Energy Policy 39 (2011) 4541–4550

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Analysis of potential energy saving and CO_2 emission reduction of home appliances and commercial equipments in China

Nan Zhou [a,*], David Fridley [a], Michael McNeil [a], Nina Zheng [a], Virginie Letschert [a], Jing Ke [a], Yamina Saheb [b]

[a] Energy Analysis Department, Environmental Energy Technologies Division, Lawrence Berkeley National Laboratory, 1 Cyclotron Road, MS 90R4000, Berkeley, CA 94720, USA
[b] OpenExp, 75 paris, lle de France, France

ARTICLE INFO

Article history:
Received 24 November 2010
Accepted 14 April 2011
Available online 25 May 2011

Keywords:
China
Appliance
Energy efficiency

ABSTRACT

China has implemented a series of minimum energy performance standards (MEPS) for over 30 appliances, voluntary energy efficiency label for 40 products, and a mandatory energy information label that covers 19 products to date. However, the impact of these programs and their savings potential has not been evaluated on a consistent basis. This paper uses modeling to estimate the energy saving and CO_2 emission reduction potential of the appliances standard and labeling program for products for which standards are currently in place, under development or those proposed for development in 2010 under three scenarios that differ in the pace and stringency of MEPS development. In addition to a baseline "frozen efficiency" scenario at 2009 MEPS level, the "Continued Improvement Scenario" (CIS) reflects the likely pace of post-2009 MEPS revisions, and the likely improvement at each revision step. The "Best Practice Scenario" (BPS) examined the potential of an achievement of international best-practice efficiency in broad commercial use today in 2014. This paper concludes that under "CIS", cumulative electricity consumption could be reduced by 9503 TWh, and annual CO_2 emissions of energy used for all 37 products would be 16% lower than in the frozen efficiency scenario. Under a "BPS" scenario for a subset of products, cumulative electricity savings would be 5450 TWh and annual CO_2 emissions reduction of energy used for 11 appliances would be 35% lower.

Published by Elsevier Ltd.

1. Introduction

In recent years, China has become one of the world's largest producers and consumers of household appliances as urban and rural ownership rates grew at an extraordinary pace. As China continues to develop its economy, urbanization and rising disposable incomes are expected to drive demand for appliances and related energy services. In fact, sustained rises in urban appliance ownership have already corresponded to growing urban residential electricity use at an annual average rate of 13.9% between 1980 and 2007 with similar paces in rural appliance ownership and electricity use (Figs. 1 and 2) (NBS, various years).

In light of the rapid rise in household appliance ownership, China's first equipment energy efficiency standards program was established in 1989 to cover most common household appliances such as refrigerators, air conditioners, clothes washers, televisions, radios and electric fans.[1] China's minimum energy performance standards (MEPS) program was strengthened and expanded under the Energy Conservation Law of 1997 with greater regulatory attention and now covers over 30 different types of appliances and equipment including those common in the residential and commercial sector, and industrial equipment such as transformers and motors (National People's Congress, 1997; Zhou et al., 2010). At the same time, it has expanded the coverage of its voluntary energy efficiency label to over 40 products (Table 1). Typically, MEPS are developed through a process involving government, industry and research experts and can take 18 to 24 months depending on the product. The China National Institute of Standardization (CNIS) is responsible for drafting new and updated standards and in some cases, MEPS test procedures are based on internationally accepted test standards (CNIS, 2002). The MEPS mandate the maximum allowable energy consumption for a given appliance product and are generally updated every 4–5 years, with each update typically increasing stringency by about 10% over the previous level (Fridley et al., 2001). In order to provide manufacturers with longer lead times for design and production of new products, new and revised standards since 2003 have included a second period "reach standard" of even greater stringency with a typical 3-year lead time to implementation.

China has had a voluntary energy label endorsing products that meet a certain efficiency threshold since 1998, and adopted a

* Corresponding author. Tel.: +1 510 486 5534; fax: +1 510 486 6996.
E-mail address: NZhou@lbl.gov (N. Zhou).

[1] China's first MEPS were introduced in 1989 and included eight products: household refrigerators (GB 12021.2-1989), room air conditioners (GB 12021.3-1989), clothes washers (GB 12021.4-1989), electric irons (GB/T 12021.5-1989), automatic rice cookers (GB 12021.6-1989), televisions (GB 12021.7-1989), radio receiver and recorders (GB/T 12021.8-1989), and electric fans (GB 12021.9-1989).

0301-4215/$ - see front matter Published by Elsevier Ltd.
doi:10.1016/j.enpol.2011.04.027

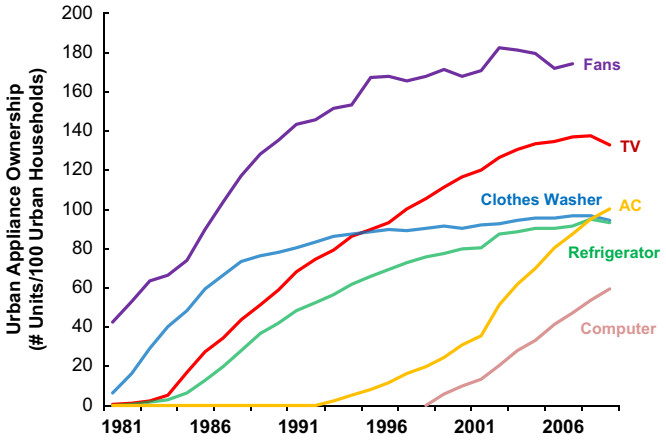

Fig. 1. Urban appliance ownership.
Source: National Bureau of Statistics, various years.

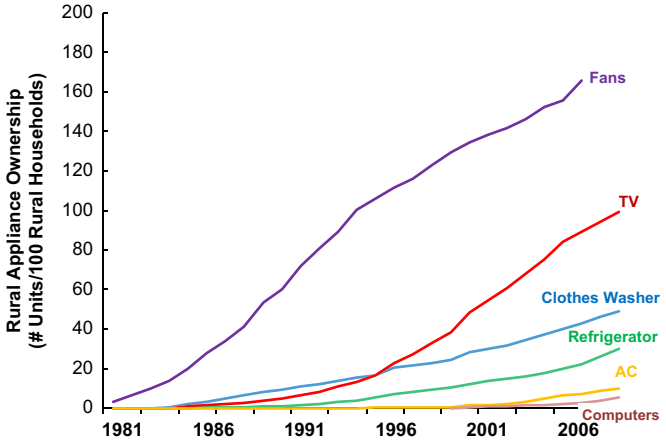

Fig. 2. Rural appliance ownership.

mandatory information label that ranks product models of the same type by efficiency category to inform consumer purchase decisions in 2005. This mandatory categorical energy information label is known as the China Energy Label and was established following legal provisions in the Energy Conservation Law with supporting regulation and support for implementation in the Product Quality Law and Legislation on Certification & Accreditation (Jin and Li, 2006). The China Energy Label includes five categories of efficiency, ranked from 1 (highest) to 5 (MEPS), and a given product's rating is based on self-reported energy consumption data from manufacturers. At its launch in March 2005, the label was implemented for use only on refrigerators and air conditioners, and now further expanded to cover 15 products by the end of 2009. Complementary to appliance standards, the Energy Label is intended to promote consumer awareness and market transformation.

Besides quantifying energy and economic impacts of standards and labeling (S&L) programs, consistent impact evaluations also help justify program funding, assess program effectiveness and identify potential weaknesses in program design or implementation and are thus a crucial factor for S&L program success (Vine et.al., 2001; Wiel and McMahon, 2005; Levine et al., 2010). To date, however, the impact of China's S&L programs and their saving potential has not been evaluated on a consistent basis. This research involves modeling to estimate energy saving[2] and emission reduction potential of the appliances standard and labeling program for products for which standards are already in effect, currently under development and those proposed for development in 2010.

The baseline or "Frozen" scenario for evaluating the impact of S&L programs is based on the absence of any appliance efficiency policy and assumes that an appliance's energy intensity as measured by unit energy consumption is frozen at the average level of when the first standard was implemented. Two additional scenarios that have been developed differ primarily in the pace and stringency of MEPS development. The Continued Improvement Scenario (CIS) reflects the likely pace of post-2009 MEPS revisions, and the likely improvement at each revision step considering the technical limitation of the technology. The Best Practice Scenario (BPS) examined the potential of an achievement of best-practice efficiency in broad global commercial use today in 2014 for a subset of products evaluated in the CIS scenario.

This paper presents the modeling methodology of three scenarios of possible efficiency improvements in residential, commercial and industrial equipment and compares the savings potential of both BPS and CIS scenarios against a frozen efficiency scenario. Conclusions are drawn to provide policymakers and other energy analysts with details of the success and shortcomings of the program as well as a guide to targets for further strengthening of the program.

2. Methodology

Data on production, sales, efficiency, ownership, usage patterns and other technical details of each product are challenging to acquire and compile in China. This study relies on a wide range of materials and information sources including national statistics, reports, websites, testing results, as well as judgment gained from long term working collaboration between LBNL and CNIS on standard development and implementation.

2.1. Scenarios

The analysis focused only on the standards or voluntary labeling efficiency criteria that were implemented as of 2009 and applicable "reach" standards to be implemented for air conditioners, refrigerators, televisions and lighting in 2014. Although the mandatory energy information label for refrigerators and air conditioners was implemented in 2005 and expanded to 15 products by 2009, the impact of this program was not included in the analysis because of insufficient market data. The two scenarios of efficiency improvements developed for this preliminary analysis differ primarily in the pace and stringency of MEPS development and are compared against the frozen efficiency scenario which uses the 2009 MEPS level as the baseline average energy consumption through 2030.

In the CIS, the projection is made based on the likely pace (every 4–5 years) of post-2009 MEPS revisions and the likely improvement (5–10%, depending on the product) at each round of update considering the technical limitation of the technology

[2] Energy use and energy savings are reported in Chinese units of standard coal equivalent (sce); values are typically expressed as metric tons of coal equivalent (tce) and million metric tons of coal equivalent (Mtce). One tce equals 29.27 gigajoules (GJs) and 27.78 million British thermal units (MBtus) (NBS, 2008b). Energy use and energy savings are reported in both final (site) and primary (source) values that reflect electricity conversion efficiencies as well as transmission and distribution losses. To convert electricity to a final (site) coal equivalent value, the conversion factor of 0.1229 kilogram coal equivalent (kgce)/kilowatt hour (kWh) is used. To convert electricity to a primary (source) coal equivalent value, the conversion factor of 0.404 kgce/kWh is used.