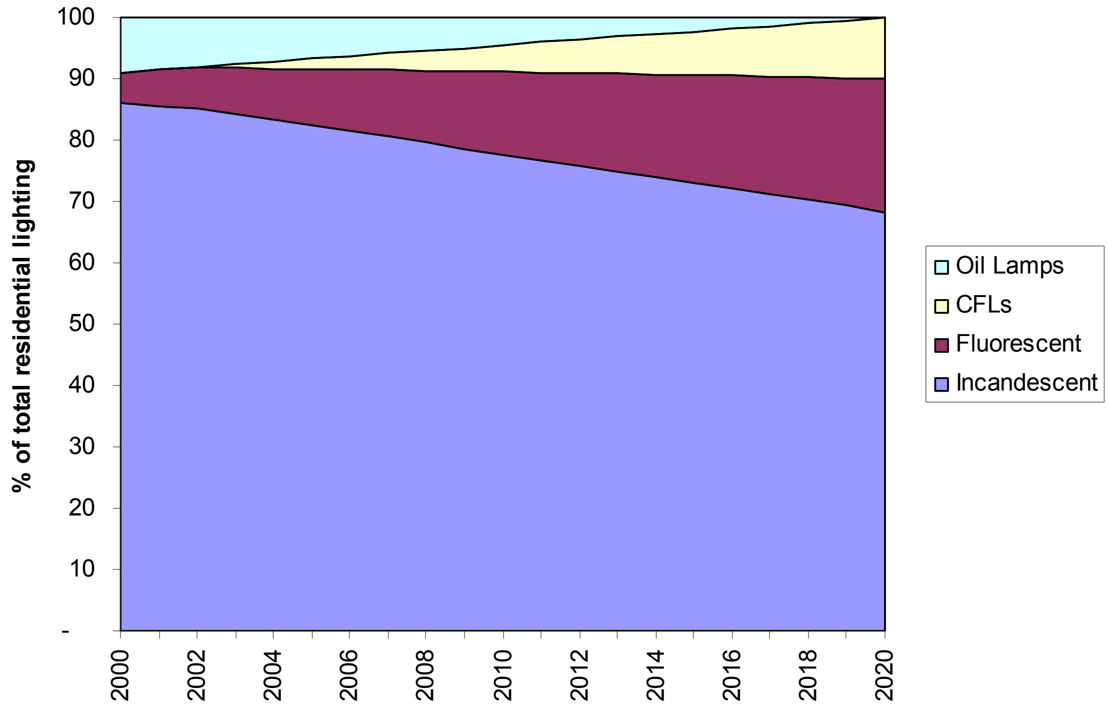
The lack of solid data on sales, lifetimes and turnover makes it difficult to use a full vintaging approach to estimation of the savings from lighting standards and labels. In this case, the approach was to look at lighting intensity in households in terms of kWh of lighting energy use per square meter. In both urban and rural households, it is expected that lighting intensity will increase as incomes rise (Figure 24: Assumed Lighting Intensity of Urban and Rural Households).

Figure 24: Assumed Lighting Intensity of Urban and Rural Households



Based on surveys of selected urban and rural households, it is apparent that incandescent lamps remain the primary lighting choice. In recent years, incandescents account for about 82% of the lighting market, followed by 9% for fluorescents, and just less than 2% for CFLs. In total, oil lamps, at 7%, account for a great share of lighting than CFLs. By 2020, it is expected that the share of incandescents will drop to about 68% of the total, and oil lamp lighting will entirely disappear. The remainder of the market will be served by linear fluorescents and CFLs (Figure 25).

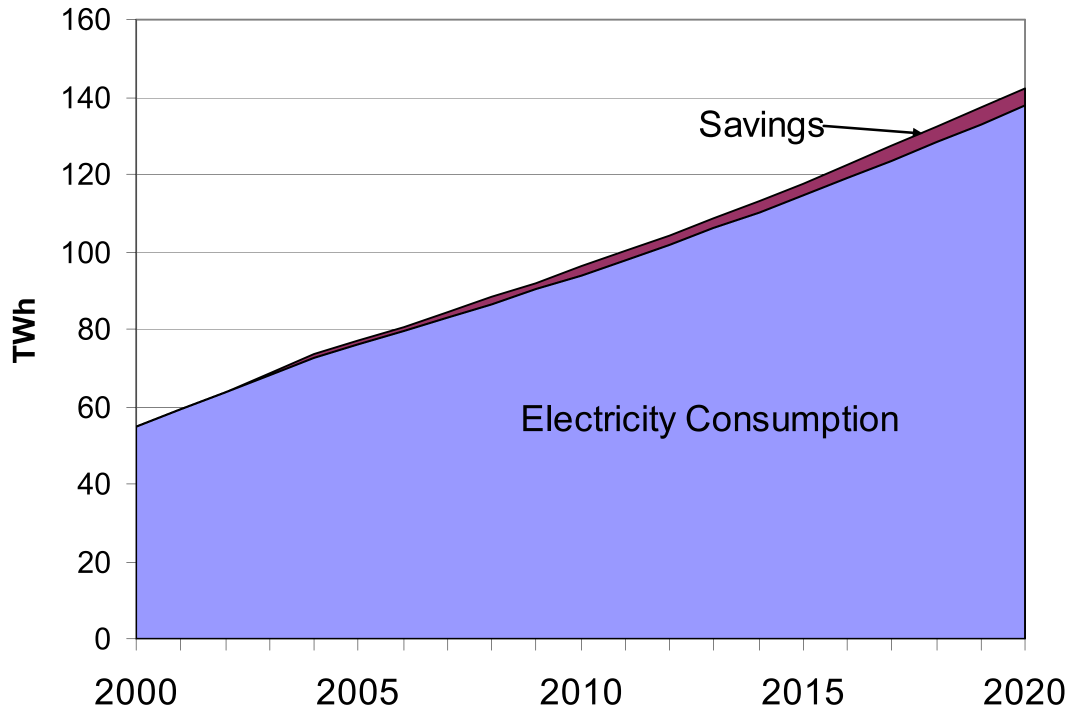
Figure 25: Residential Lighting Shares



The estimation of savings in this report is based on the calculation of efficiency gains of each class of lighting itself; in other words, the savings do not include those derived from switching from incandescent to either linear fluorescent or to CFLs. Although this is legitimate to include in some cases, there is yet no quantitative basis for assessing how much of the switch was due to either the standards or labeling programs. Growth in the CFL market share, for example, may be driven more by the decreasing price and increasing reliability of Chinese-produced CFLs. Similarly, the growth in linear fluorescent market share may be driven by new construction installation, as retrofitting linear fluorescents into residences with incandescent lighting is less common owing to the costs. As a result, the savings presented here are less than if the declining incandescent market share were attributed to CFLs or linear fluorescents.

Specifically, the increase in the efficiency of linear fluorescent lamps in 2003 and 2006 generates most of the savings. Because CFLs were virtually unknown in residences prior to the 2003 standard, and because the CLF MEPS did not include a second, higher tier of efficiency, the savings attributed to the MEPS program is virtually nil (Figure 26).

Figure 26: Annual household lighting electricity consumption and savings, 2000-2020



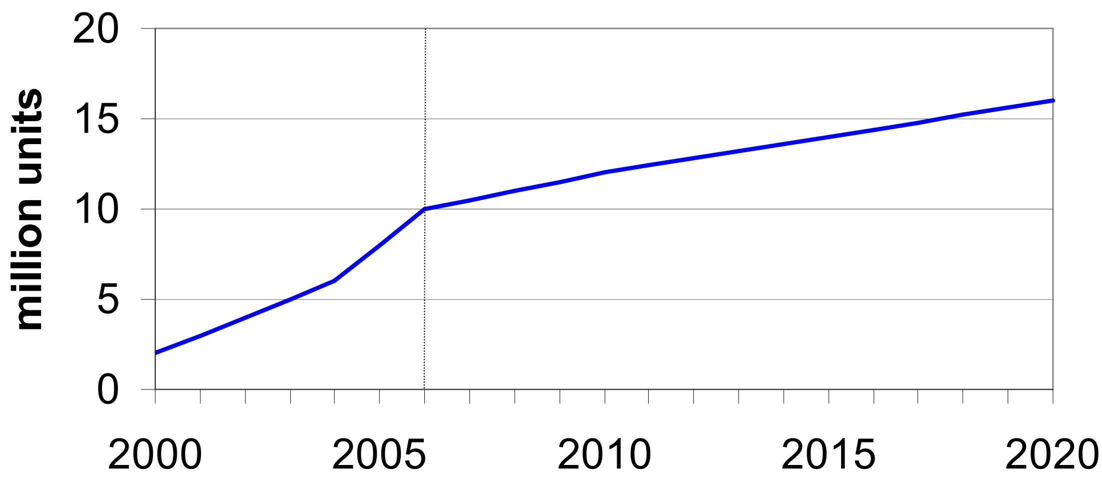
Cumulative electricity savings from the existing lighting standards and labeling programs are expected to total 44.5 TWh by 2020.

2.7.2 Gas Water Heaters

There are three types of domestic water heaters in China: gas water heaters, electric water heaters, and solar water heaters. The most popular type is the gas water heaters (57.4%), followed by electric water heaters (31.3%), and solar water heaters (11.3%).[8] Among gas water heaters, the instantaneous type is dominant type with 94% of market share. Therefore, the focus on potential energy savings from standards is on instantaneous gas water heaters. The gas water heater MEPS, to go into effect on July 1, 2007, is China's first standard for a gas-consuming product. Unlike other recent MEPS, this one does not have a tier-2 "reach" standard.

[8] CNIS unpublished report, 2006.

Figure 27: Historical and Forecast Annual Gas Water-Heater Sales, 2000-2020



According to a recent CNIS report, the current stock of gas water heaters is estimated to be around 62 million units. Sales are estimated to be 10 million units in 2006, rising by 2 million units every five years until 2020 (Fu, 2005). Total sales of gas water heaters are projected to reach 16 million by 2020.

Testing at the National Test Laboratory for Gas Appliances in Tianjin indicates that the average efficiency of gas water heaters is about 86.9%[9], above the minimum standard of 84% efficiency, though significantly below the top-tier standard of 94% (Table 23)

Current baseline usage is estimated to be 182 m^3 of natural gas per unit in north China and 146 m^3 natural gas per unit in south China, with an average usage of 161 m^3 per water heater per year.[10] These numbers may be small in comparison to energy use for hot water in developed countries, since Chinese households use hot water heaters mostly for taking showers. Hot water for drinking is either heated on a stove (coal or gas) or by electric thermos.

Table 23: Gas Water Heater MEPS 2007

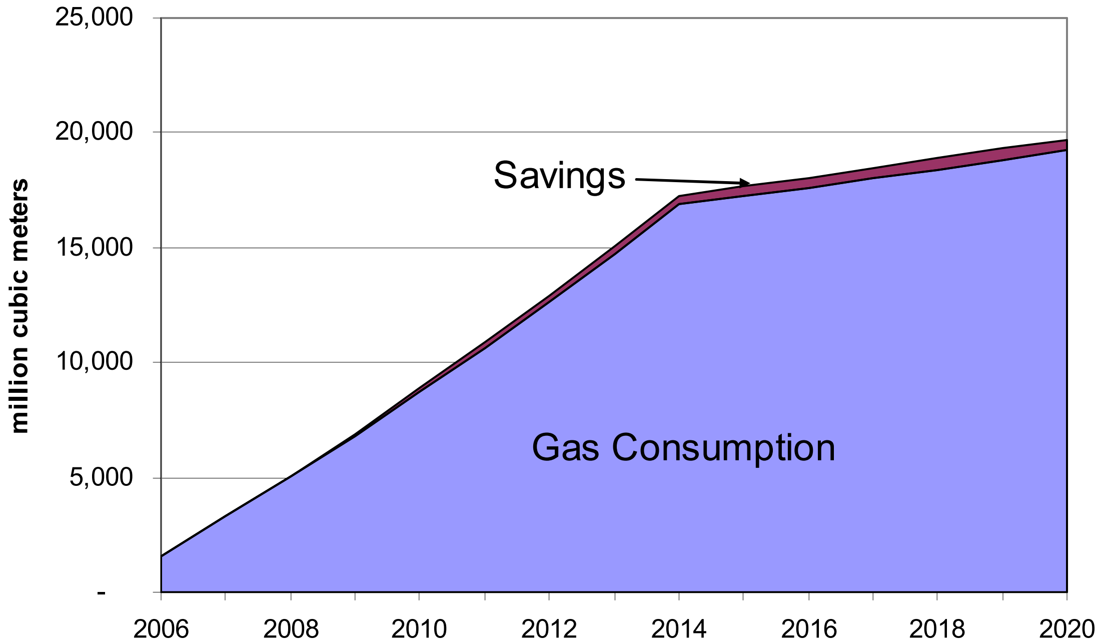
Grade	Efficiency requirement at rated power	Efficiency requirement at ≤50% rated power	UEC (m^3/year)
1	≥96%	≥94%	148
2	≥88%	≥84%	158
3	≥84%	---	165

Note: the assumed lifetime of gas water heaters is 8.5 years

[9] 燃气快速热水器能效测试结果报告 (Testing report on the energy efficiency of instantaneous gas water heaters, National Quality Supervision and Testing Center for Gas Appliances, 2005)
[10] Fu Z., 2005, research note on gas water heaters.

Figure 28 shows that the current MEPS level for gas water heaters delivers only modest savings to 2020, when annual savings are expected to reach nearly 500 million cubic meters per year.

Figure 28: Annual household gas water heater gas consumption and savings, 2006-2020



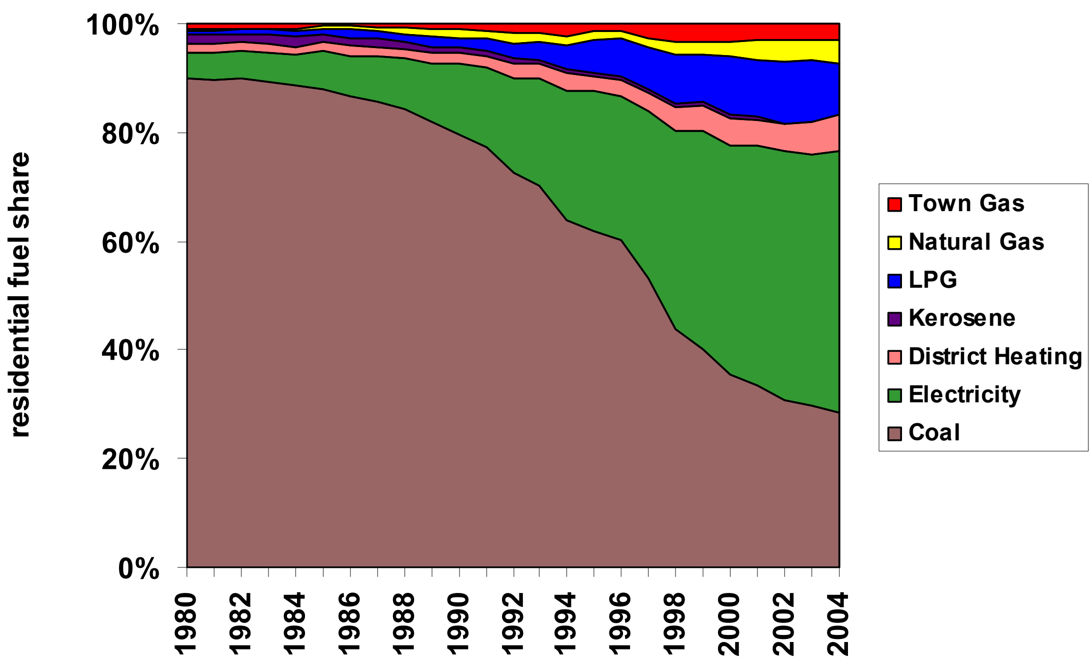
Cumulative 2006-2020 natural gas savings from the new gas water heater standard are expected to total over 4 billion cubic meters.

The development of the gas water heater standard in China was challenging because of the variety of gas sources available in different cities, and lack of a standard model type as result. For example, a number of cities still rely on coal gas or coker gas of low and variable heat content as a household fuel; others have switched to natural gas, and yet others use LPG. It is thus likely that absent a mature natural gas market with standard heat content delivered throughout major markets, the gas water heater industry will remain fairly fragmented in model types, presenting challenges to increasing the efficiency of the whole market through MEPS.

3 National Energy Savings Analysis

In sharp contrast to the situation at the beginning of China's economic reforms in the early 1980s, electricity now accounts for the largest proportion of household energy use. In 1980, coal provided 90% of a household's energy. In 2004, the share of coal had dropped to just 28% and electricity now provides nearly half of all residential energy use (Figure 29).

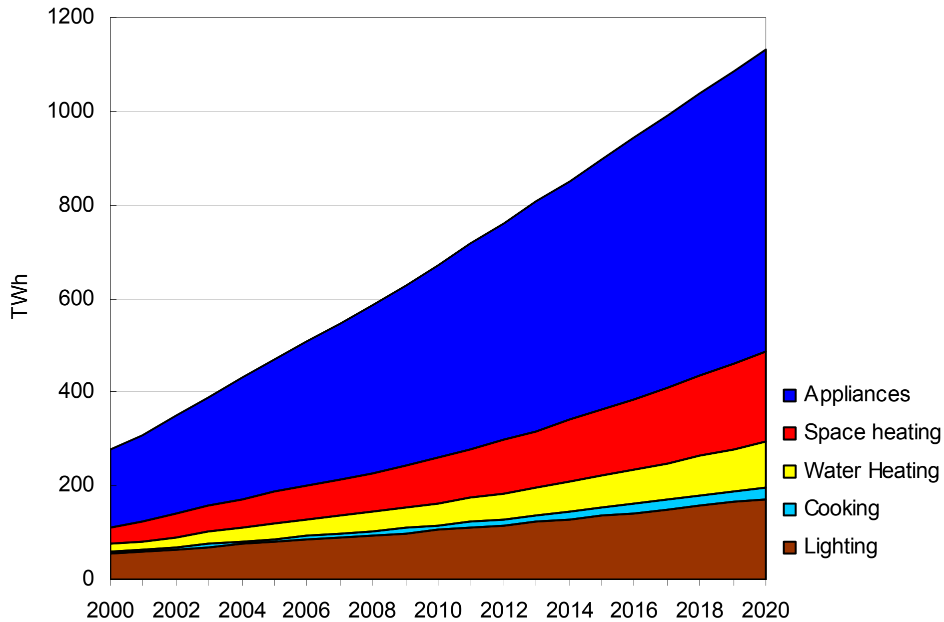
Figure 29: Residential Energy Use by Fuel Type



Over this same period, electricity consumption growth has increased at an astounding 14% per year on average, down only slightly from the robust 16% per year average rate recorded between 1990 and 1995. Since 2000, however, the growth rate has dropped somewhat, falling to an average 10.2% per year. However, even slower growth on a higher base requires higher absolute quantities of electricity to be supplied. Between 1990 and 1995, household electricity use grew by an average 10.5 terawatt-hours (TWh) per year. Further, since 2000, households have increased consumption by nearly 20 TWh per year on average. The main driver of this high sustained rate is quite clear—the growth of appliance and other equipment ownership in the home.

A breakdown of electricity use in Chinese households shows that appliances account for 60% of total electricity consumption, the balance being split among space heating, water heating, cooking, and lighting uses. Except for lighting, electricity is only a secondary energy source for these other functions (Figure 30).

Figure 30: China Residential Electricity Consumption and Forecast (Base Case Scenario)



In 2005, appliance electricity consumption (including lighting) totaled about 342 TWh. In the absence of programs to reduce electricity use, this figure would have been expected to rise to 790 TWh in 2020 (Figure 31). Total appliance usage is dominated by refrigerators (now 31% of total appliance energy consumption), televisions (23%), lighting (22%) and air conditioners (13%) (Figure 32). Although the unit energy consumption of air conditioners is higher than that of televisions, the stock of televisions (now about 410 million) is much larger than that of air conditioners (now about 150 million). This ratio will change significantly by 2020. At about 77 TWh, lighting electricity consumption accounts for about 17% of total residential electricity use. This figure is expected to rise to 142 TWh by 2020, when its proportion will drop to 13% of the total, offset by strong increases in appliance and space heating electricity use.

The current standards and labeling program addresses active power usage of the three major appliances. But in the case of televisions, the new generations of plasma and LCD televisions are excluded from active power use restrictions. Given the expected continued rise in television ownership and the decline in the stock of CRT televisions in use, China will need to revise their standards coverage to capture a rapidly rising proportion of television electricity consumption.

Figure 31: Residential Appliance Electricity Consumption (Base Case Scenario)

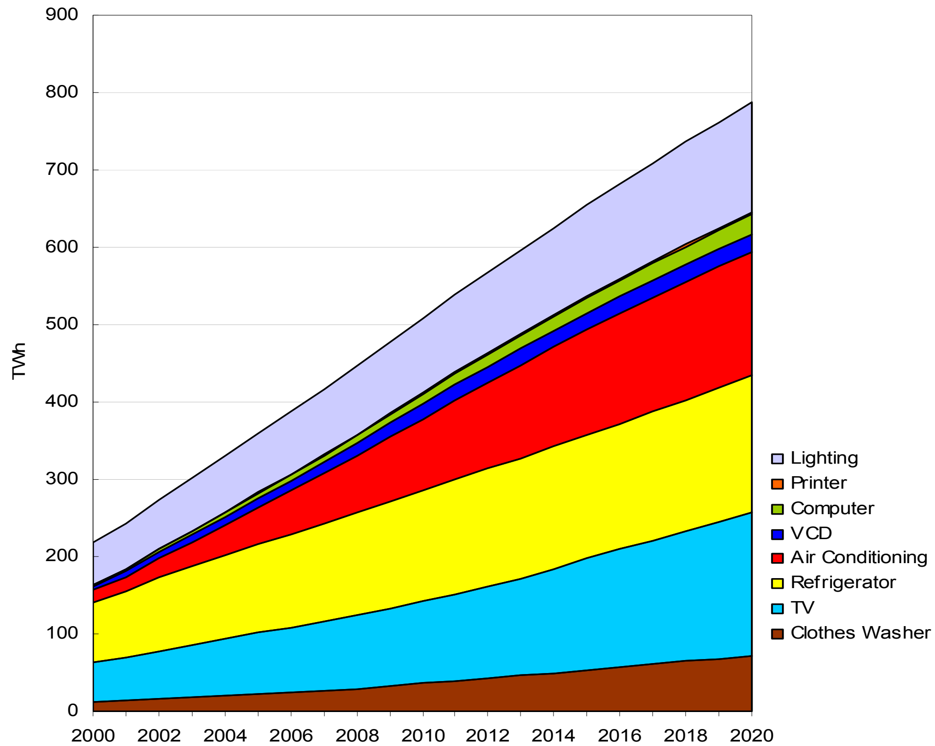
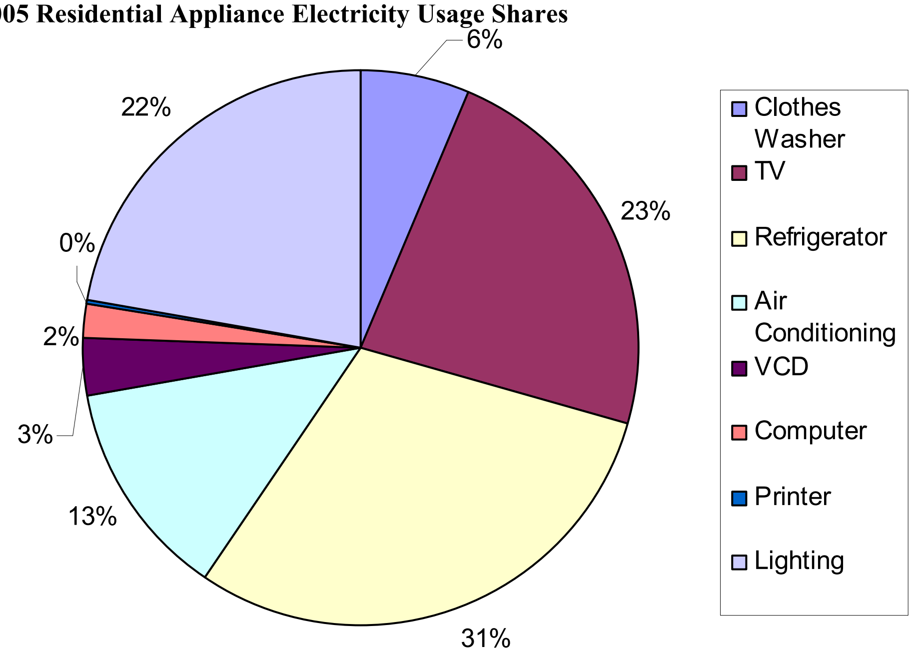
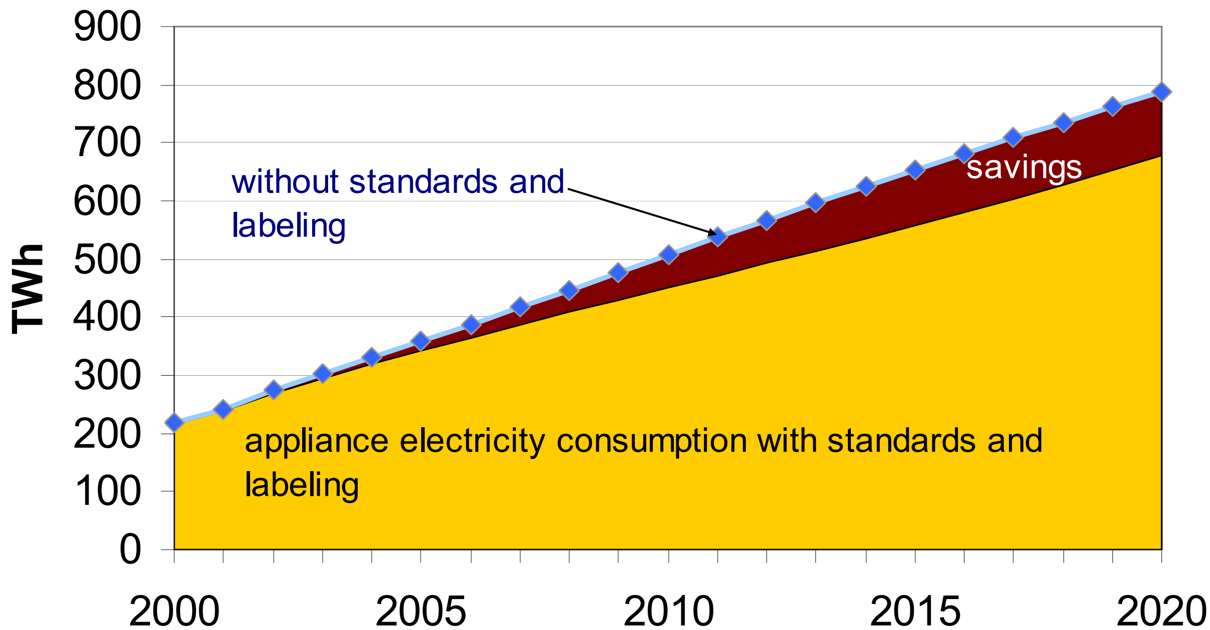


Figure 32: 2005 Residential Appliance Electricity Usage Shares



As described in Section 1, the impact analysis assumes that in the base case, the energy intensity of each appliance is frozen at the average level found at the time that the first standard or label program for the appliance begins. Further, in the case of the voluntary energy efficiency label, savings generated by appliances that had already achieved the efficiency labeling criteria were deducted from the total in order to focus on the impact of the labeling program alone. Overall, as seen in Figure 33, China's standards and labeling programs reduce total electricity consumption in 2020 by an annual 106 TWh, or 16% of what would otherwise been expected in that year in the absence of standards and labeling programs.

Figure 33: China annual appliance electricity consumption and savings, 2000-2020

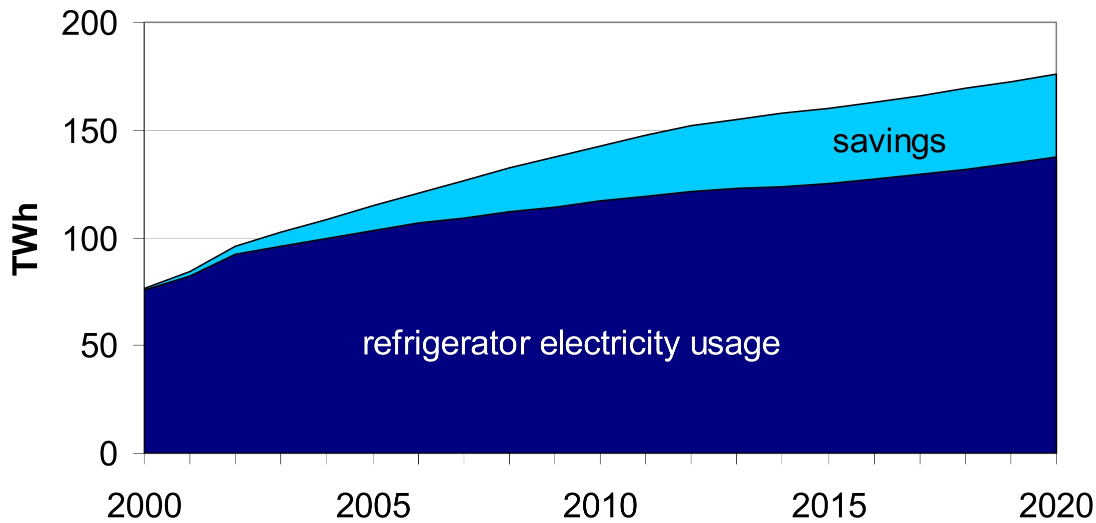


In the following sections, the impact of each standards and labeling program will be addressed by product, followed by a national summary.

3.1 REFRIGERATORS

Refrigerators consumed the largest amount of residential electricity in 2005—103 TWh. By 2005, electricity savings from the 1999 standards and labeling program, along with its 2003 revision, had reached 11 TWh. Given the ownership and demographic assumptions described previously, and with average refrigerator volume rising over this period, total 2020 refrigerator electricity usage is expected to reach 137 TWh, with 39 TWh of savings from the existing standards and labeling programs (Figure 34).

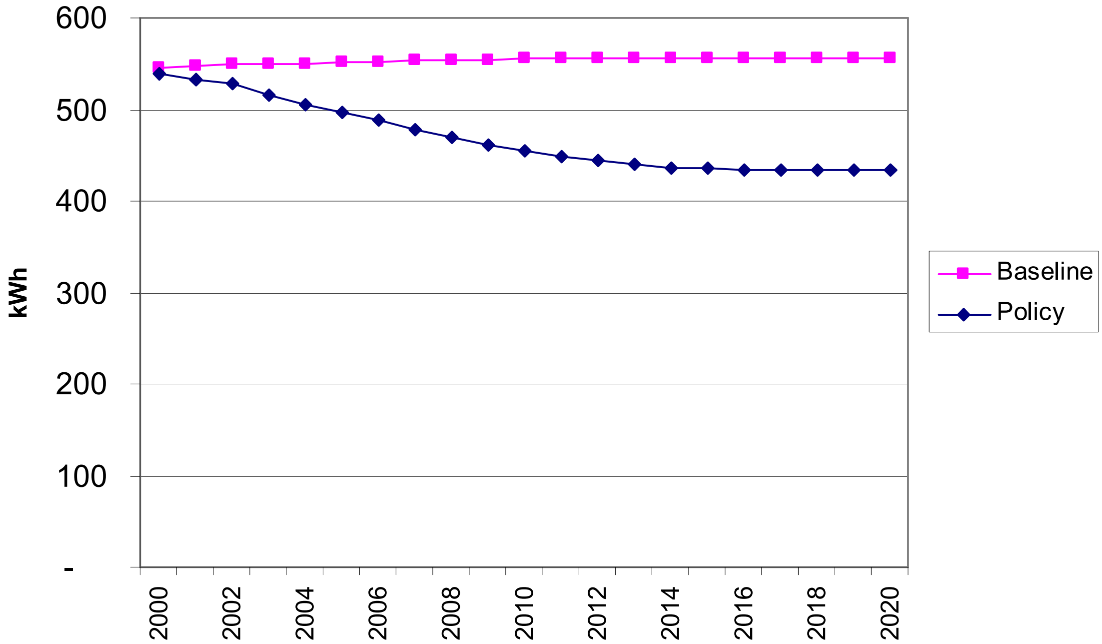
Figure 34: Annual household refrigerator electricity usage and savings, 2000-2020



Cumulative 2000-2020 electricity savings from existing programs are expected to reach 480 TWh.

By 2020, the average weighted unit energy consumption of refrigerators is expected to fall by about 120 kWh per year below that of a market without the current standards and labeling programs. In the case of baseline consumption, the average rises somewhat, reflecting the market shift from 170 liter, to 220 liter, and finally to 270 liter as the average size of refrigerator over this period. Even with this shift to larger refrigerators, the increase in standards through 2007 serve to offset the higher unit consumption (Figure 35).

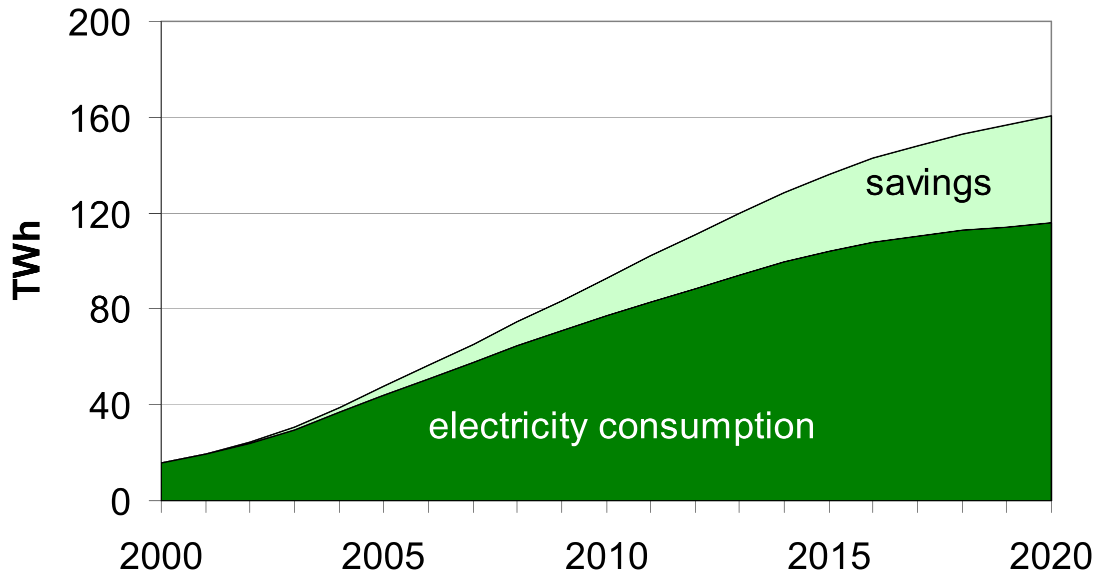
Figure 35: Weighted Average Unit Energy Consumption of Refrigerators



3.2 AIR CONDITIONERS

Whereas refrigerator electricity consumption is expected to double between 2000 and 2020, room air conditioner household electricity consumption is forecast to expand more than eight-fold. In 2005, residential household room air conditioning units consumed 44 TWh of electricity, and about 4 TWh of electricity were saved from the standards and labeling program begin in 2000. By 2020, consumption is expected to rise to 116 TWh with savings of 45 TWh from the existing programs. (Figure 36).

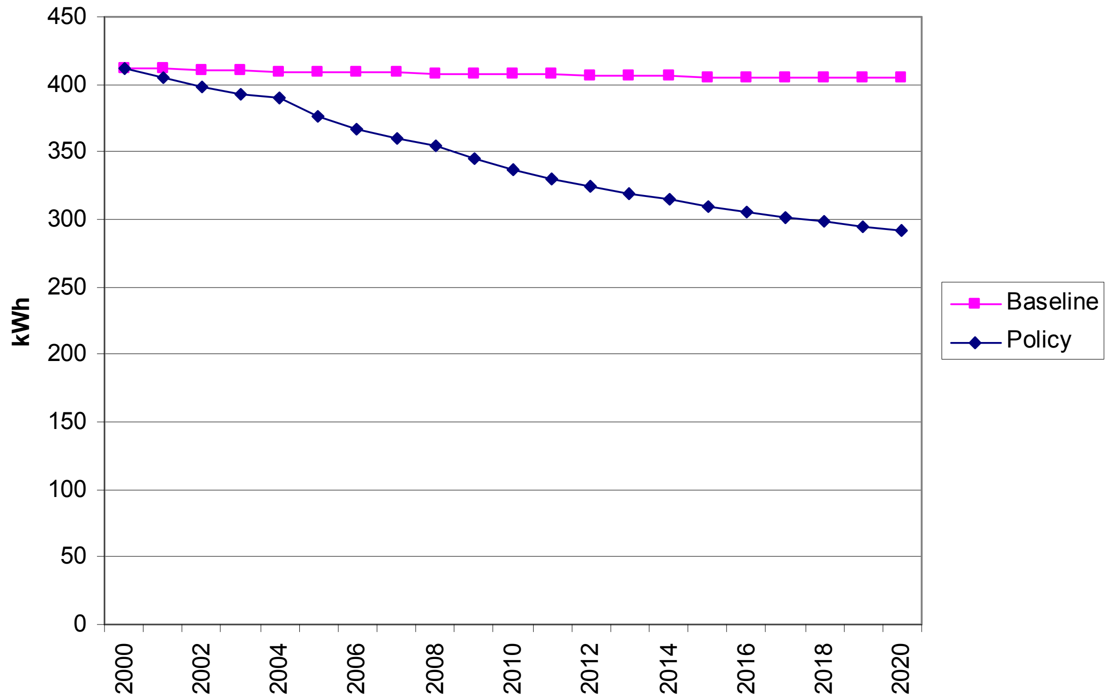
Figure 36: Annual room air conditioner household electricity consumption and savings, 2000-2020



Cumulative 2000-2020 electricity savings from existing room air conditioner standards and labeling programs are expected to reach 388 TWh.

The average unit energy consumption of air conditioners drops steadily throughout the period of assessment, and by 2020, the average unit in the market is expected to consume over 100 kWh per year less than if no standards or labeling program had gone into effect (Figure 37). This trend accelerates after 2009 when the much more stringer second-tier reach standard goes into effect.

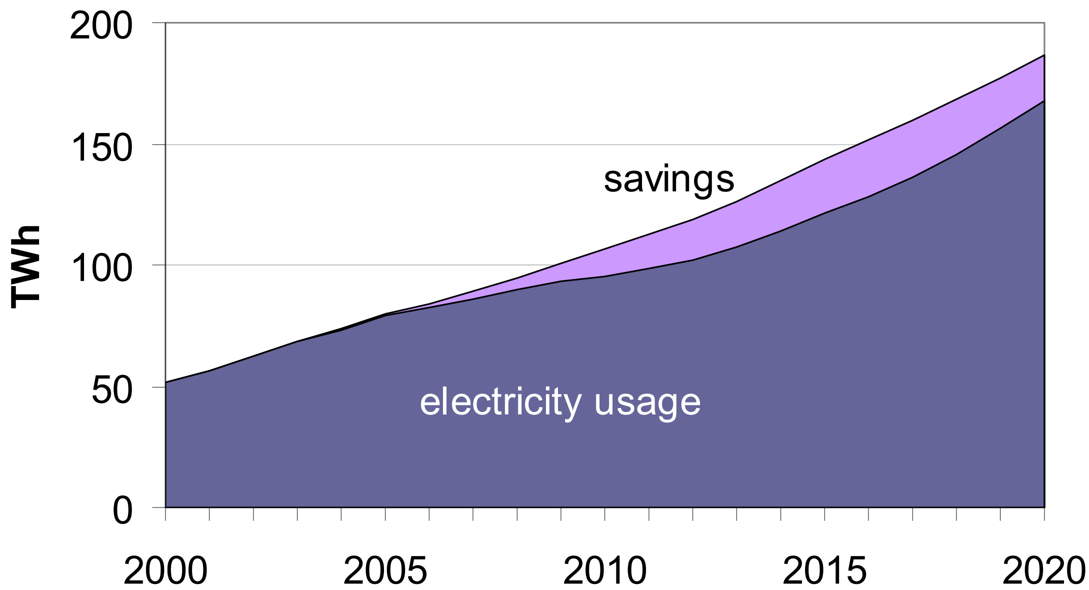
Figure 37: Weighted Average Unit Energy Consumption of Room Air Conditioners



3.3 TELEVISIONS

As one of the major electricity consumers in Chinese households, television efficiency gains can have a significant impact on total residential electricity use. In 2005, televisions consumed 79 TWh with 1 TWh savings from the 2002 labeling program. By 2020, TVs are expected to consume 168 TWh, with 19 TWh savings (Figure 38). The annual rate of savings actually begin to decline after 2017 as the stock of CRTs in use is replaced by a rapidly growing number of flat-screen (LCD, plasma) units. Because these units are subject only to standby energy requirements, while CRTs are subject to both active mode and standby requirements, total savings decline as the flat-screen segment of the market grows.

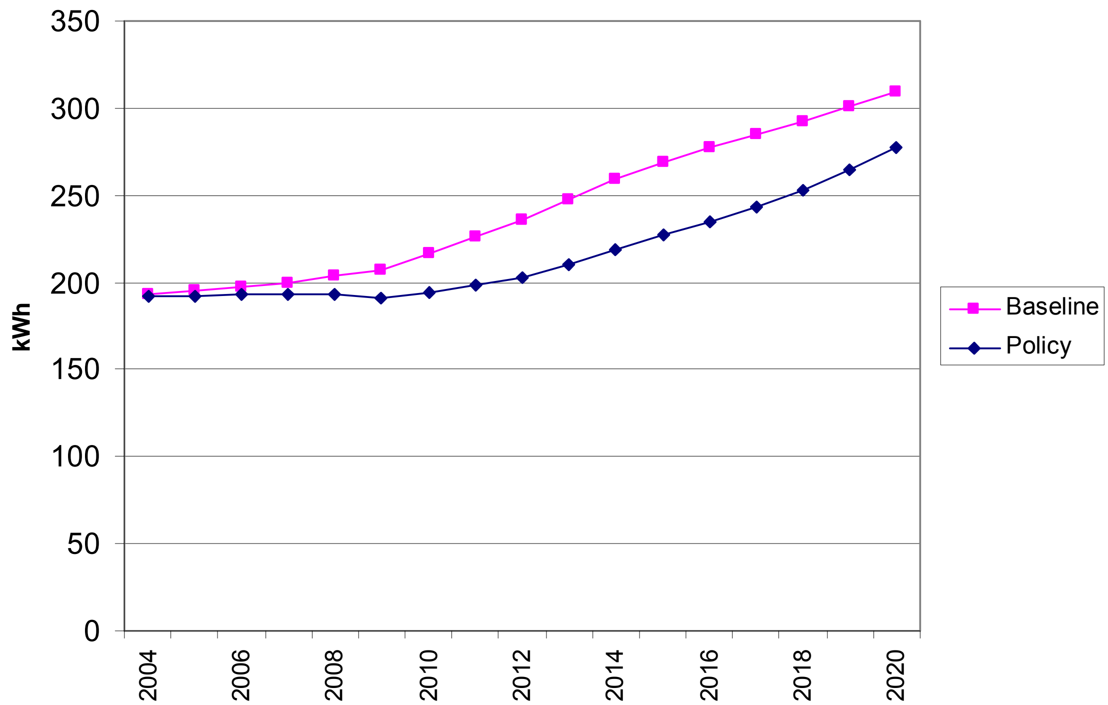
Figure 38: Annual television household electricity usage and savings, 2000-2020



Cumulative 2000-2020 electricity savings from existing television standards and labeling programs are expected to reach 233 TWh.

Because of the expected decline in CRT stock and the rise of the flat-screen stock, average unit energy consumption is expected to increase over this period. As shown in Figure 39, both the baseline and policy case consumption level rises as the higher energy consumption (active and standby modes) of flat-screens televisions begins to dominate in market share.

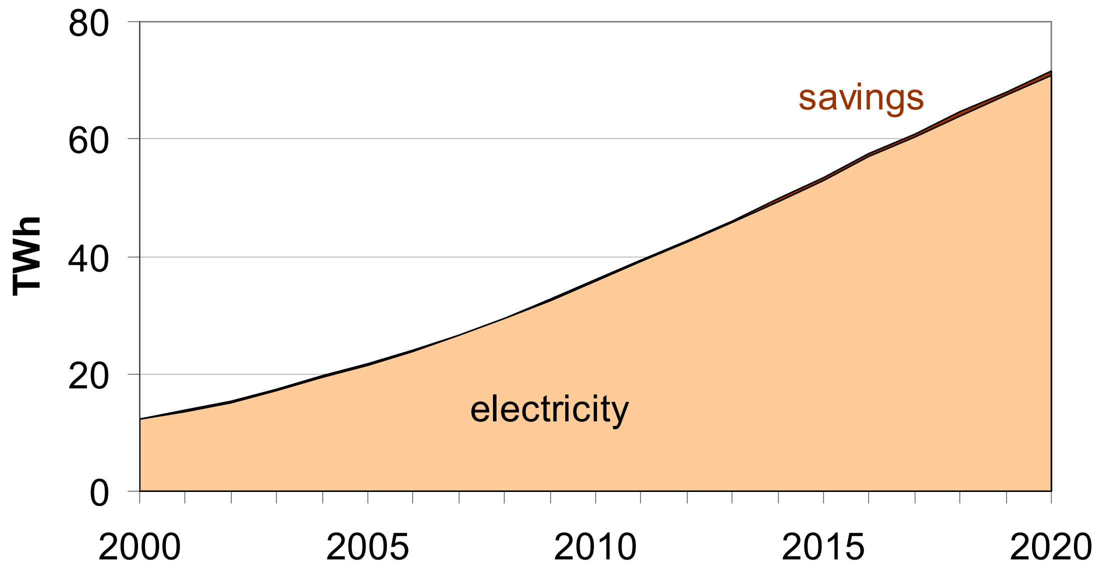
Figure 39: Weighted Average Unit Energy Consumption of Televisions



3.4 CLOTHES WASHERS

Clothes washers account for about 8% of total residential appliance electricity consumption. Because the existing standard is only for a single period, savings are dependent on the state of the market prior to the introduction of the standard. Laboratory test data show that the average efficiency of vertical (impeller) washers in the market at the time of the standard implementation already exceeded the minimum specified by the standard. In this case, the model derives no savings from the standard over the period to 2020. Those savings that are generated are due to the increase in the efficiency of the average horizontal (drum) washer, and the expected increase in the market share of horizontal washers by 2020. In 2005, clothes washers consumed 22 TWh with savings of 0.2 TWh from the standard. By 2020, clothes washers are projected to consume 71 TWh, with 1 TWh savings (Figure 40).

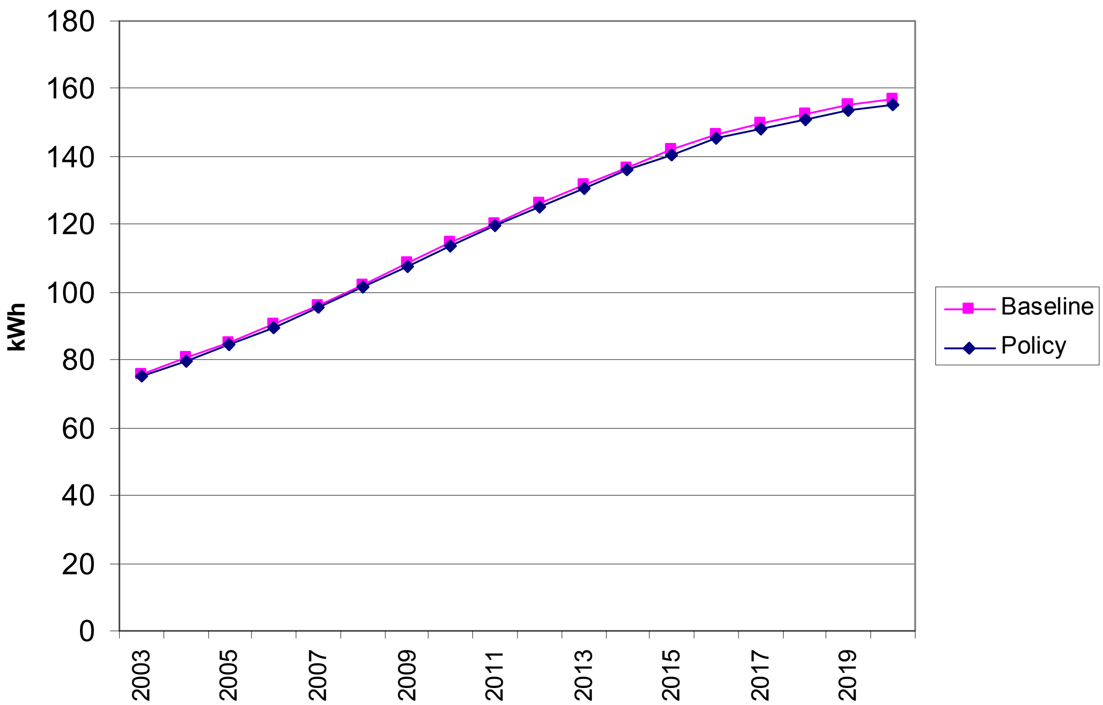
Figure 40: Annual household clothes washer electricity consumption and savings, 2000-2020



Cumulative 2000-2020 electricity savings from existing clothes washer standards and labeling programs are expected to total 6 TWh.

On a weighted average unit energy consumption basis, it is apparent from Figure 41 that the lack of average savings from vertical clothes washers, and the growing expected market share of horizontal clothes washers results in a rising trend of average energy consumption over this period. Indeed, with nearly a 10-times difference in unit electricity consumption between the two types of washers, it appears that a shift to horizontal washers serves primarily to conserve water.

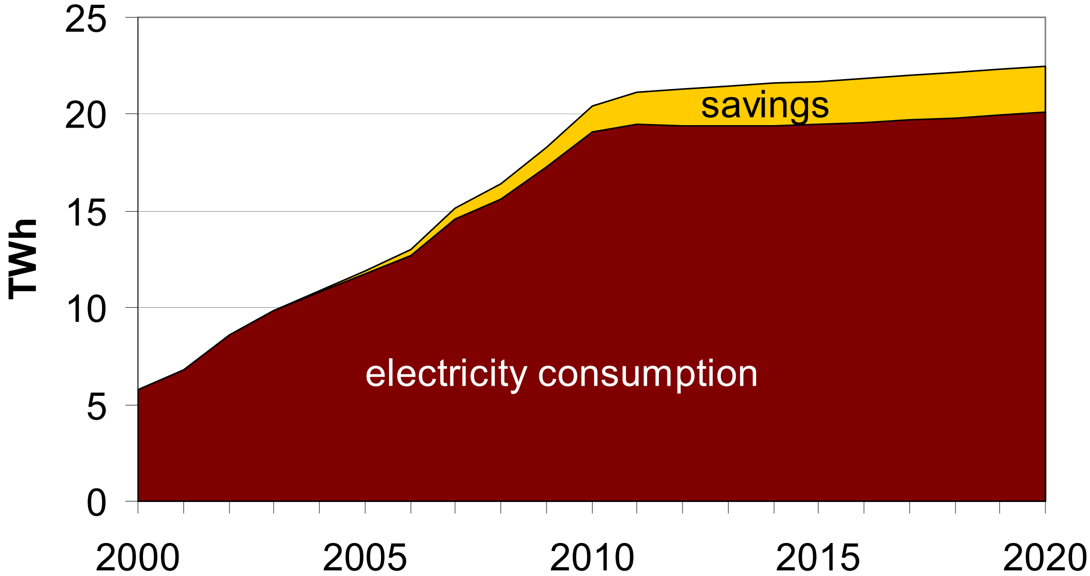
Figure 41: Weighted Average Unit Energy Consumption of Clothes Washers



3.5 VCD/DVD PLAYERS

DVD and VCD players are currently subject only to the voluntary energy efficiency labeling program. In 2005, DVD and VCD players consumed 12 TWh of electricity, with 0.2 TWh savings. By 2020, DVD/VCD players are expected to consume 20 TWh, with 2 TWh annual savings. These savings derive from the expected growth of efficient VCD/DVD players to 88% of the market by 2012 and thereafter (excluding those already efficient at the time the program was launched) (Figure 42).

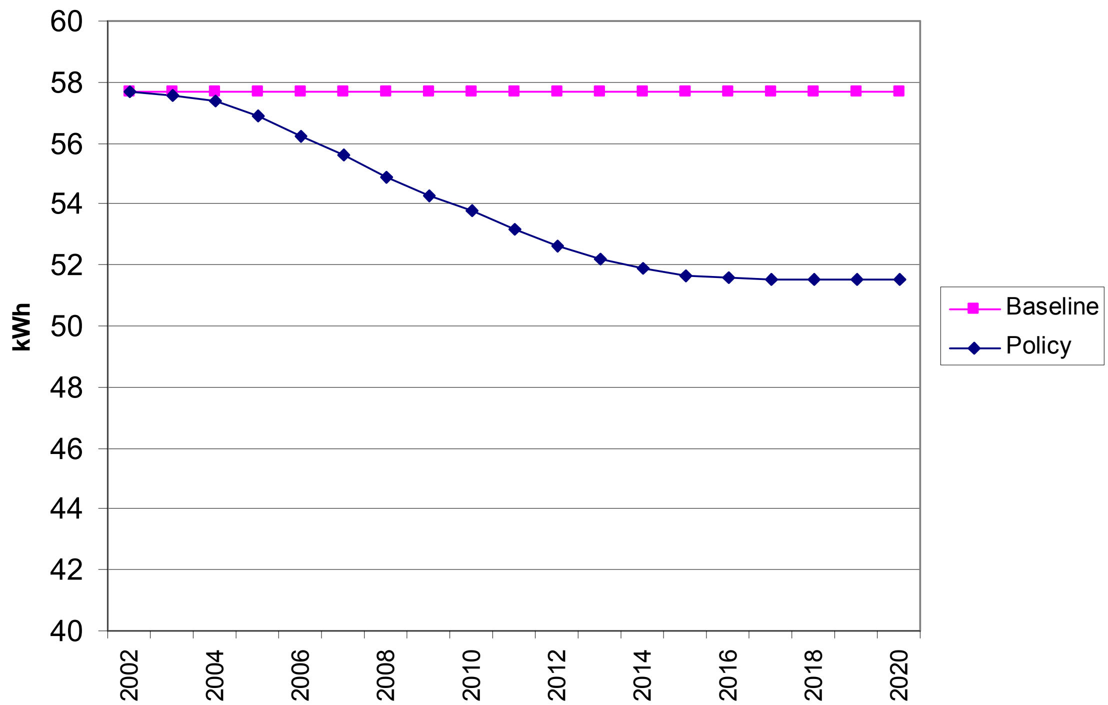
Figure 42: Annual household DVD/VCD player electricity usage and savings, 2000-2020



Cumulative 2000-2020 electricity savings from DVD and VCD players are expected to reach 26 TWh.

The savings accrue from the differences in standby energy use between ordinary and efficient DVD/VCD players. By the end of the period, the average unit energy consumption of efficient players moves towards the marginal value established by the program as market share of efficient players exceeds 90%, as noted earlier (Figure 43).

Figure 43: Weighted Average Unit Energy Consumption of DVD/VCD Players

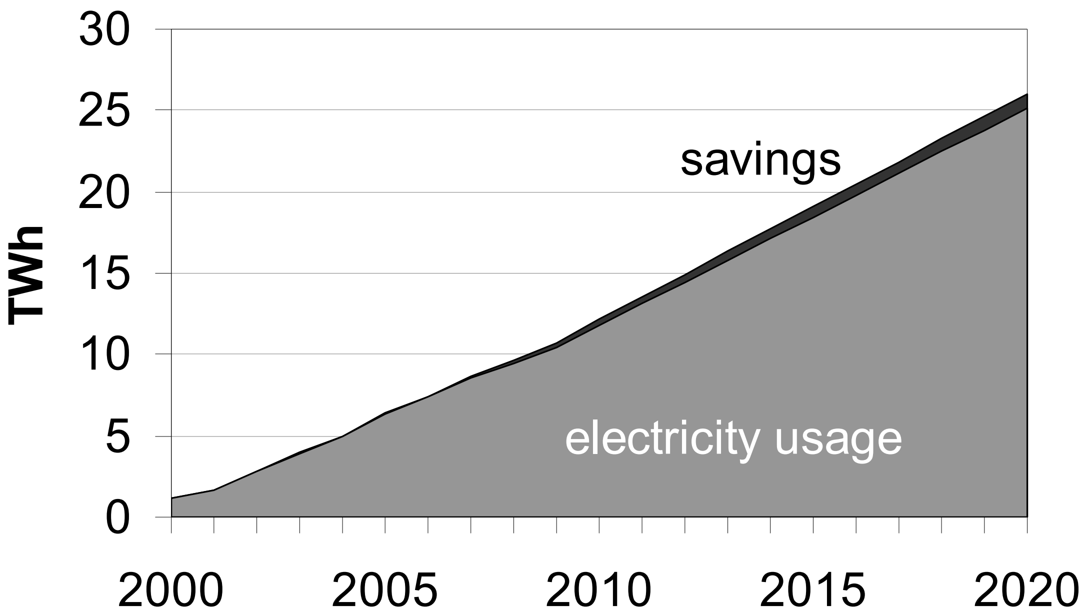


Note: Y-axis is not zero-scaled.

3.6 Computers

Currently, computers are subject only to the voluntary energy efficiency labeling program, which limits computer standby power consumption. In 2005, computer electricity consumption totaled 6 TWh with 0.3 TWh savings from the labeling program, and is expected to grow to 25 TWh in 2020. Annual electricity savings are expected to remain below 1 TWh through 2020 (Figure 44). These savings exclude the savings from the 10.5% of computers that were already efficient at the time that the labeling program began.

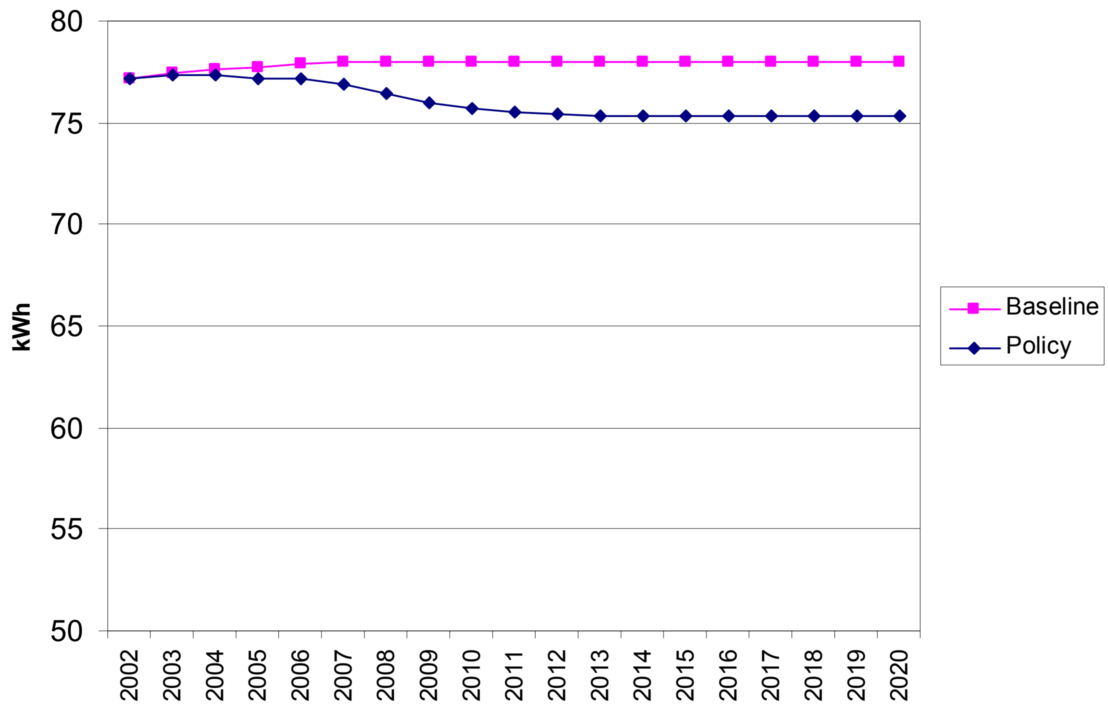
Figure 44: Annual household computer electricity consumption and savings, 2000-2020



Cumulative 2000-2020 electricity savings from the existing computer labeling program are expected to reach 8 TWh.

Savings accrue from the small difference in standby power usage between efficient and ordinary models. After all current computers are fully retired, the average weight unit energy consumption of efficient models approaches the marginal value established when the computer labeling program began (Figure 45).

Figure 45: Weighted Average Unit Energy Consumption of Computers

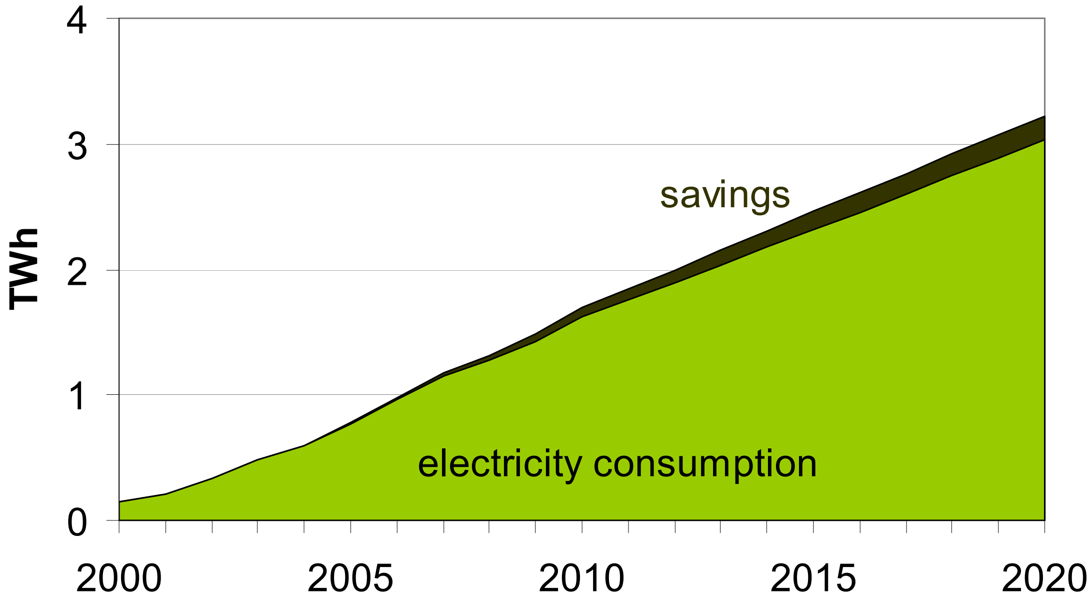


Note: Y-axis is not zero-scaled.

3.7 PRINTERS

Printers currently are subject only to the voluntary energy efficiency labeling program, which sets a limit on printer standby power consumption. Overall, printers consume the lowest aggregate amount of electricity of the appliances reviewed in this report. Electricity consumption is forecasted to grow from 0.8 TWh in 2005 to 3 TWh in 2020; electricity savings are expected to grow to 0.2 TWh in 2020 from 0.01 TWh in 2005. These savings exclude the savings from the 59% of printers that were already efficient at the time that the labeling program went into effect (Figure 46).

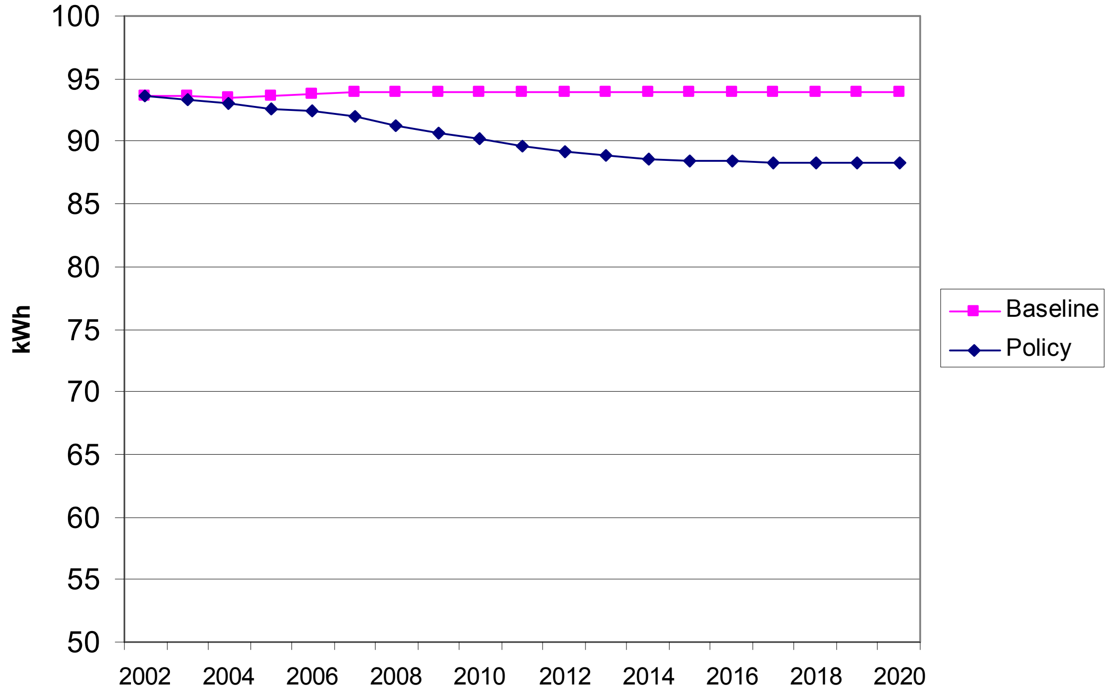
Figure 46: Annual household printer electricity consumption and savings, 2000-2020



Cumulative 2000-2020 electricity savings from the printer labeling program are expected to nearly reach 2 TWh.

On a weighted average basis, unit energy consumption continues to decline throughout this period, moving towards the marginal value established by the labeling program. As noted earlier, by the end of the period, it is assume all printers achieve this efficiency level (Figure 47).

Figure 47: Weighted Average Unit Energy Consumption of Printers



Note: Y-axis is not zero-scaled.

3.8 National Summary

Electricity savings from current programs are expected to increase through 2020 for all analyzed appliances with the exception of televisions, savings from which are forecast to peak in 2017 due to the declining share of CRTs in the national market. As illustrated in Figure 48, the largest cumulative amount of electricity savings is derived from the refrigerator standards and labeling programs, although the room air conditioner standards and labeling program generates the largest volume of annual savings after 2017 (Table 24).

Figure 48: Annual Appliance Electricity Savings from Standards and Labeling and Market Shift, 2000-2020

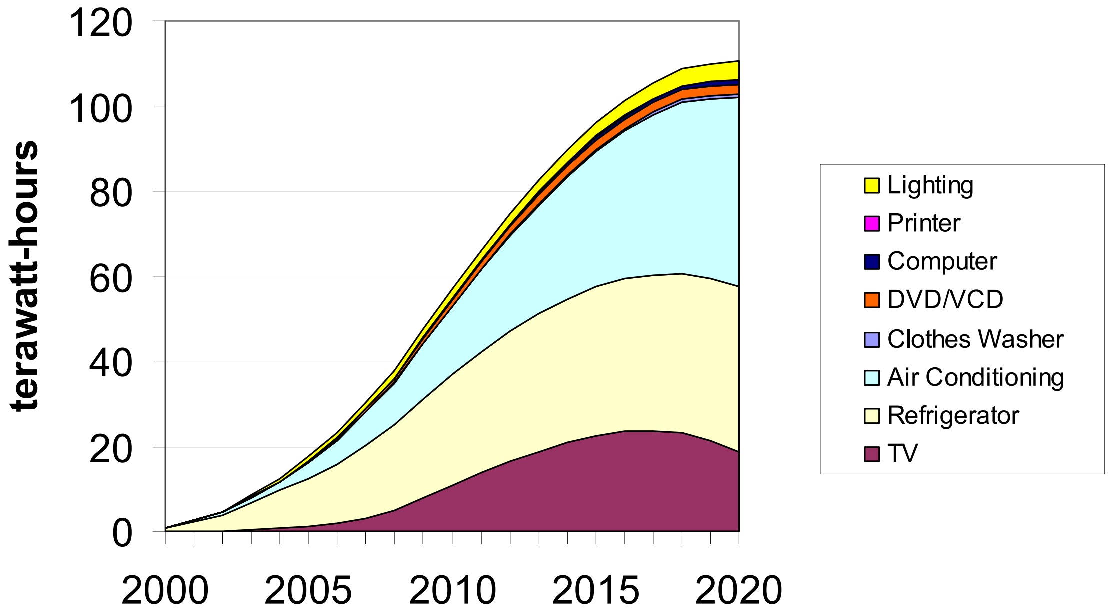
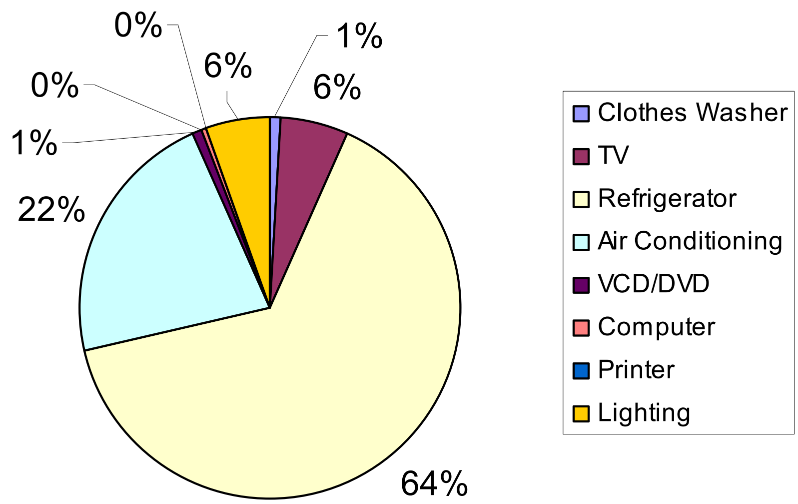


Table 24: Annual and Cumulative Appliance Electricity Savings (TWh), 2000-2020

Appliance	2005	2010	2015	2020	2000-2020
Clothes Washer	0.16	0.22	0.45	0.68	6.28
TV	1.00	11.01	22.53	18.88	233.18
Refrigerator	11.40	25.94	34.93	38.74	480.33
Air Conditioning	3.82	16.06	31.94	44.50	388.31
VCD	0.16	1.37	2.26	2.39	26.03
Computer	0.03	0.35	0.64	0.88	7.65
Printer	0.01	0.07	0.14	0.19	1.64
Lighting	0.99	2.12	3.14	4.51	44.54
Total	16.58	55.04	92.91	106.26	1,143.42

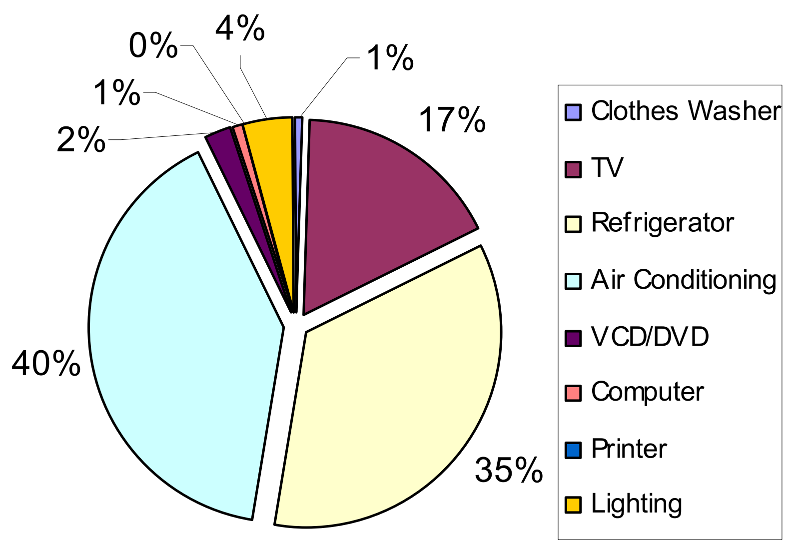
With only a few years of the standards and labeling programs underway by 2005, savings from China's programs reached a modest 16.6 TWh. Nearly two-thirds of these savings were generated from the refrigerator standard alone (Figure 49). This period also marked the rapid growth of air conditioner sales to the residential market, and the existence of a standard since 2000 captured savings from this expansion. Nonetheless, because the refrigerator market in urban areas is already mature, but significant expansion of air conditioner usage in both urban and rural markets is still expected, the distribution of savings in 2020 shifts significantly. By that year, over 40% of the savings will come from the air conditioner standards and labeling programs, over one-third from refrigerators, and a further 17% from televisions. These three appliances alone will then account for 92% of total savings in 2020.

Figure 49: Appliance Share of 2005 Residential Electricity Savings



The juxtaposition of Figure 49 and Figure 50 illustrates the distribution of residential savings from refrigerators to televisions and room air conditioners.

Figure 50: Appliance Share of 2020 Residential Electricity Savings

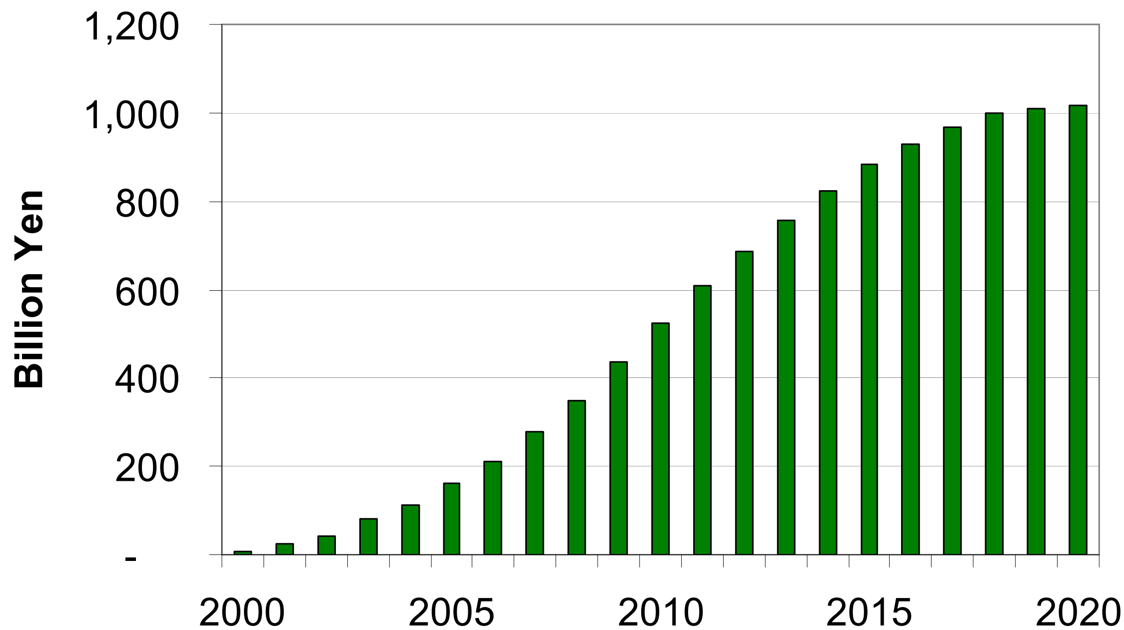


4 Economic and Environmental Impacts

4.1 Financial Savings

By stimulating adoption of more energy-efficient appliances, standards and labeling programs generate consumer financial savings. Figure 51 illustrates the growth and scale of gross retail savings expected to accrue from the electric appliance programs reviewed in this report. Consumer financial savings are estimated based on a real average electricity tariff of 0.60 RMB/kWh and an exchange rate of 15.3 Yen per RMB. Between 2000 and 2020 cumulative consumer savings are expected to amount to more than 10.9 trillion Japanese Yen (more than 700 billion RMB).

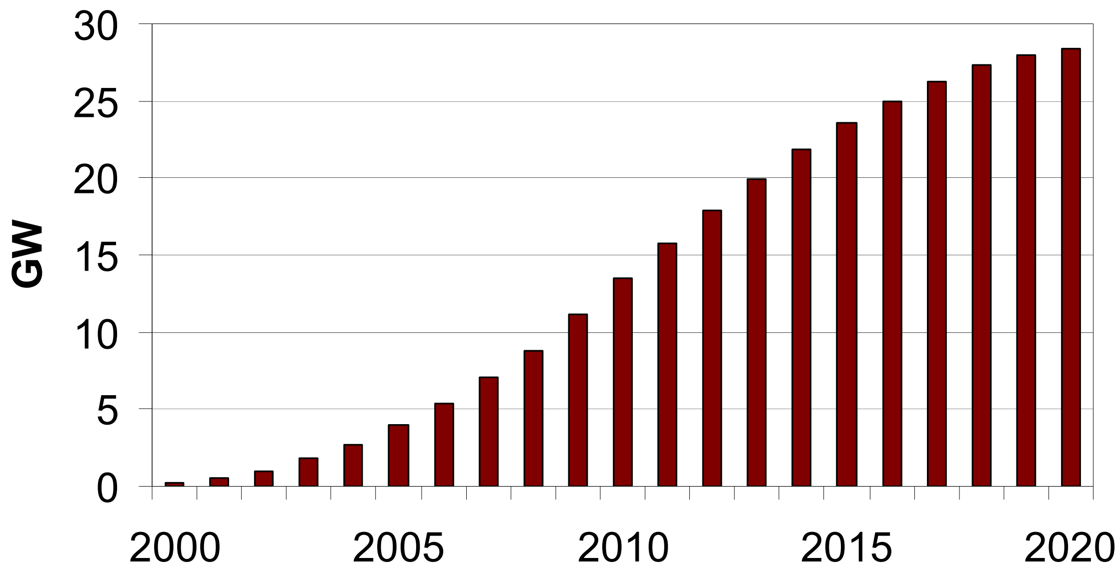
Figure 51: Annual Appliance Consumer Savings, 2000-2020



Lower final electricity demand also generates supply-side savings through avoided capacity costs. Figure 52 illustrates cumulative supply-side savings arising from avoided power plant construction. Two usage assumptions are used to calculate capacity savings: peak room air conditioner impact is calculated according to noon to 3:00 PM usage data and savings are estimated according a 60% load factor for all other electric appliances. ACEEE usage data indicate that China room air conditioners are used an average 564 hours per year, thereby yielding a peak load coefficient of 0.000355 peak kW capacity savings per unit kWh appliance savings. The peak usage effect amplifies room air conditioner savings to 56% of cumulative appliance capacity savings by 2020. Between 2000 and 2020 cumulative supply-side savings from the electric appliance programs reviewed in this report are expected to amount to more than 28 gigawatts of capacity (25% of

China's 2005-2006 capacity growth). Under an assumed average cost of $600 per kW of thermal power capacity and a flat 118 Yen-per-dollar exchange rate, cumulative financial supply-side savings amount to 2 trillion Yen between 2000 and 2020 (more than 131 billion RMB).

Figure 52: Cumulative Supply-Side Capacity Savings, 2000-2020



4.2 Greenhouse Gas and Other Emissions Reductions

Given the dominance of coal-fired electricity generation in China, appliance standards and labeling programs also help to mitigate air-pollution problems. Between 2000 and 2020, improved efficiency among electric appliances and gas water heaters will reduce carbon dioxide emissions by more than 300 million tons carbon equivalent. Figure 53 illustrates annual carbon dioxide emission reductions from electric-appliance and gas-water-heater programs. These reductions are calculated assuming thermal marginal power generation and future improvements in generation efficiency, as well as diminishing losses in electricity transmission and distribution.

Figure 53: Annual CO_2 Emissions Reductions, 2000-2020

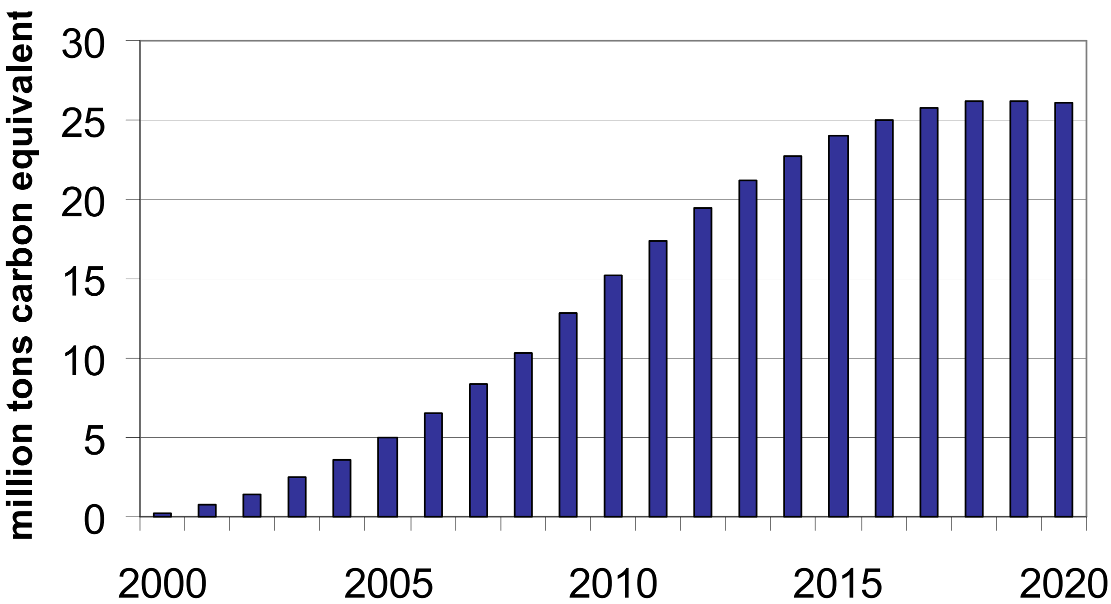


Figure 54 illustrates annual sulfur dioxide emission reductions generated by electric appliance programs and based on reported 2004 and 2005 SO_2 emissions. Given the increased SO_2-intensity of power generation between 2004 and 2005, this estimate does not incorporate possible future efficiency improvements. According to these assumptions 2000 to 2020 cumulative sulfur dioxide emission reductions are expected to reach 6.8 million tons.

Figure 54: Annual Sulfur Dioxide Emission Reductions, 2000-2020

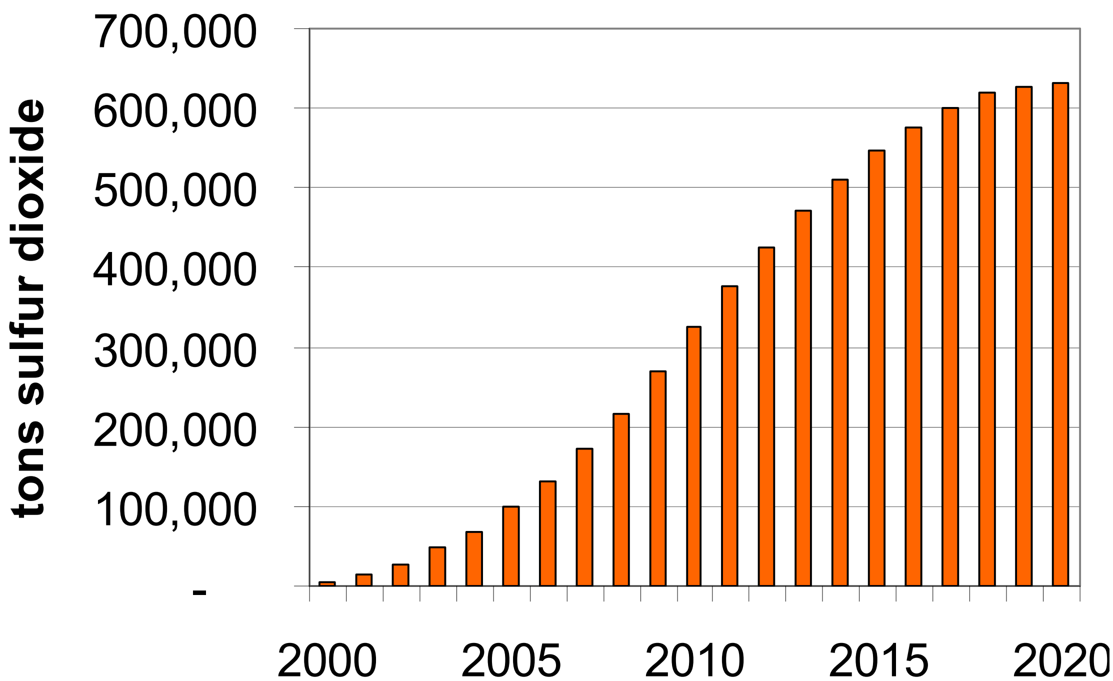
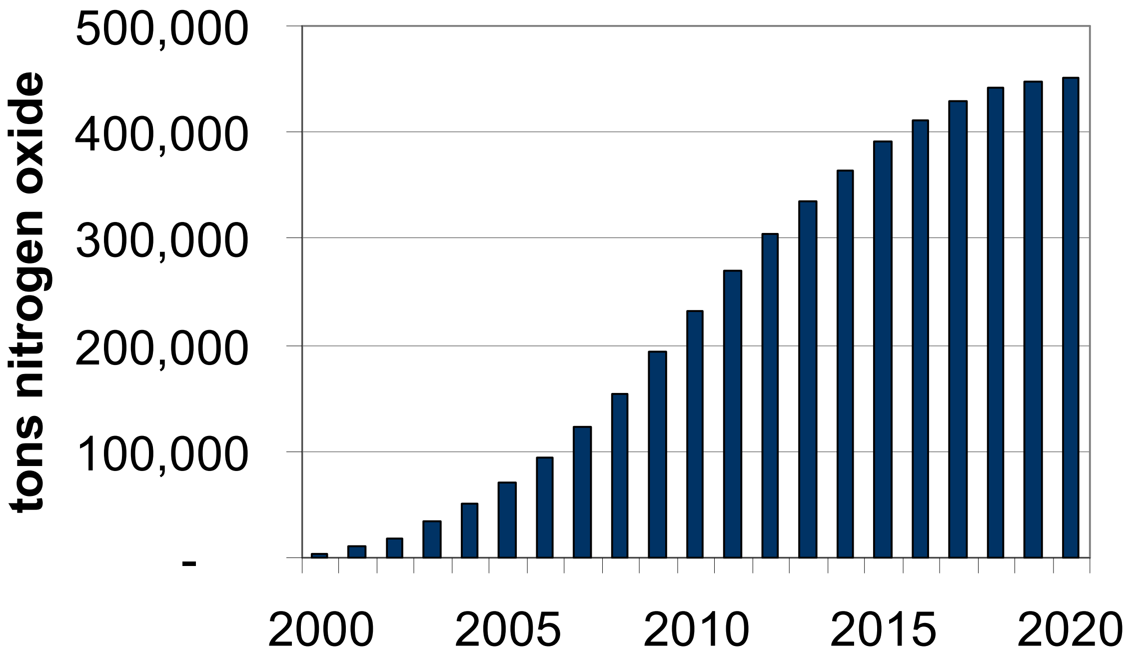


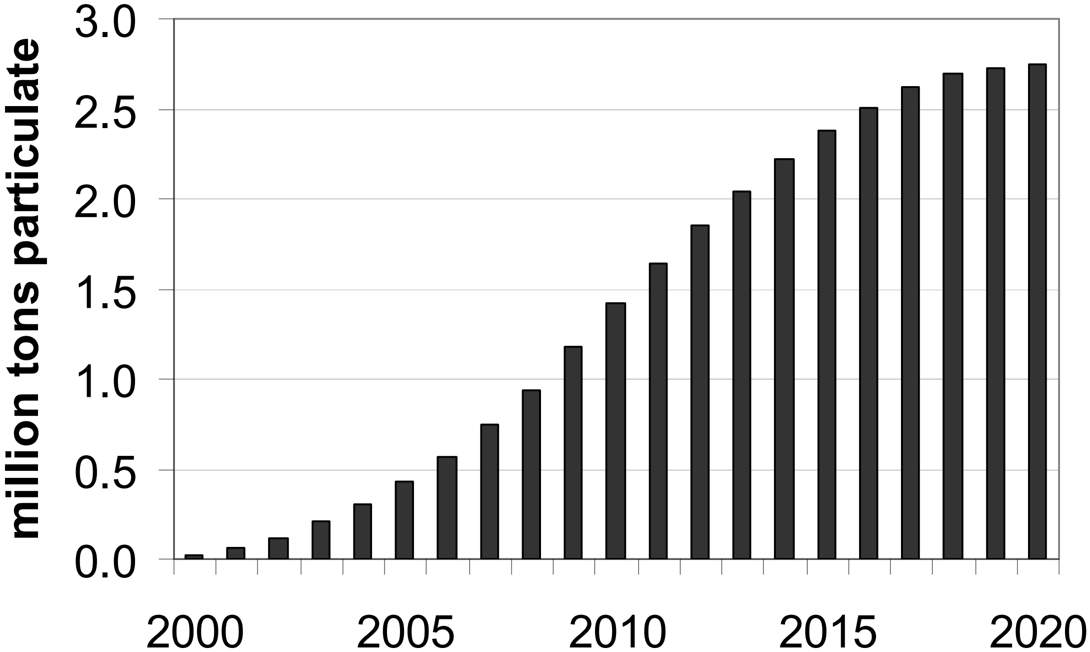
Figure 55 illustrates annual nitrogen oxide emission reductions resulting from electric appliance standard and labeling programs. These data are calculated on the basis of a frozen 2000 emission coefficient. Between 2000 and 2020, cumulative NO_X emission reductions are expected to reach 4.8 million tons.

Figure 55: Annual NO_X Emission Reductions, 2000-2020



Particulates are a particularly problematic and visible aspect of China's current environmental crisis. Figure 56 illustrates annual particulate emission reductions generated by electric appliance programs. Between 2000 and 2020, program-derived cumulative particulate emission reductions are expected to reach 29 million tons.

Figure 56: Annual Particulate Emission Reductions, 2000-2020



The data presented in Section 4 illustrate extensive financial and environmental benefits that are expected to accrue from China's current appliance standards and labeling programs.

5 Conclusions

5.1 Overall Summary of Results

China's modern standards and labeling programs have been in effect for less than a decade, but the impact is already beginning to be felt in terms of energy savings. In a rapidly growing economy like China's, energy savings serve more to bring down the rate of demand growth rather than to reduce consumption. Nonetheless, these efficiency programs have resulted in a lower amount of emissions of CO_2, NO_x, SO_x and particulate matter than would have otherwise occurred if the programs had not been developed. Moreover, they have saved Chinese consumers a lot of money.

In total, the programs currently in place are expected to save a cumulative 1143 TWh by 2020, or 9% of the cumulative consumption of residential electricity to that year. In 2020 alone, annual savings are expected to be equivalent to 11% of residential electricity use. In average generation terms, this is equivalent to 27 1-GW coal fired plants that would have required around 75 million tonnes of coal to operate. In comparison, savings from the US appliance standards program alone is expected to save 10% of residential electricity consumption in 2020.

China has built up a strong infrastructure to develop and implement standards, and has instituted many reforms over the years based on extensive cooperation with international experts and standards and labeling bodies. International harmonization is a goal, particularly as China has become a manufacturing center for many appliances and other equipment in wide use globally. Harmonization can provide an opportunity to reduce manufacturers' costs and reduce barriers to trade.

Within China's suite of energy efficiency standards and labels, there are several clear opportunities for further savings. Currently, the clothes washer, refrigerator, and television standards are likely candidates for further strengthening. In the case of clothes washers, the standard appears to be too low, as already the market average efficiency of vertical washers is higher than the minimum standard. In the case of refrigerators, although refrigerators were among the first appliances subject to standards, and are projected to provide a substantial portion of the projected savings to 2020, the absolute level of the standard is far lower than more stringent international standards in use in the US, Australia, or Japan. This is demonstrated as well in the high proportion (65%) of refrigerators that meet the CSC voluntary label criteria, which requires energy consumption at 75% or lower than the minimum standard. In the case of televisions, further savings are to be largely derived from application of a minimum standard for active mode power to the flat screen televisions (LCD and plasma), which promise to rapidly supplant CRT televisions over the next decade. Indeed, China is reportedly already working on such a standard.

For products subject only to voluntary labeling, the high degree of "already efficient" products in the market—which serves to reduce the amount of applicable savings from the labeling program—is largely a function of global homogenization of design and style.

Printers, computers, monitors and other office equipment vary little between China and other countries. Given this high rate of "already efficient" products in the market, it appears timely to consider further revision of these specifications and to consider criteria for active mode power consumption as well. CSC's general principle is to restrict their certified products to the top 25% of the market, but this has been exceeded in many cases, indicating a need for further strengthening. CSC also looks to international best practice and harmonization as a guiding principle, and this creates further opportunities for international cooperation.

In the case of room air conditioners, the tier-2 standard to come into effect in 2009 will bring the requirements for China's mainstream split room air conditioners up to international levels, though still behind Japanese averages. Although not part of the current air conditioner standard, China is also developing a standard to take into account the growing popularity of air conditioners with variable speed motors, which promises further savings.

The payback of these programs to China's economy is high, though only partial details of the costs are known. In terms of standards development, CNIS, on average, receives about 100,000 RMB (about 1.5 million Yen) of direct budget allocation for each product. In the last 6 years, however, a number of international funders have supplemented this amount, both through direct grants to CNIS and to support of other international experts to work with CNIS. On average, an additional, $150,000 (17.7 million Yen) has been spent on both domestic and international assistance for each product under an international cooperation program. Compared to these expenditures, consumers in 2005 alone enjoyed over 10 billion RMB in savings (about 161 billion Yen) from conserved electricity.

5.2 IMPLICATIONS FOR CHINA'S CURRENT ENERGY POLICY AND SUGGESTED NEXT STEPS

China's current energy policy is strongly focused around the need to bring down the rising energy intensity of the economy and to achieve a 20% reduction in economic energy intensity by 2010. In 2006, a target of a 4% per year reduction was set, but the actual outturn in 2006, at 1.23%, failed to meet it. Even more aggressive steps will be needed in 2007 and beyond, and energy efficiency standards can be an important tool in the government's arsenal of policies to implement and accelerate. Although a direct calculation of improved economic energy intensity of the residential sector as a result of these programs is not possible (as the residential sector is not a direct GDP component), the savings from the program nonetheless are captured in the aggregate totals of national energy use over national gross domestic product. However, given the long lag times between the introduction of new standards and their significant impact because of the large existing stock of appliances in most cases, the current program is likely to contribute only a small part of the savings needed to reach the 2010 goal.

Because China's appliance stock is growing so rapidly, it may be appropriate to consider more rapid adoption of the second tier of efficiency standards where they exist. China's 2009 air conditioner standard, for example, represents a significant jump over the current efficiency levels. Because of the strong impact this standard has on peak electricity requirements, bringing the second tier standard forward could provide additional relief, especially for those cities and provinces where electricity supply remains tight, such as Shanghai. Although this raises question of central government preemption over regional governments, pilot programs, perhaps on a voluntary basis, may be possible to capture some of the additional savings. The current study supported by METI should contribute to the furthering of this approach in China.

In the longer term, however, China should continue aggressive development of new and revised standards. It would be helpful for the government to provide a larger budget allocation and additional staff for such work, and continued international assistance is warranted. Currently, both CNIS and CSC are commencing work on the GEF-sponsored End-Use Energy Efficiency Program, under which they are committed to develop additional standards and efficiency labeling criteria for a range of residential and industrial equipment. Unlike residential equipment, where experience in both domestic and international markets is quite extensive, industry equipment standards are less common. It would likely be beneficial for China to receive additional international assistance in the area of industrial standards development, including introduction of new approaches that consider process or systems energy efficiency instead of a focus solely on single pieces of equipment. Because industry accounts for 60% of total energy consumption in China, efficiency programs for the industrial sector promise to have even greater impact on China's long-term energy consumption than those for the commercial and residential sectors.

Another area of growing concern internationally is the rising energy consumption from the proliferation of electronic equipment in the household. It has been estimated that the energy consumption of a home theater system (television, set top box, with audio equipment) is higher than that of a typical household refrigerator, and much of this occurs while the equipment is in "standby" mode. However, since the lifetime and design cycles for much of this equipment (except, perhaps, televisions) is fairly short, it may be warranted to develop a strong voluntary labeling program with strict efficiency criteria for the full range of household audio-visual equipment. As widely internationally traded goods, audio-visual equipment are also a good candidate for wider international harmonization.

The impact of both standards and labels are diminished in the absence of appropriate enforcement. Although China has a legal framework to undertake enforcement, it lacks adequate financial, administrative and infrastructure support. Work has begun to explore options for increasing the scope and scale of enforcement, and continued international support for this work, as has been proffered by METI, is also warranted.

The effort undertaken in this analysis through the development of a bottoms-up technology representation of China's residential sector represents the first of its kind. This model, and its application, can be further extended to additional products, additional sectors, and can be used as well to test the potential savings beyond what have already been achieved. This application in particular allows the model to be used as a prioritization tool, through which those products with the largest potential savings can be selected for near-term implementation of standards and labeling. It also can serve as a policy evaluation tool, by testing the impact of programs such as accelerated adoption of reach standards, or of revision of current standards and labeling criteria.

6 Selected References

Brockett, Debbie, David Fridley, Jieming Lin and Jiang Lin "A Tale of Five Cities: The China Residential Energy Consumption Survey" *ACEEE Summer Study on Building Energy Efficiency*, August 2002.

China Customs Bureau (2006). Chinese Customs data were accessed via the *World Trade Atlas* (http://www.gtis.com/).

"China Industry Development Report 2004: Household Appliances"

Fu Zhongcheng, 2005, research note on saving potential for gas water heaters

Lin, Jiang (2006) "Mitigating Carbon Emissions: the Potential of Improving Efficiency of Household Appliances in China," Ernest Orlando Lawrence Berkeley National Laboratory Report LBNL-60973.

Lu, Wei (2006) "Potential energy savings and environmental impact by implementing energy efficiency standard for household refrigerators in China," *Energy Policy* 34: 1583-1589.

Lu, Wei (2007) "Potential energy savings and environmental impacts of energy efficiency standards for vapor compression central air conditioning units in China," *Energy Policy* 35: 1709-1717.

National Bureau of Statistics of China (2006) *China Statistical Yearbook* 2006; Beijing: China Statistics Press.

Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat; *World Population Prospects: The 2004 Revision*; http://esa.un.org/unpp (accessed 12.2006).

U.S. Energy Information Agency (2001) "RESIDENTIAL ENERGY CONSUMPTION SURVEY 2001" http://www.eia.doe.gov/emeu/recs/recs2001/detailcetbls.html#air (accessed 1.2007)

Wiel, S., McMahon J.E., 2005. *Energy-efficiency labels and standards: a guidebook for appliances, equipment, and lighting, 2nd Edition*. http://www.clasponline.org/files/Guidebook_2ndEdition.pdf (accessed 12.2006)

7 Appendix: Description of the Model

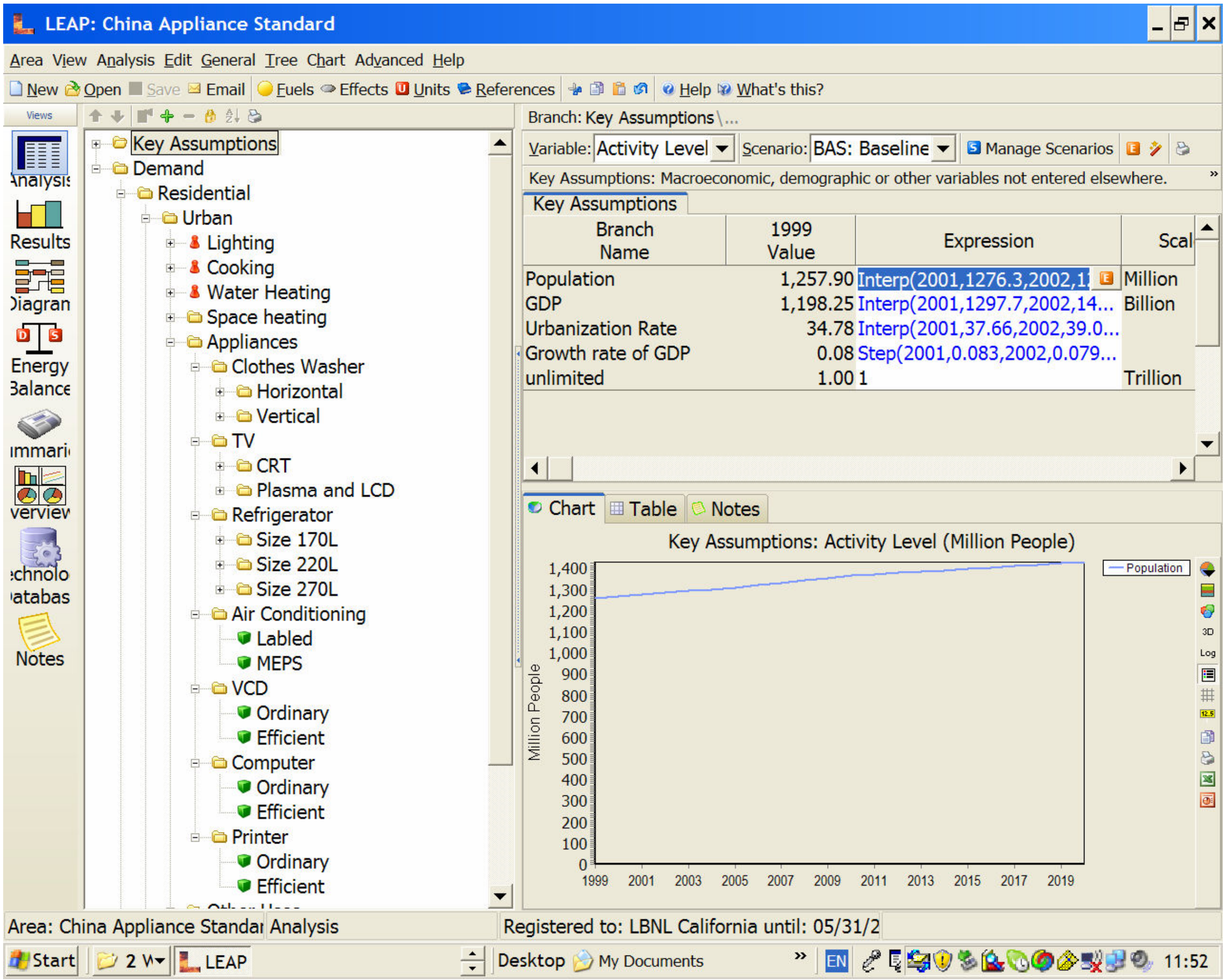
7.1 SECTORAL MODELING APPROACHES

Two general approaches have been used for the integrated assessment of energy demand and supply – the so-called “bottom-up” and “top-down” approaches. The bottom-up approach focuses on individual technologies for delivering energy services, such as household durable goods and industrial process technologies. The top-down method assumes a general balance or macroeconomic perspective, wherein costs are defined in terms of changes in economic output, income, or GDP. Each approach captures details on technologies, consumer behavior, or impacts that the other does not. Consequently, a comprehensive assessment should combine elements of each approach to ensure that all relevant impacts are accounted for and that technology trends and policy options for reducing energy consumption or mitigating climate change are adequately understood.

In this study, LEAP (Long-range Energy Alternative Planning System) was used to build the end-use model, and the bottom-up approach allowed a detailed consideration of end-use efficiency and technology share. The model incorporates selected technologies and related data including stock, energy intensity and saturation levels, to reach the energy consumption levels envisioned. The end uses were further broken out by technologies; some appliances were broken out into classes by level of service, associated with different levels of efficiency (Figure 57).

For a given technology branch, stock turnover modeling was implemented. In this method, energy consumption is calculated by analyzing the current and projected future stocks of energy-using devices, and the annual energy intensity of each device. LEAP then calculates the stock average energy intensity and across all vintages and hence, ultimately, the overall level of energy consumption

Figure 57: Structure of LEAP model



The following equations describe the calculations for the stock analysis methodology:

7.1.1 Stock Turnover

$$Stock_{t,y,v} = Sales_{t,y} * Survival_{t,y-v}$$

$$Stock_{t,y} = \sum_{v=0..V} Stock_{y,v,t}$$

Where:

t is the type of technology (i.e. the technology branch)
v is the vintage (i.e. the year when the technology was added)

y is the calendar year
Sales: is the number of devices added in a particular year
Stock is the number of devices existing in a particular year:
Survival is the fraction of devices surviving after a number of years, and
V is the maximum number of vintage years

Published NBS appliance ownership, sales, and trade data are not always internally consistent. Most of the appliance sales estimates in this report were calculated according to household ownership data and implied retirement replacement. Section 2 outlines the ownership and lifetime assumptions that serve as the basis for LBNL's stock turnover model.

7.1.2 Energy Intensity

$$EnergyIntensity_{t,y,v} = EnergyIntensity_{t,y} * Degradation_{t,y-v}$$

Where:

EnergyIntensity is energy use per device for new devices purchased in year y.
Degradation is a factor representing the change in energy intensity as a technology ages. It equals 1 when y=v. In our analysis, the degradation profile is only used for Refrigerator and Air Conditioner.

7.1.3 Energy Consumption

$$EnergyConsumption_{t,y,v} = Stock_{t,y} * EnergyIntensity_{t,y-v}$$

7.2 DEMOGRAPHIC ASSUMPTIONS

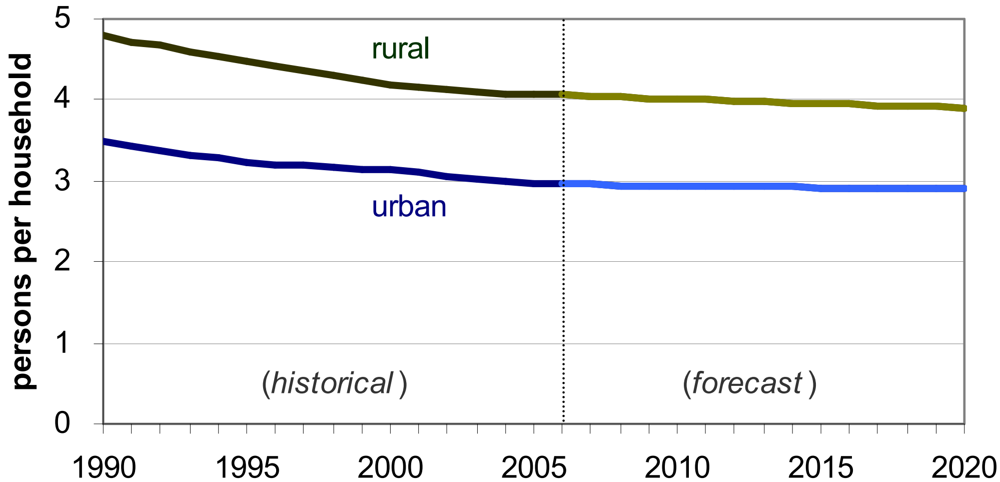
Historical population and household data are sourced from China Statistical Yearbook 2006 (NBS). Forecast population data are sourced from the United Nations "World Population Prospects: The 2004 Revision." As shown in Table 25, China's urban population is expected to maintain rapid growth, while the number of people living in rural areas is projected to continue its post-1995 decline. Continued growth is expected to increase the proportion of people living in urban areas from 43% in 2005 to 54% in 2020.

Table 25: Historical and Forecast Population (million persons)

	1990	1995	2000	2005	2010	2015	2020
Urban	302	352	459	562	612	690	763
Rural	841	859	808	745	743	703	661
Total	1,143	1,211	1,267	1,308	1,355	1,393	1,424

Urban and rural average household size data are used to calculate the total number of households in a given population. Figure 58 illustrates the historical and projected decline of average household size in rural and urban areas. Average household size is projected to decline from 2.96 persons per urban household to 2.9 persons per urban household between 2005 and 2020, and from 4.07 to 3.9 persons per rural household over the same period.

Figure 58: Historical and Forecast China Average Household Size, 1990-2020



Urban population growth and diminishing household size have resulted in a rapid increase in the number of urban households: aggregate urban households surpassed rural households in 2005. Table 26 also shows that the aggregate number of rural households peaked between 1995 and 2000. Because they are smaller than their rural counterparts, urban households are expected to account for 61% of all Chinese households in 2020.

Table 26: Historical and Forecast Number of Households (million households), 1990-2020

	1990	1995	2000	2005	2010	2015	2020
Urban	86	109	147	190	208	236	263
Rural	175	192	192	183	180	178	170
Total	262	301	339	373	388	414	433