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Market Analysis of China Energy Efficient Products (MACEEP)

by

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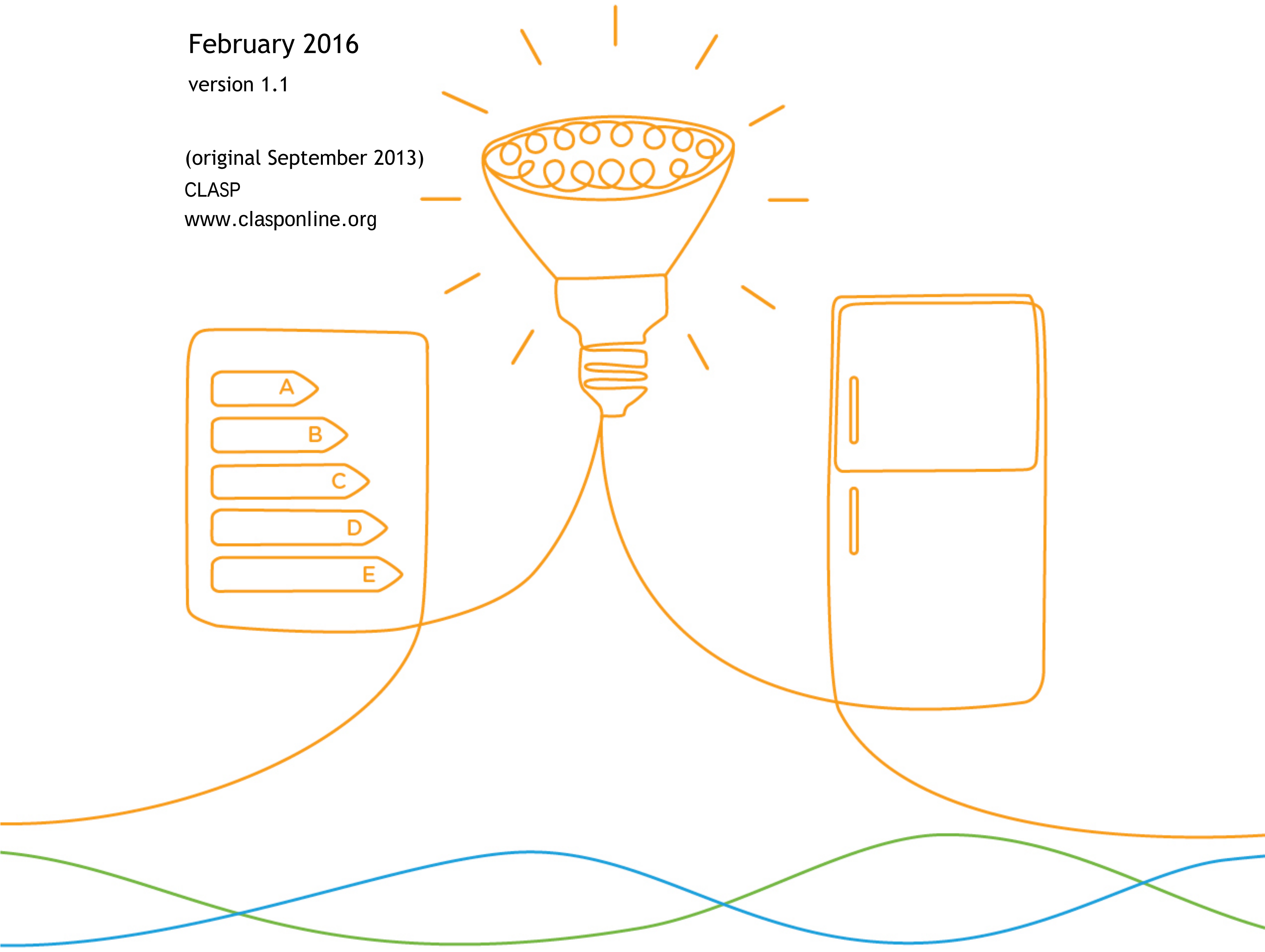

Disclaimer

Revision History

Version 1.1 was issued to correct misreported data in Table 12 on page 60. The table originally gave the M and N values from the 2003 version of the refrigerator standard. This has now been corrected to show the 2008 values as intended.

Acknowledgements

This report was prepared by the China offices of CLASP and Top10. Primary authors of the report were

Hu Bo: Top10 (washing machines, monitors, variable and fixed speed air conditioners)

Jayond Li: CLASP (induction cookers, rice cookers, copiers and televisions)

Zheng Tan: Top10 (refrigerators)

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Extended Executive Summary

In recent years, the market for domestic appliances in China has flourished due to the continual increase in personal income, speed of urbanization, and the population's desire to improve their quality of life. However, without policy intervention to reduce the amount of energy consumed by these products, their projected electricity consumption will rise from 591 TWh per year in 2012 to 748 TWh per year in 2020, and to 821 TWh per year in 2030 (a 39% increase electricity consumption over the period).

In 2012, CLASP identified an opportunity to collect and analyze market data that would help Chinese policy makers set achievable and more stringent targets for upcoming revisions of minimum energy performance standards (MEPS) for various energy-consuming appliances. With support from the US Energy Foundation, CLASP partnered with Top10 China and several international experts to conduct the *Market Analysis of China Energy Efficient Products* (MACEEP) and a parallel study on potential energy savings[1] that could result from more stringent policy measures and improved product efficiency.

The goal of this research is to improve policy maker knowledge by providing a comprehensive and transparent picture of the Chinese market for domestic appliances. This includes the number of appliances currently available on the market, the energy efficiency and consumption distributions of these appliances, and the market and policy influences that affect their regulation. Ultimately, the study provides recommendations for policy interventions that could lead to improved efficiency or reductions in the energy consumption of Chinese appliances in the future, with associated estimates of potential energy savings.

The MACEEP study covers nine specific products: fixed and variable speed air conditioners, induction cookers, copy machines, monitors, refrigerators, rice cookers, televisions, and washing machines. Data was drawn from surveys of products available on the market in July 2012, supplemented by information from public sources such as the China Energy Label website and the China National Bureau of Statistics. Notably, MACEEP is the first study of its kind to be conducted based on independently-collected, third party market data. Overall, the data in the individual product analyses derives from over 6,000 individual appliance models. The study provides over 90 recommendations to Chinese policymakers within the individual appliance analyses. In each case, these recommendations are specific to the appliance. However, we have compiled the following overarching recommendations that are likely to be of particular interest to policymakers. These are as follows.

Immediate energy saving opportunities

Significant energy saving opportunities are immediately available through relatively simple revisions to the minimum energy performance requirements for induction cookers, monitors, refrigerators, rice cookers, TV, copier, and fixed speed air conditioner. If policymakers choose to adopt all of the recommendations for these

[1] Energy Saving Potential (ESP) Study for Nine Appliances in China, CLASP 2013.

products immediately, the revisions would result in cumulative energy savings of at least 269 TWh by 2030.

Policymakers should be reassured that there is little evidence to suggest that such revisions would have an adverse impact on product price. In some cases, it may be necessary to support some manufacturers in adapting to higher performance requirements if a change in production is necessary – such as switching from compact fluorescent (CCFL) to light-emitting diode (LED) television technology.

Revise current strategy for developing energy efficiency Tiers

The current strategy being pursued by Chinese policymakers when developing energy efficiency standards has resulted in a large proportion of products qualifying for the higher efficiency levels, or "Tiers," with little apparent difference in efficiency. This means that consumers do not have the opportunity to preferentially select the most efficient products at the point of purchase. Moreover, there is limited incentive for manufacturers to develop higher efficiency products, since they will not be distinguished in the market.

Policymakers face challenges in revising the energy efficiency Tiers, as there is relatively little spread in efficiencies between products. Consequently, the lack of additional efficiency requirements makes it difficult to effectively implement additional policy support measures (such as subsidies) or to promote the most efficient products.

Therefore, policymakers may wish to consider a strategy whereby future revisions to the energy efficiency Tiers for all appliances will introduce new performance requirements such that:

- Tier 1 requirements are set at the efficiency level of the best performing appliance in the market at that time, thus creating the equivalent of a "Top Runner" target – i.e., the top 5% of products in terms of energy efficiency – to encourage the development of new high performance products, and as desired by policymakers under separate initiatives;
- The Tier 2 requirements dictate that only the top 10% of efficient appliances are eligible for qualification at the time the standard is introduced; and,
- The remaining products are evenly distributed across the remaining labeling categories.

Furthermore, an automatic revision of the Tier requirements should be initiated when 10% of products in the market achieve Tier 1 performance, or 25% of products achieve Tier 2 performance. This would ensure that higher efficiency products are continually differentiated from other appliances on the market.

Such a strategy would allow consumers to choose higher-efficiency products and allow policymakers to more effectively pursue other policy support measures that target the best performing products. This strategy is also in line with current (or likely) developments in other countries such as Australia, Canada, Korea, and Japan – where premium products are effectively identified in the market, or automatic standards revisions are undertaken when approximately 25% of products reach a level considered to define premium efficiency.

Reorient the focus of future subsidy programs

There is little doubt that the use of subsidies in support of efficient appliances has achieved the primary goal of stimulating national demand for the appliances and increasing their penetration into rural areas. However, there is some evidence to suggest that these subsidies have been less effective in promoting the development and adoption of higher efficiency products due to the large number of products that are typically eligible to receive subsidy support. In some cases, the subsidies have been supporting products that are highly efficient, yet still consume very high levels of energy. For example, LED-backlit televisions with very large screens may be highly efficient, but will still consume over twice as much power as a television of half the screen size.

Therefore, if policymakers want to continue the use of subsidies to promote energy efficient products, they may wish to consider:

- Only providing subsidy support for Tier 1 or higher products; or, if the current standard-setting strategy is revised in line with the study recommendations, including Tier 2 products if Tier 1 products are restricted to "Top Runner" status; and
- Setting a maximum cap on total energy that can be consumed by the appliance. This introduces the concept of sufficiency in addition to efficiency – i.e. not subsidizing expensive products of large size or volume, and/or those containing sophisticated but energy-consuming functions.

Make efficiency requirements technology-neutral

Currently, a number of appliances with the same functionality qualify for differing energy efficiency Tiers and minimum performance requirements based on different technologies. For example, plasma display panel (PDP) and liquid crystal display (LCD) televisions, ceramic and non-ceramic rice cookers, and impeller and drum washing machines all have differing energy performance requirements – and in some cases, different test procedures. This is very likely to mislead consumers in the relative performance of the various appliance types and is likely to lead to inadvertent purchases of products that consume significantly more energy than necessary.

Therefore, the study strongly recommends that policymakers attempt to ensure that all appliance standards are based on technology-neutral test methods and performance requirements. It should be noted that some manufacturers may require additional policy support to shift production where their existing product range is adversely affected by the switch to a technology-neutral standard.

Research consumer usage patterns

How consumers use a product in real life in their homes directly impacts several factors used in the development of energy efficiency standards. It affects projections of energy consumption and saving potentials, the accuracy and relevance of test methods, and determines the actual energy used by the consumer in their household. Despite this, very little public information appears to be available on current consumer usage patterns for the majority of appliances in China. The study therefore recommends initiating a research program to establish how individual appliances are typically used by households and with what frequency.

Revise labels to include actual energy consumption data

Currently, a number of the criteria displayed on energy labels are not assisting consumers in selecting the most efficient or lowest energy-consuming appliance. For example, the declared energy efficiency index (EEI) of televisions and the thermal efficiency of rice and induction cookers have little meaning to consumers and are unlikely to impact their purchasing decisions.

Using efficiency as a measure of comparative performance is not always beneficial. For example, a Tier 1 five-liter rice cooker will almost certainly use more energy than a Tier 4 four-liter rice cooker, but that information is not communicated effectively on the label. A consumer aiming to purchase efficient products may purchase the five-liter unit due to its apparent high efficiency, but ultimately that unit will consume more energy.

Therefore, the study recommends that a typical daily, monthly, or (ideally) annual energy consumption figure be included on the label for most products, similar to that which is used for refrigerators and copiers. This is already a nominal requirement of the energy labeling management rules.2 In the longer term, the calculation of the energy consumption should be based on typical usage patterns established by consumer research.

Require energy labels to reflect typical product performance, and review allowable testing and labeling tolerances

There is evidence to suggest that some manufacturers are reporting energy performance values on appliance energy labels that are higher or lower than the typical performance of the model. This has the potential to lead consumers to select an appliance that is not appropriate for their needs or that fails to meet their expectations of energy consumption. It can also lead to the development of inappropriate revisions to the affiliated energy efficiency standard or hamper the development of a more appropriate one.

Therefore, the study strongly recommends that policymakers require declarations of energy efficiency and other performance indicators on an energy label in order to accurately reflect the true performance values reported in the test certificate submitted with the label application. This test certificate must represent the typical performance of the model under production conditions. Furthermore, once clarity is achieved in product claims, policymakers may wish to re-examine the tolerances, or allowable level of variance between test results, in test methods and labeling claims to ensure they are appropriate for each appliance type.

Revise some test methodologies and thresholds for performance

A number of potential shortcomings have been identified in the existing test methodologies for TVs, rice cookers, and induction cookers, such as the brightness setting in the television test methodology. Policymakers may wish to encourage

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[2] Clause 8 of the “energy label management rules” states “the label should include information of energy consumption.”
http://energylabel.gov.cn/NewsDetail.aspx?Title=%e6%94%bf%e7%ad%96%e6%b3%95%e8%a7%84&CID=31&ID=137

revision of these test procedures – possibly through the adoption of existing and accepted international methodologies – to ensure that the performance of the appliance is represented accurately. This information is essential for consumer decision-making and for the development of appropriate policy measures.

Similarly, an issue has been identified in the use of a linear functions and adjusted volumes as the basis for regulation of refrigerated appliances. The current Energy Efficiency Standard is based on a linear function and adjusted appliance volume to derive the energy efficiency performance Tiers and the associated minimum energy performance levels. However, the use of such a linear function *and* adjusted volumes has the effect of increasing the price of smaller units and/or improving the apparent efficiency of larger appliances. Either (or worse both) of these outcomes is giving an incentive for consumers to purchase larger appliances which leads to higher overall energy consumption. The approach used in China is in line with current practice in the majority of countries around the world. However, Chinese policy makers may wish to consider a move to curved exponential functions based on adjusted appliance surface area as a basis for minimum performance and Tier thresholds. Such an approach would more effectively responds to the inherent increase in efficiency as product sizes increase, and removes the potential for the perverse outcome of increased unit volumes improving apparent unit efficiency but increasing consumption.

Consider a technical study examining variations in standby modes

In general, existing energy efficiency standards have some Tier or minimum performance requirement related to the “standby” of the appliance. Typically these standards refer to a single standby mode; for example, “off-mode power” where a unit is plugged into the main power supply but the appliance is switched off. However, with the advent of microprocessor control and additional appliance functionality, an increasing number of appliances have varying standby modes. For example, televisions have “fully off,” “standby with no activity,” instant “on” functionality, internet connectivity, and so on – all of which have varying levels of energy consumption that are not currently captured by existing Chinese test methodologies.

Therefore, policymakers may wish to conduct a technical study examining appropriate appliances to establish the type and extent of standby modes currently available. This study, in combination with consumer research on typical usage patterns, should identify any additional standby modes that result in significant energy consumption and are commonly used by consumers. The results can then be integrated into the testing and energy efficiency standards for that appliance. Similar research is underway in other parts of the world and there is a potential for Chinese policy makers to collaborate with, or learn from, these studies.

Improve the collection of sales data

The analysis in this report was conducted on a product basis rather than a sales weighted basis due to limited access to sales data. This study found although the results of sales and models analysis come close,[3] this has the potential to distort

[3] This study found the difference between analysis results based on sales and models is less than 10%.

findings as, for example, particularly efficient or inefficient products may sell in significantly larger quantities than an average product on the market. If policymakers are similarly limited in their access to sales figures for products, it may lead to similar potential distortions in the analyses conducted for the development of energy efficiency standards and associated energy saving projections.

Therefore, policymakers may wish to consider following the examples of Australia, Canada, and Korea, and require suppliers of all appliances registered for sale within China to supply annual sales figures for those appliances, or to formally advise the China National Institute of Standardization that the products are not currently on the market.

Projected Potential Energy Savings

Based on projected growth in appliance ownership, changes in consumer usage patterns, product lifetimes, and other factors, the CLASP 2013 projections[4] suggest that the revision of energy efficiency standards detailed in each of the individual product analyses would likely result in cumulative potential energy savings of 269 TWh by 2030.

Similar projections estimate that, by 2030, *annual* energy savings of 187 TWh per year (with cumulative savings of 1,057 TWh) are possible should all future appliance sales match the efficiency of the most efficient representative model already on the Chinese market. In other words, even by adopting the revisions to the energy efficiency standards proposed in this study, huge potential energy saving opportunities remain available to policymakers based on existing technology already on the market.

[4] Energy Saving Potential (ESP) Study for Nine Appliances in China, CLASP 2013.

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Glossary and Acronyms

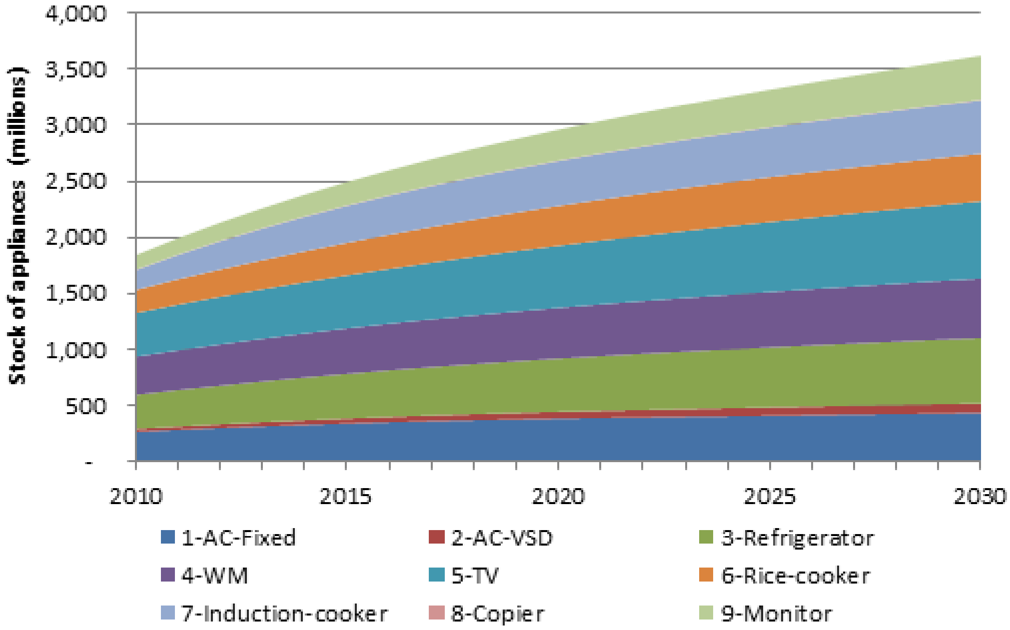
Acronym/ Abbreviation	Meaning
auto-off	The state a copier enters after a period of inactivity following completion of a task
BC, BC/CD, BCD, BCDW	Designations of refrigerated appliance types in Chinese energy efficiency standards, respectively refrigerator, refrigerator or freezer units, combination refrigerator freezer units, and combination refrigerator freezer units with compartments side by side
cd	Candela, the unit of luminance (in the context of this report associated with televisions and monitors
CEL	China Energy Label
CELP	China Energy Labeling Program
COP	Co-efficient of performance (for air-conditioners)
CRT	Cathode Ray Tube (television)
CCFL	Compact Fluorescent Lighting (in the context of this report, used for backlighting of monitors and TVs)
DFE	Digital front equipment used to define a specific subset of (typically) commercial printers have digital display screen which often also function as the unit control panel
EFF	Energy Efficiency Performance metric (used to measure on-mode performance of monitor in cd/W)
EEI	Energy Efficiency Index (defined as the measured efficiency of the product under test divided by the nominal energy efficiency of a “standard” product).
EEI_{ref}	The nominal reference value(s) defined in the Energy Efficiency Standard for televisions, used in the calculation of a television’s EEI.
EER	Energy Efficiency Ratio (metric for fixed speed air conditioners)
EES	Energy Efficiency Standard
EET	Energy Efficiency Tiers as defined in the Chinese GB standards
GB Standards	The Chinese standards used to define the test methods, energy efficiency Tiers and the minimum energy performance requirements (the GB designation is drawn from the Romanized pinyin version of Chinese and standards for GuoBiao meaning National Standard)
Hz	Frequency in Hertz
L	Liter (volumetric measure)
LCD	Liquid Crystal Display (in the context of this report, used in televisions)
LED	Lighting Emitting Diode (in the context of this report, used for backlighting of monitors and TVs)
MACEEP	Market Analysis of China Energy Efficient Products
MEPR	Minimum Energy Performance Requirement, ie the limiting level defining the least efficient unit that can legally be supplied to the market.

Acronym/ Abbreviation	Meaning
MFD	Multi-Functional Devices, ie office copier machine which have functionality beyond copying including, for example, the ability to print, send faxes, scan, etc.
Off-mode standby	The power consumption of an appliance when the appliance is switched off, but still connected to the mains power supply.
On-mode standby	The power consumption of an appliance while in any state except that of performing its primary function (eg cooking) and off-mode standby.
η	Used to denote efficiency in a number of Chinese standards including thermal efficiency (for induction cookers) where efficiency is the quotient of the theoretical energy used to heat water and the containment vessel over the total true power consumed, and the quotient of the measured energy consumption of the appliance during the test to the baseline energy consumption (unit less percentage).
PDP	Plasma Display Panel (in the context of this report, used in televisions)
ppm	Pages per minute [referring to the speed of reproduction for printers, copies, etc]
Simple Copier	An office copier machine where functionality is limited to copying and does not include, for example, the ability to print, send faxes, scan, etc.
SS	Screen Size (for TVs and Monitors in inches)
TEC	Typical Energy Consumption (the energy efficiency metric for copiers and MFDs which includes an operational cycle deemed typical of weekly operation – unit kWh/week)
Top Runner	A Japanese product efficiency program whereby government and industry reach agreement on the efficiency of products to be sold in the future (based on a fleet average of sales)
TV	Television
USB	Universal serial bus [a type of high speed connection between computing and peripheral devices]
V	Electrical voltage (unit Volts)
W	Watts, the SI unit for power (joule/second)

Introduction

China is the world's largest manufacturing hub for household appliances and now, for many appliances, also has the highest level of sales and number of products installed. In the past two decades, a range of appliance types have been widely adopted among urban households, many of whom are now at the stage of renewing their appliances or replacing them with newer generation models. More recently, the penetration of appliances into rural areas has been accelerating, partly through increasing wealth levels in these regions, and partly through specific government initiatives such as Appliances to Rural Areas[5] aimed at stimulating appliance ownership in these areas. This increase in appliance ownership levels is expected to continue into the future as illustrated in Figure 1[6].

Figure 1: Current and projected installed stock of selected appliances (projection to 2030)



Consequently, under a business as usual scenario, energy consumption and associated emissions of these appliances will grow rapidly. As shown in Figure 2, under a business as usual scenario, electricity consumption of air conditioners, copiers, induction cookers, monitors, refrigerators, rice cookers, televisions and washing machines will increase from 591 TWh per year in 2012 to 748 TWh per year in 2020, and 821 TWh per year in 2030 (a 39% increase electricity consumption over the period).

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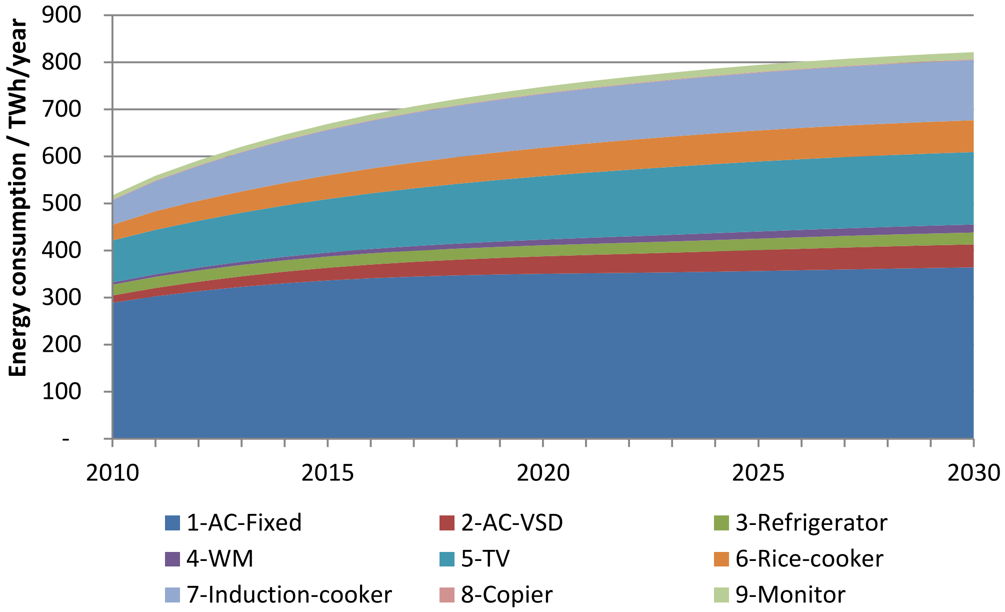
[5] http://jdxx.zhs.mofcom.gov.cn
[6] Refer to section 10.

Figure 2: Current and projected energy consumption of selected domestic appliances in China under a business as usual scenario (projection to 2030)



Fortunately, it appears that consumers are increasingly paying attention to energy saving as one of the key factors in evaluating which appliances to purchase[7]. Furthermore, the Government of China's 12th Five Year Plan (2011-2015)[8] has included energy saving and emissions reduction as one of the mandatory indicators of social development and sets a goal to reduce the energy intensity per capita 16% by 2015, relative to 2010.

To achieve this goal, the Chinese government has chosen to focus on end-use energy consuming products and has indicated that high priority will be given to projects promoting wider production and use of high-efficiency products. Under the national policy of Energy Saving and Emission Reduction, three major incentive programs are already in place: Old to New[9], Appliances to Rural Areas, and the Subsidy Program for Energy Efficient Products.[10] These programs have set direct and indirect requirements on the energy efficiency of products. This shows that the Chinese Government not only realizes the importance of high-efficiency products to the Energy Saving and Emission Reduction policy, but is also dedicated to promoting high-efficiency products via national policies and programs.

However, China's appliance market is very large and increasingly sophisticated. Product development is accelerating, with shorter design and production phases, leading to shorter shelf lives for products in the market. Thus, developing policies that are appropriate for rapidly evolving products and relevant to the disparate market segments

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[7] Market Research on the Impacts of China's Energy-Efficient Appliance Subsidy Program on Customer Behavior, CLASP, 2013.
[8] http://www.gov.cn/2011lh/content_1825838_2.htm
[9] http://jdyjhx.mofcom.gov.cn
[10] http://www.jienenghuimin.net/

is increasingly challenging. This situation is made significantly worse by limited real data on the energy and efficiency performance of products within the market place.

In 2012, CLASP identified an opportunity to collect and analyze market data that would help Chinese policymakers set achievable and more stringent targets for upcoming revisions of minimum energy performance standards (MEPS) for various energy-consuming appliances. With support from the US Energy Foundation, CLASP partnered with Top10 China and several international experts to conduct the Market Analysis of China Energy Efficient Products (MACEEP) and a parallel study on energy savings potential (ESP)[11] that could result from more stringent policy measures and improved product efficiency.

MACEEP provides a transparent picture of the levels of efficiency and comparative energy consumption of nine domestic appliances currently for sale on the Chinese market: fixed and variable speed air-conditioners, induction cookers, copiers, monitors, refrigerators, rice cookers, televisions and washing machines. The study also provides suggestions for policy interventions that could lead to improved efficiency and/or reductions in the energy consumption of these appliances in the future.

These products were selected due to their current and potential energy consumption levels, the potential savings that may accrue from the implementation of future policy actions, and the mandatory requirement that they all display the Chinese energy label[12]. Sections 1-9 of the report contain individual analyses for each product, including (with slight variations):

- *Product background information,* including a definition of the product scope; production, sales and stock levels and associated projections of energy consumptions; product usage patterns; relevant national test methods and relationships to international standards; national energy efficiency standards, and levels of applicable economic stimulus subsidies.
- *Appliance performance information,* which provides a snapshot of the current efficiency distribution and energy consumption of the appliance within China, as well as efforts to correlate the levels of efficiency and consumption with a range of product, market, and policy variables (e.g., product size, price, and labeling requirements).

The individual product analyses are followed by an overall analysis of potential energy savings from the nine products as a whole, including projections of estimated future national energy consumption levels based on:

- A business as usual scenario;

[11] Energy Saving Potential (ESP) Study for Nine Appliances in China, CLASP 2013

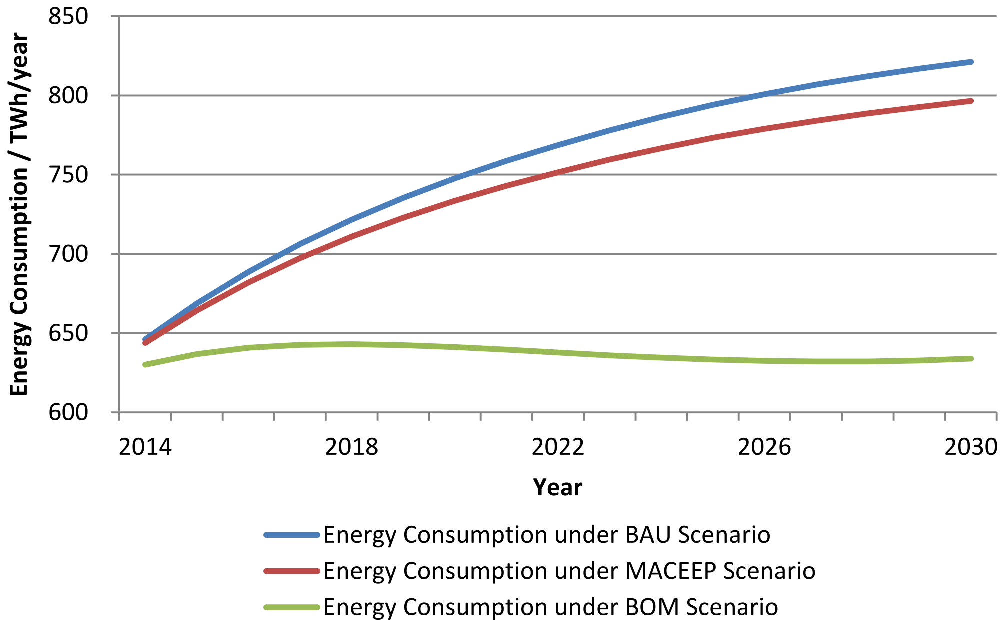
[12] During the final stages this analysis, updated proposals were issued for revisions to the energy efficiency standards for televisions, variable speed air conditioners, induction cookers, and washing machines. Additional analysis of the new proposals for induction cookers and televisions was conducted and has been included in a separate Annex to the relevant product analyses. It was not possible to provide additional analysis for variable speed air conditioners and washing machines.

- Potential energy savings that could be achieved in the near future based on policy recommendations in this report; and
- Adoption of the best appliances currently available in the Chinese market.

Based on projected growth in appliance ownership, changes in consumer usage patterns, product lifetimes, and other factors, the CLASP 2013 projections[13] suggest that the revision of energy efficiency standards detailed in each of the individual product analyses would likely result in cumulative potential energy savings of 269 TWh by 2030.

Similar projections estimate that, by 2030, *annual* energy savings of 187 TWh per year (with cumulative savings of 1,057 TWh) are possible should all future appliance sales match the efficiency of the most efficient representative model already on the Chinese market. In other words, even by adopting the revisions to the energy efficiency standards proposed in this study, huge potential energy saving opportunities remain available to policymakers based on existing technology already on the market.

Figure 3: Energy consumptions of the appliances covered in this study under different stringency levels of Energy Efficiency Standards (projection to 2030)



The following sections detail the approach and methodology used in the MACEEP research, and the major policy interventions in China to date that influence product efficiency.

[13] Energy Saving Potential (ESP) Study for Nine Appliances in China, CLASP 2013.

Approach and Methodology

Unless otherwise specifically referenced, all data in this report has been gathered from three primary sources, detailed in Table 1 below. Overall, the data in the individual product analyses derives from over 6,000 individual appliance models.

Table 1: Summary of major data sources used in the research

Source	Data gathered	Notes
On-line dealer websites: • www.360buy.com • www.zol.com.cn • www.suning.com • www.gome.com.cn	Source of data on products available in the market in July 2012 and associated product attributes. Attributes are product specific but include information such as to draw data as follows: • Product model numbers; • Energy Efficiency (EE)and EE Tiers; • Size/Volume/Capacity; • Power; • Type; • Price	Single data collection in July 2012. Where attribute values varied by supplier, the average value across suppliers was used. In particular, such averaging was used for price.
Product's energy label information from the China Energy Label website	Verification of product attributes data where part of the declaration and displayed on the China Energy Label website. Also data of product registration.	
National Bureau of Statistics (NBS)	Macro national and regional statistics ranging from population to product ownership levels.	
Miscellaneous publications and reports.	Mainly macro statistics and generic technical information on certain product types such as shipment, stock, products' average lifetime, etc.	

The data used in all product-level analyses is based on a snapshot of models available in the market in July 2012. This data was collected purely from online sources and does not represent a full database of all models available in China at that time. However:

- The number of models available from the online sources used is greater than the number models available in any single store;
- Many online retailers seek to capture markets from first Tier to third and fourth Tier cities[14], so their product lines are more diverse than many on-street retailers; and
- The majority of large retail chains (e.g. GOME and Suning) and some of the largest manufactures have online supply capacity, and this is captured within the survey.

[14] Chinese cities are categorized in a 1 to 4 scale related to size and levels of development. Tier 1 cities are the largest, most developed urban areas, Tier 4 cities the converse.

Therefore, it is believed that the July 2012 snapshot should represent a good approximation of the market for most products at the time.

In some cases, not all product parameters were available for all models in a particular data set; for example, product size/volume or price may not have been known for a number of models. For each individual product analysis, there is a specific sub-section that provides details of the total number of models analyzed and a listing of the product attributes/parameters for which data was available. Where analysis is conducted on less than this number of models due to incomplete data, this deficiency is noted in the analysis. However, no attempt has been made to evaluate the impact of such data omission.

In all cases, the data analysis was conducted on a model (*not* sales) basis. Therefore, the analysis may not be truly representative of the products entering the stock. However, anecdotal experience in China appears to suggest model availability is focused on most popular product types and sizes. Therefore, although skewed by low selling product types, the use of product weighted averages will give a broad indicator of the overall purchase patterns and changes in stock.

Policy Interventions

There is a very broad range of national and local policy actions that are affecting the market for appliances in China. Such policies include minimum energy performance standards, certification and labeling schemes for high efficiency products, mandatory procurement lists, efficient product subsidy programs, and more. For the purposes of this research, however, the national policies that are thought to have most impact on the efficiency of household appliances, and which are considered in the analysis, are outlined below.

Tiered Electricity Pricing

Until recently, domestic consumers paid a fixed rate tariff for the electricity they consumed, approximately 0.5 RMB per kilowatt hour consumed[15]. However, in the last 12-18 months, tiered electricity pricing has been introduced across the country on a city or provincial basis (e.g., tiered pricing was introduced in Beijing in July 2012). The three-Tier progressive pricing system replaced the current "one price fits all" scheme with a new system wherein the more electricity a household uses, the higher the bills it will have to pay.

In this new scheme, electricity prices for first-Tier users are likely to remain the same. For example, Beijing households consuming less than 2,880 kWh per year are considered first Tier-users and represent about 80 % of all households. However, second-Tier users whose annual electricity consumption is above the first Tier threshold will pay a slightly higher tariff on this marginal consumption. In Beijing, those households consuming over 2,880 and below 4,800 kWh per year will pay an additional 0.05 RMB per kWh on the marginal electricity consumption. There is a third Tier for users above the 4,800 kWh threshold. Users in this third Tier are required to pay a penal rate on the marginal

[15] Actual prices vary by region within the country.

consumption above the upper second-Tier threshold (in Beijing an extra 0.3 RMB per kWh, or around USD 0.05 on the marginal consumption). Table 2 shows this tiered electricity-pricing scheme for Beijing, although the specific thresholds and electricity price varies by city or region.

Table 2: Tiered electricity-pricing in Beijing (from July 1, 2012)

Tier	Annual Electricity Consumption (kWh)	Price (RMB/kWh)
1	≤ 2880	0.4883
2	2880-4800	0.5383
3	> 4800	0.7883

Source: Beijing Municipal Commission of Development and Reform

Clearly this revision to the electricity pricing strategy aims to encourage consumers to use energy more rationally and efficiently, and to control their monthly electricity consumption such that it remains below the (in Beijing) 400kWh per month threshold. Consequently, the Government hopes that this action will encourage consumers to be more aware of product efficiency and/or consumption at the time of purchase of new appliances, and thus accelerate the adoption of more efficient appliances. However, enabling consumers to choose more efficient options requires that product labels clearly differentiate between more and less efficient and higher and lower energy-consuming appliances.

Minimum Energy Performance Standards

According to China National Institute of Standardization (CNIS)'s website, by the end of 2012, there were energy efficiency standards in place for 46 household and industrial products[16]. The Government has also planned to develop or revise 40 energy efficiency standards during the 12th Five Year Plan period (2011-2015)[17]. These energy efficiency standards have proven to be effective tools in eliminating inefficient products pushing the market towards higher efficiency.

The exact formulation and nomenclature of these standards and labeling requirements can be confusing, especially to international audiences for whom similar terminology may have fundamentally different meanings. To assist these audiences in understanding China's standards and labeling program, we here describe the specific meanings of standards and regulatory language used in China, as well as the terminology used within this analysis.

In most countries, the term "minimum energy performance standard" (MEPS) is a specific level of energy consumption, energy efficiency, or other performance parameter that a product is required to meet in order to be allowed to enter the market. These MEPS can be either voluntary or mandatory. In China, however, MEPS typically include four separate but interlinked items, described below.

[16] All products analysed in this study have energy performance Tiers, minimum energy performance requirements and are subject to the mandatory energy label.
[17] http://www.gov.cn/2011lh/content_1825838_2.htm

Energy Efficiency Standard (EES)
This is the actual document in which all energy efficiency specifications, and in some cases other required specifications such as test methodology, are contained. An Energy Efficiency Standard will have an official GB standard designation[18], and a title which will normally begin with the words "The minimum allowable value of energy efficiency and energy efficiency grade for XXX *(product name)*."

However, as this study contains information and specifications beyond MEPS, as understood by most international audiences, we use the term "energy efficiency standard" (EES) throughout this analysis to describe the standard which contains energy efficiency Tiers, minimum energy performance requirements, and any additional information specific to the product being analyzed.

Energy Efficiency Tiers (EET)

Rather than simply defining a single level of performance that all products are required to meet, an EES typically defines a range of three or five Tiers of performance that define increasing levels of efficiency, or decreasing levels of allowable energy consumption, for the specific product. The lower the Tier number, the higher the energy efficiency (or the lower the energy consumption) of the product. In other words, Tier 1 identifies the most efficient and/or lowest energy consuming products. The tested performance of the particular product then defines which performance Tier the product meets.

Table 3 provides an example of the three performance Tiers applicable to induction cookers (hobs) in China from September 1, 2012. For instance, an induction cooker that yields a thermal efficiency of 89% and standby power no more than 2W under testing would be considered a Tier 2 product.

Table 3: Tiers of performance and minimum energy performance standards for induction cookers (hobs) in China from 1 September 2012.

Energy Efficiency Tier	Minimum Energy Efficiency Level (thermal efficiency, η, %)	Standby Power (W)
1	90	2
2	88	
3	86	

Throughout this analysis, the term "energy efficiency Tier" (EET) will be used in the context of these incremental steps in improving product performance.

Minimum Energy Performance Requirements (MEPR)

Within an EES, there is also a minimum energy performance threshold that *all* products must meet. This threshold is initially set to match the required performance of the

[18] The GB designation is drawn from the Romanized pinyin version of Chinese and standards for GuoBiao meaning National Standard)

lowest EET. For example, in Table 3 the minimum energy performance threshold that all induction cookers must meet is 86%. Throughout this study, the term "minimum energy performance requirement" (MEPR) will be used to describe this minimum energy performance threshold.

High Efficiency Products

An EES also defines the energy performance threshold that products must meet to be defined as high efficiency. This threshold is almost always defined as the top two Tiers of performance. For example, in Table 3, high efficiency products are the induction cookers with thermal performance greater than 88%.

This threshold is important as it not only allows products to be designated as high efficiency, but is also used as the threshold for product certification[19] and often as a qualifying factor for subsidy programs. Throughout this study, the term "high efficiency products" will be used to describe products that have met this premium energy performance threshold.

Comparative Energy Performance Labeling

There are a number of different labels in use in China's appliance market, including product certification labels and labels defining some kind of premium performance (e.g. the 6A label for washing machines). However, the primary label that impacts consumer purchasing decisions is the mandatory China Energy Label.

Figure 4: Example of the Chinese comparative Energy Label Induction Cookers (2012)

[19] In this instance, and throughout this report, product certification refers to certification under the China Energy Conservation Certification scheme. Certification under this scheme allows products to bear the CQC mark that enables them to be eligible for government procurement and other preferential policies. Certification requires not only Tier 2 or higher energy performance, but also requires additional checks (including factory inspections) and formal registration. Authorisation to use the certification label is granted by the China Quality Certification Centre (CQC)

The mandatory energy label was first introduced in 2005, and at the time of publications was required to be displayed on 27 products. The label is comparative, displaying either three or five bands that represent the Tiers of performance for a specific product[20]. As with the Tiers of performance, Tier 1 identifies the best performing products, and Tiers 3 or 5 denote the worst performers. In addition to the performance bands, labels are also sometimes required to display additional product information, such as noise level or some physical attribute of the product (e.g. the capacity of refrigerator compartments). Figure 4 shows an example of the label for induction cookers.

Throughout this analysis, we use the term "energy label" to describe the comparative label depicted above. All products analyzed in this research are required to display the energy label at the point of sale.

Subsidy Programs

The use of financial subsidy programs has had a major impact on the domestic appliance market in recent years. To date, the Chinese Government has facilitated three major subsidy programs, which are detailed below. However, where "subsidy program" appears in individual product analyses, it only refers to the Subsidy Program for Energy Efficient Products.

Household Appliances to Rural Areas

This program was initiated by the Ministry of Finance, the Ministry of Commerce, and the Ministry of Industry and Information Technology in December 2008 and implemented on January 1, 2009[21]. The program was designed to stimulate domestic demand and consumer spending in order to combat the global financial crisis and recession that began in 2008. The program targeted consumers in rural areas in China, providing rural residents with subsidies equivalent to 13% of the retail prices when they purchased household appliances. Four product categories (televisions, refrigerators, clothes washers, and cell phones) were included in the program from the beginning. Due to its resounding success, the program was later expanded to include more product categories, namely air conditioners (wall-mounted and free-standing), computers, induction cookers, microwave ovens, and water heaters (solar, storage-type electric, and gas types)[22]. Ultimately, the program provided subsides for 298 million appliances and

[20] Note that the labels on some products have three or five Tiers based on the original mandatory Tiers of performance. However, more recent revisions of the requirements have led to the reduction of the number of performance Tiers; hence, some of the lower Tiers on the label are still displayed, but products in these categories may no longer be supplied.

[21] Circular of the Ministry of Finance, the Ministry of Commerce, the Ministry of Industry and Information Technology of the People's Republic of China, on Work of Extending Electronic Household Appliance to Rural Areas Nationwide (In Chinese).
http://www.mofcom.gov.cn/aarticle/b/g/200901/20090105990038.html [Accessed on March 8, 2013]

[22] Circular of the Ministry of Finance, the Ministry of Commerce, the Ministry of Industry and Information Technology of the People's Republic of China, on Further Intensifying the Implementation of the Policy for Bringing Home Appliances to the Countryside (In Chinese).
http://www.mofcom.gov.cn/aarticle/b/g/201002/20100206793004.html [Accessed on March 8, 2013]

cost 720.4 billion RMB ($115.7 billion USD) by the end of 2012[23]. The program concluded in January 2013.

Subsidized Trade-in of Home Appliances ("Old to New")

This program aimed to stimulate domestic consumer demand, improve resource and energy efficiency, reduce environmental pollution, and promote energy conservation and a circular economy. It was national-level program implemented through seven Government ministries and agencies in 2009[24]. The program was initially piloted in nine cities/provinces between June 1, 2009, and May 31, 2010. The programs offered subsidies equivalent to 10% of the retail price of new household appliances in return for the participants' old appliances. The trade-in appliances were recycled by selected electronic recycling companies. The program covered five product categories, televisions, refrigerators (including freezers), clothes washers, air conditioners and computers. After the completion of the pilot program, it went nationwide, comprising 19 additional provinces/cities[25]. According to statistics released by the Ministry of Commerce, 92.48 million appliances were purchased under the program, contributing to 342RMB billion of direct expenditure on appliances. This program concluded in December, 2011.

Subsidy Program for Energy Efficient Products

The Subsidy Program for Energy Efficient Products is the most recent nationwide subsidy program initiated by national departments and specially tailored for the promotion energy efficient products. The program was organized and launched by the Ministry of Finance and the National Development and Reform Commission (NDRC) in 2009[26]. It was designed to subsidize highly energy efficient household appliances, typically products that achieve Tier 1 or 2 of the energy efficiency standard[27].

Room air conditioners were the only household appliance covered by the program in 2009, but the program was renewed and expanded in 2012. In 2012, the Chinese Government committed 26.5 billion RMB ($4.26 billion USD) to subsidize energy

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[23] Ministry of Commerce News Release (In Chinese). http://www.mofcom.gov.cn/article/ae/ai/201301/20130108513698.shtml [Accessed on March 8, 2013]

[24] Circular of the Ministry of Commerce, the Ministry of Finance, the National Development and Reform Commission, the Ministry of Industry and Information Technology, the Ministry of Environmental Protection, the State Administration for Industry and Commerce, the General Administration of Quality Supervision, Inspection and Quarantine of the People's Republic of China, on Printing and Issuing the Measures for Implementation of the Subsidized Trade-in of Home Appliances (In Chinese). http://www.mofcom.gov.cn/aarticle/b/g/201008/20100807062260.html [Accessed on March 8, 2013]

[25] Circular of the Ministry of Commerce, the Ministry of Finance, the National Development and Reform Commission, the Ministry of Industry and Information Technology, the Ministry of Environmental Protection, the State Administration for Industry and Commerce, the General Administration of Quality Supervision, Inspection and Quarantine of the People's Republic of China, on Printing and Issuing the Measures for Implementation of the Subsidized Trade-in of Home Appliances (Revised Edition) (In Chinese). http://www.mofcom.gov.cn/aarticle/b/g/201008/20100807062260.html [Accessed on March 8, 2013]

[26] Ministry of Finance News Release (In Chinese). http://www.mof.gov.cn/zhengwuxinxi/caizhengxinwen/200905/t20090520_159473.html [Accessed on March 8, 2013]

[27] It has to be noted that this program include not only household appliances but also automobiles, air compressors, and transformers, etc.

efficient televisions, refrigerators, washing machines, water heaters and desktop computers[28]. NDRC expected the market share of energy efficient products to rise from 10-20% to over 30% over the one year subsidy period, which could result in 75 TWh of annual electricity savings[29]. This program will be the focus of "subsidy programs" described in this analysis, unless otherwise specified.

[28] State Council News Release (In Chinese). http://www.gov.cn/ldhd/2012-05/16/content_2138815.htm [Accessed on March 8, 2013]
[29] National Development and Reform Commission New Release (In Chinese). http://www.ndrc.gov.cn/xwfb/t20090521_280642.htm [Accessed on March 8, 2013]

Section 1: Analysis of the Market and Product Performance of Induction Cooker (Hob)

This section of the report examines the market, product performance and regulatory framework for induction cookers[30].

Induction cookers are of importance as product numbers are rising as consumers respond to the apparent advantages over other conventional heating methods in a number of situations, i.e. induction cookers are cleaner, quieter and often safer than conventional cooktops.

The ESP projections[31] indicate that the number of induction cookers installed will rise from approximately 250 million in 2012, to 430 million in 2030. Under the business as usual scenario prepared as part of this analysis (refer to section 10.1), by 2030 the projected stock of induction cookers would consume approximately 128 TWh/yr of energy. Such projections clearly demonstrate the need to address the energy efficiency and overall consumption of these products.

1.1 Product Background

Induction cookers in households and the catering industry use the heat resulting from energy loss from high frequency eddy currents which are generated when magnetic cooking vessels are placed onto an induction hob generating a magnetic field.

Most induction cookers in the Chinese market are portable with a single-heating hob (based on the preliminary market investigation, single-hob units account for more than 90% of the models available). However, other types exist, e.g. cookers built into kitchen units and/or multi-hob units, but it is unusual to find such cookers with more than three hobs.

As the power of induction cookers is adjustable, the declared rating of a unit normally gives both the lowest and highest powers. A typical induction cooker on the market has a maximum power in the 2000-2100W range.

In line with the national energy efficiency standard, this analysis looks at induction cookers where any individual hob has a maximum power rating ranging from 700W to 2800W.

1.1.1 Production, sales and stock level

Induction cookers began entering the Chinese market as a residential cooking appliance around the year 2000. Their household penetration increased rapidly from the beginning

[30] Important note: Before this report was completed, a revised draft EES for induction cookers was published. An analysis of this revision is included as an Addendum to the induction cooker analysis in section 1.6

[31] Energy Saving Potential (ESP) Study for Nine Appliances in China, CLASP 2013

of 2005[32]. By 2011, 141 million induction cookers were produced in China, of which annual domestic sales totaled 43.2 million cookers[33].

By the end of 2011, it was estimated that the over 222 million induction cookers were installed in households in China.

1.1.2 Usage patterns

In Chinese households where natural gas is unavailable, induction cookers are normally used as the primary alternative to solid fuel based cooking. However, since natural gas is available in most buildings, gas cooktops are still the primary cooking method with induction cookers normally used for special occasions such as the preparation of hotpot.

Across all Chinese households (i.e. where induction cookers are used as both the primary or secondary cooking method), it is estimated the average household usage of induction cookers is 0.5 hours per day operating at an average power of 75% of the maximum rated power**Error! Bookmark not defined.**. However, there appears to be no ublically available information on actual household usage, and therefore more research is recommended to establish actual usage patterns.

1.2 Regulation, Labeling and MEPS

1.2.1 Energy Efficiency Standard

As noted above, the current Energy Efficiency Standard (EES) for induction cooker is GB 21456-2008. The standard was issued in February 2008 and came into force in September 2008[34]. The EES applies to induction cookers with single or multiple heating hobs, with the maximum power of each hob falling within the range 700W to 2800W. Commercial, concave, and low-frequency induction cookers are excluded from this standard.

When the EES was first introduced, induction cookers were categorized into five Tiers based on their thermal efficiency and standby power as shown in Table 4. The minimum energy performance requirement (MEPR) for induction cookers was set at the lower threshold of Tier 5, i.e. 82% thermal efficiency and 5W for standby power. Hence products with energy performance at levels below Tier 5 were excluded from the market[35].

[32] White paper for the energy efficiency status of China energy-use products-2011, China National Institute of Standardization.
[33] White paper for the energy efficiency status of China energy-use products-2012, China National Institute of Standardization.
[34] EES of "The Minimum Allowable Values of the Energy Efficiency and Energy Efficiency Grades for Household Induction Cookers, GB 21456-2008".
[35] Note, where cookers have more than one hob, each hob is required to meet the MEPR and the labeled value of the whole cooker is the EET of the worst performing hob.

Table 4: 2008 Energy Performance Requirements for Induction Cookers

Energy Efficiency Tier	Energy Efficiency (thermal efficiency, η, %)	Standby Power (W)
1	90	2
2	88	
3	86	5
4	84	
5	82	

However, the original GB 21456-2008 set a further MEPR target, raising the MEPR to 86% thermal efficiency and 2W standby power respectively, i.e. the lower threshold for Tier 3, but with the lower 2W standby requirement. This revised MEPR level was set to be implemented 4 years after the original standard came into force, i.e. September 2012. Thus, by the time of report publication, this revised requirement will be mandatory and products that have energy performance worse than 86% thermal efficiency and 2W of standby power will no longer be able to enter the market.

1.2.2 Energy labeling of induction cookers

In October 2008, the Chinese government announced that induction cookers would also be covered by the China Energy Label Scheme. Labeling of induction cookers became mandatory from March 2009.

The label shows basic identification information of the product, the five EETs as defined in the EES, plus absolute values for the thermal efficiency and standby power consumption of the induction cookers (refer Figure 5). Although the MEPR becomes the lower threshold for Tier 3 in September 2012, the 5 Tier label is still used although no Tier 4 and 5 products are now available.

Figure 5: China Energy Label for Induction Cookers

1.2.3 Test Method

The test method for measuring the energy efficiency of induction cookers is detailed in the energy efficiency standard (GB 21456-2008, *the Minimum Allowable Values of the Energy Efficiency and Energy Efficiency Grades for Household Induction Cookers*).

The induction cookers are tested at maximum power. The input power to the induction cooker is directly measured, and the theoretical energy consumed by the mass of water within a standard test vessel is calculated via the temperature rise of the water/vessel. Thermal (energy) efficiency (η) is calculated by dividing the theoretical energy consumption by the measured input power.

The energy efficiency is calculated based on tests at maximum power. However, as noted in section 1.1.2, it is likely that this may not represent the normal operating conditions employed by the consumer which is more *likely* to be in the range 50%-80% of the unit's maximum rated power. At present there appears to be no publically available material demonstrating that efficiency tested at maximum power is also representative of cooker efficiency at other partial load settings. Therefore, as also noted in section 1.1.2, it is recommended that a technical study is undertaken to ascertain whether testing on maximum power does produce results representative of other partial load settings and, if not, to make suggestions to policy makers on how the test method might be revised to more accurately simulate the actual operating conditions, and hence allow more informed setting of resulting efficiency requirement to minimize actual energy consumption when product are in use by the consumer. Such data would also allow more accurate projections of current and future national energy consumption levels.

Stand-by power for these products is considered "off-mode" standby, i.e. the unit is connected to the power supply, but the unit is switched off.

1.3 Subsidy Information

To date, the national subsidy program has not applied to induction cookers although other promotional activities may have been used.

1.4 Data Analysis

The analysis examines the performance, energy and market related properties outlined in Table 5. It also details the number of models for which data was available for each property. Due to limitations of the source data and the data collection processes, it has not been possible to differentiate single-hob induction cookers from multi-hob types. However, as noted above, based on the preliminary market investigation, single-hob units are the dominant product type accounting for more than 90% of the models available.

In all cases, the analysis is conducted on model (*not* sales) basis. In addition to the generic cautions provided in Approach and Methodology, readers should note that not all performance and other parameters were available for all models identified as available in the market. Where a smaller number of products are included in any particular analysis, this is noted in the text. However, it has not been possible to estimate the bias this has introduced into the analysis for any given parameter.

Table 5: Overview of the data used for induction cooker analysis

Data type	Note
Total number of models	989. All these models are used for the analysis in this report unless otherwise noted.
Types	By number of hobs, both single hob and multi-hobs; By installation, both portable and built-in.
Energy efficiency (%)	Range 82-90
Maximum power of each heating hob (W)	Range 700-2800
Price /RMB	Range 99-4880
Standby Power (W)	Range 1-5

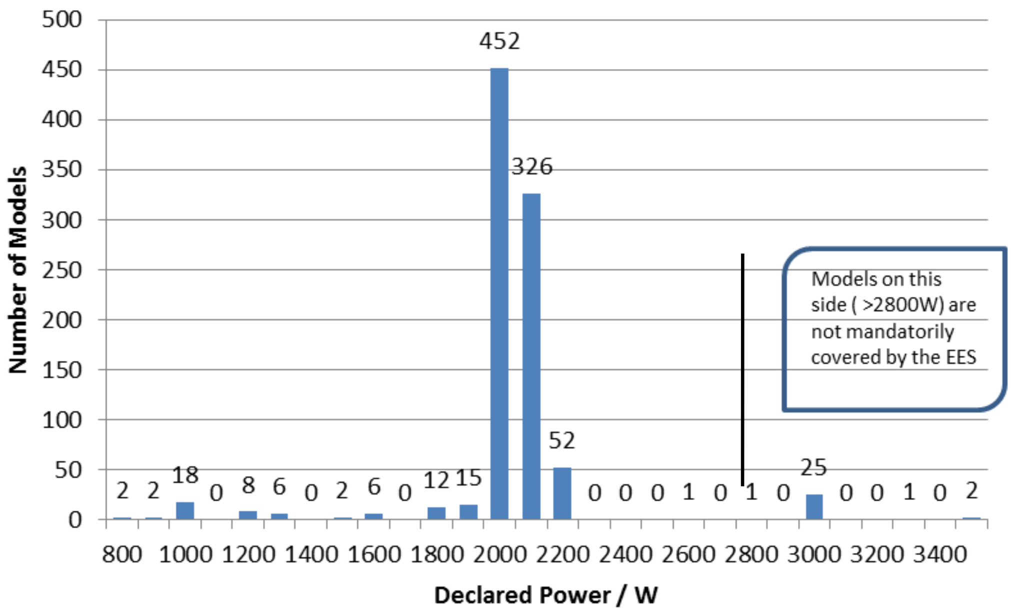
1.4.1 Product distribution by rated power

While the operating power of induction cookers is adjustable, it is the maximum rated power on which current the current EES (and consequently EET and MEPR) regulations are based (refer to section 1.2.1).

As Figure 6 illustrates, induction cookers with maximum powers of 2000W and 2100W dominate the market and account for 83% of all available models.

Although the EES includes induction cookers with maximum power as low as 700W, no model with maximum power lower than 800W was found in the market.

Figure 6: Distribution of maximum power of induction cookers in July 2012 (931 models*)



**Only 931 models out of 989 have data of declared Power.*

1.4.2 Energy consumption

At present the daily, weekly or annual energy consumption of the product is not required to be declared by manufacturers and thus it is not possible to present a market distribution of products by energy consumption. More importantly, given the current label simply requires the declaration of thermal efficiency and standby power, the consumer has no real idea of the true power consumption of the product, and thus the motivation to adopt more efficient products may be hampered.

1.4.3 Energy efficiency and energy efficiency Tier distribution

1.4.3.1 (Thermal) Energy efficiency distribution

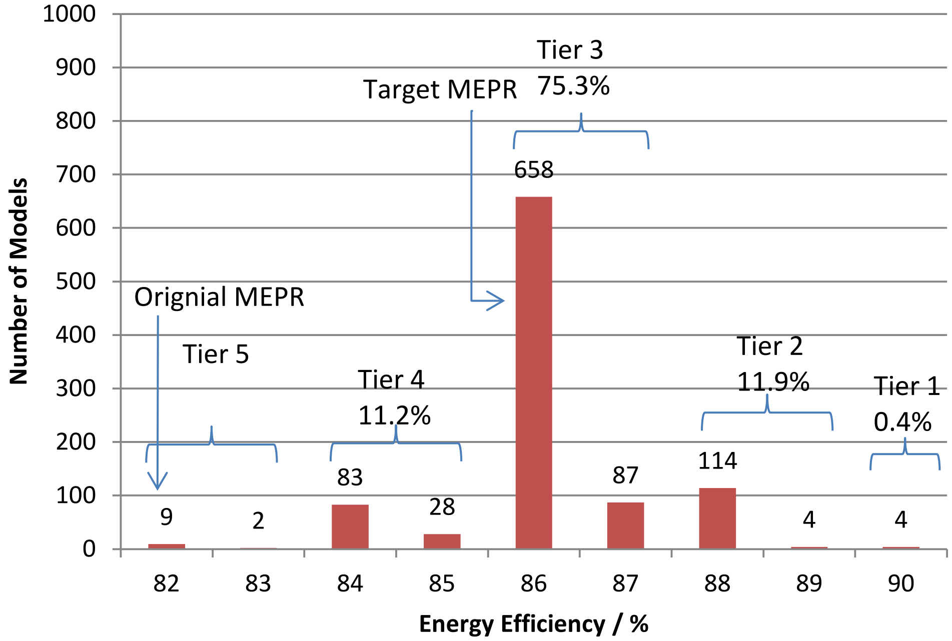
Figure 7 shows the distribution of available induction cookers in terms of thermal efficiency and their corresponding energy efficiency Tiers (noting that data was collected in July of 2012 and therefore models with Tier 4 and Tier 5 performance levels (12.3% of the total) could still legally be sold as the revised MEPR at the Tier 3 lower threshold did not come into force unit September 2012)[36].

The majority of induction cookers models fall into Tier 3 (86% - 87% thermal efficiency). They account for a dominant market share of 75.3%. Tier 1 and Tier 2 models, which are regarded as the energy efficient products, have a combined market share of 12.3% with Tier 1 models representing only 0.4% of the market. No product with efficiency over 90% is available.

It is interesting to note manufacturers appear to be developing products where declared energy efficiencies align with the minimum requirement of each respective Tier. For example, out of 745 models in Tier 3, 658 models are declared at 86% efficiency, i.e. the minimum efficiency requirement for Tier 3. Similar patterns are also observed for standby power. Overall, 88% and 91% of all models set their declared efficiencies and standby power to the minimum requirements of the Tier for which they are registered. This appears to indicate manufacturers have very accurate control of production for this product and tolerances in the test method and declarations can be limited to those necessary for the testing equipment.

[36] Note that it is not clear how many models that fail to meet the thermal requirement also fail to meet the new MEPR standby requirement as noted in the following section. If the models that fail to meet the new efficiency or standby are the same, this would mean the new MEPR will remove the 12.3% of models noted here. However, if some models meet either the new efficiency or standby, but fail to meet the other requirement, it is possible that over 20% of models could be removed from the market by the new MEPR requirement.

Figure 7: Distribution of (thermal) energy efficiency of induction cookers and associated energy efficiency Tier values in July 2012

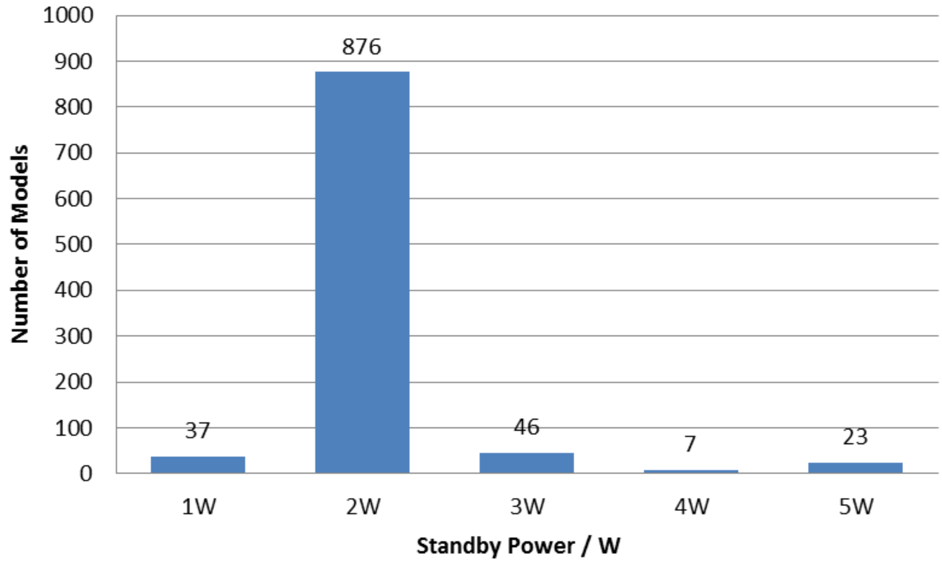


1.4.3.2 Standby power distribution

The distribution of the stand-by power of available models is shown in Figure 8.
As can be seen, in July 2012 well over 90% of models met the 2W MEPR requirement enforceable as of September 2012, although less than 4% achieve a 1W rating. Around 8% of models fail to meet the 2W level, but it is assumed these models are no longer in the market following the introduction of the new MEPR requirements.

It is interesting to note that all product declarations are in 1W increments, i.e. no products declare values such as 1.2W. This makes further revisions to the standby requirements challenging as policy makers have no idea of the true distribution of standby power of these units based on current declarations. Therefore, it is recommended that manufacturers are required to declare actual test values on registration (and on the product label should standby continue to be included) based 0.1W intervals.

Figure 8: Distribution of standby power of induction cookers in July 2012

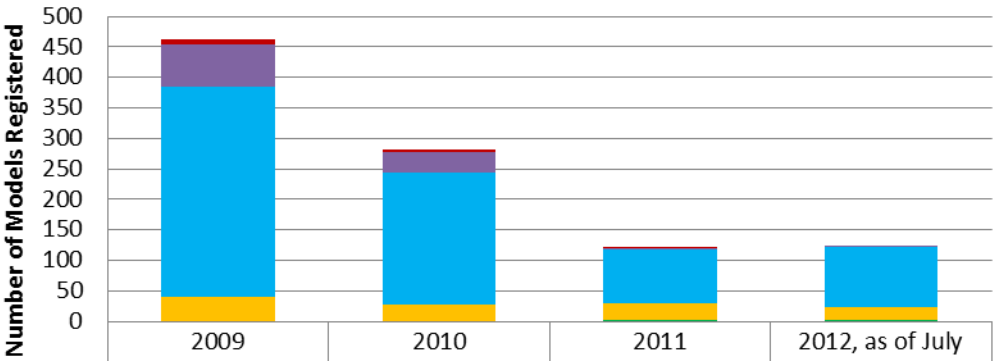


1.4.3.3 Evolution of energy efficiency and standby power over time

When first introduced in 2008, the EES clearly signaled the introduction of the revised MEPR to be introduced in 2012. Figure 9 and Figure 10 show the number of models registered for sale from 2009 to (July) 2012.

It is evident that starting from 2011, the number of newly registered induction cookers under Tier 4 and Tier 5 of energy efficiency and over 3W of standby power start diminishing. This appear to be strongly related to the September 2012 MEPR requirement and demonstrates that early signaling of regulatory revisions can be useful in allowing manufacturers time to respond to revised regulatory requirements.

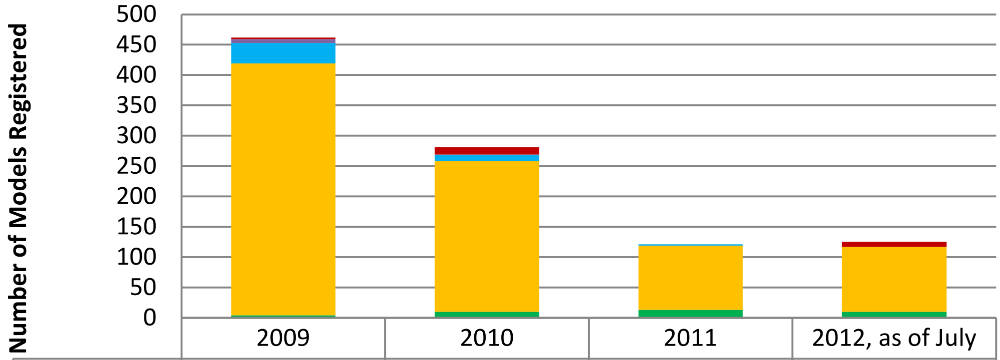
Figure 9: Distribution of (thermal) energy efficiency of induction cookers entered the market between 2009 and (July) 2012



	2009	2010	2011	2012, as of July
Tier 5	7	3	1	0
Tier 4	70	35	3	3
Tier 3	345	215	88	98
Tier 2	40	28	27	22
Tier 1	0	0	2	2

Product Market-Entry Time

Figure 10: Distribution of the stand-by power of induction cookers entered the market between 2009 and (July) 2012



	2009	2010	2011	2012, as of July
Standby 5W	3	12	0	8
Standby 4W	6	1	0	0
Standby 3W	34	10	2	0
Standby 2W	415	248	106	107
Standby 1W	4	10	13	10

Product Market-Entry Time

However, the number of registrations for induction cookers with higher energy efficiencies (Tier 1 and Tier 2 models) has remained relatively low with the total number of products registered under Tier 1 and Tier 2 in July 2012 still only 15% of the market (refer Figure 7). The lack of products registered in Tiers 1 and 2 seems to indicate that manufacturers do not feel consumers are responding to induction cookers with higher efficiency claims. Thus, it appears that, for induction cookers, policy makers may have to drive improvements in efficiency through regulatory means. Hence, policy makers may wish to consider:

- The introduction of incentives to encourage manufacturers to develop and register products in (new) higher efficiency Tiers. One option could be to subsidize induction cookers with thermal energy efficiency equal to or over 88% and standby power no greater than 2W. For products with thermal efficiency of 90% and standby power of 1W or even higher energy performance, the amount of subsidy could be greater still. This would lead the market and therefore the industry toward more efficient induction cookers. However, if such recommendation is adopted, cautions are needed as noted in the analysis in section 1.4.4.
- In parallel with the recommendations above, the impact of the incentive policy can be used to revise the EET requirements based on the new market. One option could be a 2% step, i.e. eliminating current Tier 3, and moving current Tier 1 and 2 to be the new Tier 2 and 3. The Tier 1 requirement could then be set at 92% efficiency. For standby power, it is recommended that Tier 3 be set at 2W, and Tier 1 and Tier 2 at 1W. However, the option above could be flexible. If the 2% step increment for Tier 1 is considered too ambitious for the market after support from the incentive policies, an alternative of 1% could be adopted for Tier 1 efficiency (i.e. 91% efficiency). Again, standby would be set at 2W for Tier 3 and 1W for Tier 1 and 2.

1.4.4 Relationship between price and energy efficiency

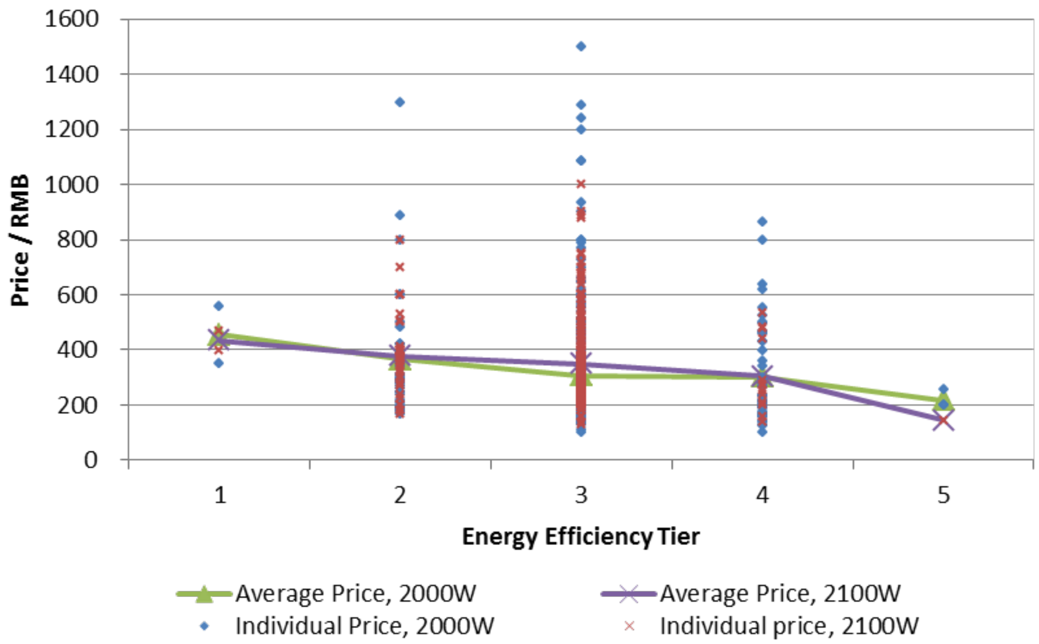
Induction cooker price potentially varies with its power. Therefore, in order to make fair comparisons, this analysis investigates the correlation between price and energy efficiency based on the models with the same power rating. Induction cookers with maximum power of 2000W and 2100W represent over 85% of the models available in 2012 and thus have been selected for this analysis. The number of products included in the analysis is shown in Table 6 (noting that there are few products in Tier 1 or Tier 5 and therefore values in these Tiers should be treated with particular caution).

Table 6: Total number of induction cooker models included in the analysis of the relationship between price and energy efficiency (2000-2100W only, available in July 2012)

Tiers	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
Number of Models, 2000W	2	42	350	52	3
Number of Models, 2100W	2	43	263	13	1

Figure 11 clearly illustrates that, while the *average* price seems to increase with higher EETs, the actual spread of prices within each Tier is substantial. This seems to imply that the price of the product is more related to factors such as brand, design, size, functionality and number of hobs rather than only the efficiency of the induction cookers. Hence, it is important that the subsidies are used for the improvement of energy efficiency rather than paying for other factors or functionalities. In order to ensure this, policy makers may need to investigate on the relationship between product cost and energy efficiency before issuing the subsidy policy.

Figure 11: Individual model and average price of EET Tier 1-5 for induction cookers with power 2000-2100W available in the market in July 2012



The inclusion of *actual* daily, weekly or annual energy consumption on the label may also assist in focusing consumer attention on the energy consumption of the product in addition to other product features.

1.5 Conclusions and Recommendations

The conclusions and recommendations drawn for induction cookers are:

Test methodology and tolerances

The energy efficiency of induction cookers is calculated based on tests at maximum power. However, it is likely that this may not represent the normal operating conditions employed by the consumer which are more likely to be in the range 50%-80% of the unit's maximum rated power. At present there appears to be no publically available material demonstrating that efficiency tested at maximum power is also representative of cooker efficiency at other partial load settings. Therefore, policy makers may wish to consider:

1. A technical study is undertaken to ascertain whether testing on maximum power does produce results representative of other partial load settings and, if not, to make suggestions to policy makers on how the test method might be revised to more accurately simulate the actual operating conditions. This should allow more informed setting of resulting efficiency requirement to minimize actual energy consumption when product are in use by the consumer, and to provide better information on which to base projections for future national energy consumption.
2. On a related issue, policy makers may wish to require manufacturers to declare *actual* test values for both thermal efficiency and stand-by power during product registration (and possibly on the energy label), and that these test value should be representative of a typical production model. This will assist in future policy making as more accurate information will be able to assess if and when further policy intervention can be undertaken.

Revisions to the energy efficiency standard and efficiency label

At present it appears there is no incentive for manufacturers to produce products of higher efficiency as the number of registrations for induction cookers with higher energy efficiencies (Tier 1 and Tier 2 models) has remained relatively low; the total number of products registered under Tier 1 and Tier 2 being only 15% of the market. One of the reasons might be the price of the product is more related to factors such as brand, design, size, functionality and number of hobs rather than only efficiency.

Thus, it appears policy makers may have to drive improvements in efficiency through regulatory measures. Hence, policy makers may wish to consider:

3. The introduction of incentives to encourage manufacturers to develop products in (new) higher efficiency Tiers. However, it is important that the subsidy is used for the improvement of energy efficiency rather than paying for other factors or functionalities. In order to ensure this, policy makers may need to investigate on the relationship between product cost and energy efficiency before issuing the subsidy policy
4. In parallel with the recommendations above, the impact of the incentive policy can be used to revise the EET requirements based on the new market. One option could

be a 2% step, i.e. eliminating current Tier 3, and moving current Tier 1 and 2 to be the new Tier 2 and 3. The Tier 1 requirement could then be set at 92% efficiency. For standby power, it is recommended that Tier 3 be set at 2W, and Tier 1 and Tier 2 at 1W. However, the option above could be flexible. If the 2% step increment for Tier 1 is considered too ambitious for the market after support from the incentive policies, an alternative of 1% could be adopted for Tier 1 efficiency (i.e. 91% efficiency). Again, standby would be set at 2W for Tier 3 and 1W for Tier 1 and 2.

5. Including the typical daily, weekly or annual energy consumption on the product label so consumers are aware of potential energy consumption rather than the rather abstract thermal efficiency value quoted. Working in combination with the recently policy introducing tiered electricity pricing, such an addition of actually energy consumption may raise the profile of efficiency in the consumer's purchasing decision.

1.6 Addendum: Analysis of the new draft energy efficiency standard for induction cookers

Before this report was completed, a revised draft EES for induction cookers was published. Although the version was "for comment" and so is technically subject to change, it is worthwhile analyzing the likely influence it will have on the Chinese induction cooker market if adopted in the current form.

The new draft EES differs from the current version in three respects:

- Product scope;
- Test method for energy efficiency;
- Energy efficiency Tier requirements.

A1. The product scope has been expanded to include induction cookers with rated power up to 3500W, while the current EES only regulates those no higher than 2800W. From the data collected from the market, at the moment the highest rated power of induction cookers is 3500W. This shows that policy makers are trying to cover induction cookers of all power range in the new EES. This is a highly desirable move and should make the new EES more influential on the market.

A2. There is only one word changed in the test method. The test method in the current EES says "t_2", the maximum achievable temperature after the induction cooker is switched off, "should be read from the thermometer ***within*** 1 minute"; while the new draft EES says "t_2 should be read ***after*** 1 minute". "t_2" is used to calculate the theoretical energy consumption by the water and the standard vessel. Currently, there is no evidence showing which direction this change of the test method would lead to, i.e. whether "t_2" would be lower or higher. However, it's believed that the difference will be minor, thus this change has been ignored for the comparison and analysis below on the current and new proposed energy efficiency requirements.

A3. Table 7 **d**etails the energy efficiency requirements in the original, current EES and the new draft. The new draft has changed in the following respects:

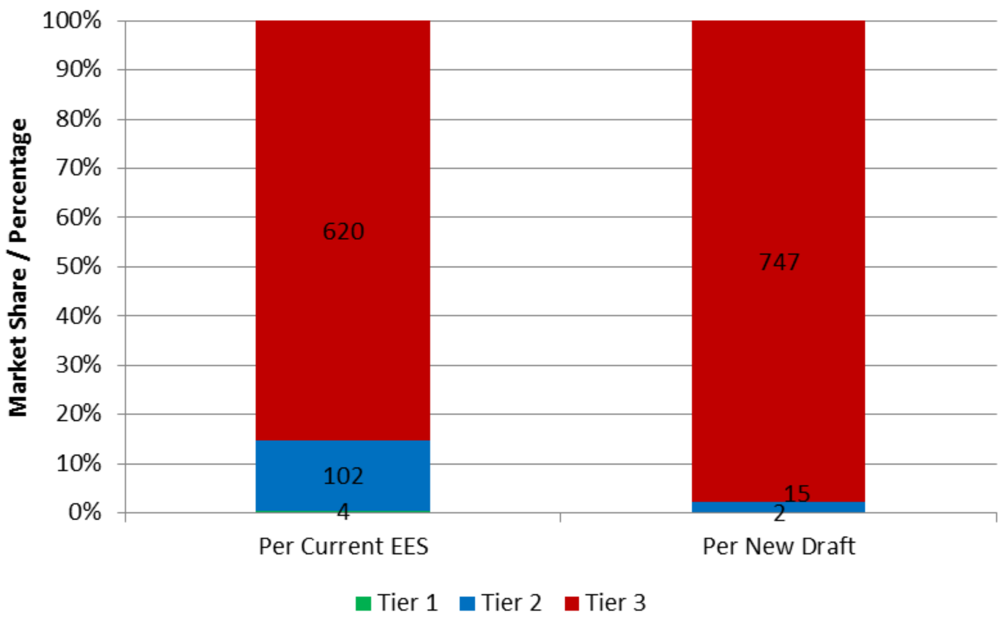
1. The efficiency requirements are set differently for different power ranges making the requirements less stringent for induction cookers with rated power below 1200W. However, requirements remain the same for induction cookers over 1200W.
2. Requirements of standby power are more stringent for products of Tier 1 and 2.

Table 7: Energy efficiency Tier requirements in the original, current and new draft energy efficiency standards

EET	Original EES (when GB 21456-2008 first implemented)		Current EES (with Target MEPR in the original EES implemented)		New Draft		
	Efficiency, all power	Standby Power (W)	Efficiency, all power	Standby Power (W)	Efficiency		Standby Power (W)
					<=1200W	>1200W	
1	90	2	90	2	88	90	1
2	88	2	88	2	86	88	1
3	86	5	86	2	84	86	2
4	84	5	/				
5	82	5					

Figure 12 shows the distribution of products within each energy efficiency tier based on the current EES and the new draft. As could be seen, the new draft has significantly reduced the proportion of energy efficient products, i.e. Tier 1 and 2 products. However, this is likely to be due to the increased stringency in standby power requirements as thermal efficiency, which is more important in terms of energy saving, remains broadly unchanged. It is therefore recommended that policy makers consider further revision to the draft EES in terms of energy efficiency requirements by adopting the recommendations in section 1.5.

Figure 12: Distribution of products within each energy efficiency Tiers based on the current EES and the new draft*



**Please note that because the product scope and the requirements of energy efficiency and standby power are all different between the current EES and the new draft, the total number of product models under each EES is different.*

Section 2: Analysis of the Market and Product Performance of Computer Monitors

Computer monitors are of importance as product numbers are rising in all sectors due to the increasing economic activity levels in the commercial and industrial fields, and the increasing disposable income of domestic consumers. Projections made as part of this analysis[37] indicate that the number of monitors installed will rise from approximately 70 million in 2006, to 255 million in 2030. The business as usual scenario indicates that by 2030, monitors would be using approximately 15 TWh/yr of electricity. Such projections clearly demonstrate the need to address the energy efficiency and overall consumption of computer monitors at the earliest possible opportunity.

2.1 Product Background

Within the context of this report and Chinese regulations, computer monitors can broadly be defined as non-integrated display units for computers. The review encompasses monitors used in all end user environments, i.e. domestic, commercial and industrial. While there are some very large monitors available on the market, these are relatively few in number and hence the analysis focuses on the monitors where screen size is below 30 inches.

Traditionally monitors were of Cathode Ray Tube (CRT) design, but such models have all but disappeared from the market and have been replaced by Liquid Crystal Display (LCD) units with back lighting provided by either "Cold-Cathode" Compact Fluorescent Lighting (CCFL) or Lighting Emitting Diode (LED) technologies.

2.1.1 Production, sales and stock level

Accurate Chinese production and net export/import data could not be found for computer monitors. However, projections made as part of the preparation of this report[37] estimate that, over the six year period 2006-2011, annual sales of computer monitors have risen from 24 million to 36 million units per year, with the installed stock more than doubling from approximately 70 million to almost 150 million units. Current projections[37] indicate that these stock levels will continue to rise rapidly to approximately 255million units by 2030. Under a business as usual scenario, the resulting energy consumption of monitors is projected to increase from 10,500GWh/yr to 15,200GWh/yr by 2030.

2.1.2 Usage patterns

Little information is known on the true usage patterns of monitors within China. However, the projection of future energy consumption under different regulatory conditions is highly dependent on the specific consumer usage patterns. As these projections are critical in the development of appropriate energy efficiency standards, it is recommended that policy makers initiate research to establish true consumer usage patterns to enable more informed standards development in the future.

[37] Energy Saving Potential (ESP) Study for Nine Appliances in China, CLASP 2013.

To allow for the energy consumption and other projections made in this report, estimates of usage patterns have been developed based on the little data available. Average monitor usage is currently estimated to be 5 hours per day in on mode, 9.5 hours per day in standby (off-mode) and 9.5 hours per day with no power supplied to the unit[38].

2.2 Regulation, Labeling and MEPS

2.2.1 Energy efficiency standard

The energy efficiency standard (EES) for computer monitors is also GB 21520-2008[39]. The EES uses an energy efficiency performance metric (referred to in the standard as EFF) and off mode standby power as the main efficiency indicators. The EFF is calculated by the following formula:

EFF = (luminance × screen area) / power consumed by the unit

The EES sets three energy efficiency Tiers (EET) as illustrated in Table 8 (note that the standard does not provide separate performance requirements for LCD monitors that are backlight by CCFL and LED technologies). The EES also specifies a minimum energy performance requirement (MEPR) that all monitors must satisfy at the lower boundary value of Tier 3. This MEPR threshold was increased to the lower threshold of Tier 2 from November 2011[40], in line with the timeframes set in GB 21250-2008.

Table 8 shows the energy efficiency performance and standby power threshold values for the EETs, and consequently the first and second MEPR.

Table 8: Minimum efficiency requirements of Tiers in GB 21520-2008

Product Type	Energy Efficiency Tier					
	Tier 1		**Tier 2**		**Tier 3**	
	EFF (cd/W)	**Standby (W)**	**Eff (cd/W)**	**Standby (W)**	**EFF (cd/W)**	**Standby (W)**
CRT[41]	0.18	1	0.16	3	0.14	5
LCD	1.05	0.5	0.85	1	0.60	2

2.2.2 Energy labeling of monitors

In October 2008, the Chinese government announced that monitors would be covered by the China Energy Label Scheme. Labeling of monitors became mandatory from 1st March 2009.

[38] Energy Saving Potential (ESP) Study for Nine Appliances in China, CLASP 2013.
[39] Note that the EES is contained in the same document as the test method.
[40] Refer to http://www.energylabel.gov.cn/NewsDetail.aspx?Title=%E8%83%BD%E6%95%88%E6%96%B0%E9%97%BB&CID=44&ID=939
[41] The standard provides performance requirements for CRT units, but there are almost no CRT products available in the market.

The energy label for monitors (shown in Figure 13) has three Tiers aligning with the EETs. In addition to the indicator showing the specific energy efficiency Tier of the monitor, the label also includes basic identification information of the model, the EFF value, and off-mode standby power. On-mode power, luminance and screen area are not disclosed by the label.

Figure 13: China Energy Label for Computer Monitors

The aim of the energy label is to guide the consumer to better (energy) performing products. However, the MEPR value has been revised to the lower boundary of Tier 2 which means only products in Tiers 1 and 2 are now available in the market. As the labeling boundaries align with the EET thresholds, consumers may be misled into thinking that Tier 2 products are of reasonable performance, when in fact they are the worst products now allowed in the market. Additionally, there is no indication on the label of the *actual energy* consumption of the monitor. Therefore a consumer may chose a high efficiency monitor, but that monitor may still use substantially more energy than an alternative of smaller screen size. However, the consumer would be unaware of this. Further, there is little evidence to suggest the consumer will understand the significance of the EFF value, nor the standby power value, quoted on the label.

Hence, it is probable the current information on the label is unlikely to impact the consumer choice as desired. Therefore, to improve transparency to the consumer and improve their ability to preferentially select lower energy consuming products at the time of purchase, policy makers may wish to consider:

- A revision of the energy efficiency standard: Increase the performance requirement of Tier 1, and revise Tier 2 and 3 threshold levels to provide a clear choice to consumers of available products in all three performance Tiers shown on the label.
- A slight revision to the information declared on the label. A potential improvement would be the replacement of the declaration of the monitor's EFF

value with the (to consumers) more useful rated power of the product. While still not giving the consumer full information on the energy consumption of the monitor, it will at least provide consumers with a measure of the comparative power (and hence probable energy) consumption of the monitor. Further, should the research on consumer usage patterns be undertaken as recommended in section 2.1.2, this labeled power measurement could actually be replaced with a typical daily, weekly or annual energy consumption of the monitor. Such a revision would not only provide more useful decision making information for the consumer, but would more accurate reflect the real difference in power demand/energy consumption between models which may be useful to policy makers in future policy development.

2.2.3 Test Method

The test method used for computer monitors is GB 21520-2008. The standard was published in April 2008 and came into force in November of the same year. The standard is unique to China with no similar international test method. Among other specifications, the test method defines the method for measuring screen area, luminance, on mode power and (off mode) standby power.

> ***Luminance*** *is measured at the centre point of a static white display (candela – cd).*
>
> ***On-mode power*** *is the average power consumption during the luminance test in Watts (W).*
>
> ***(Off-mode) Standby power*** *is the average power consumption in Watts (W) of the monitor when connected to the power source but with the power switch on and the monitor switched off (which differs from many international measures which have the power button switched to "on") .*

2.3 Subsidy Information

To date, the national subsidy program has not applied to computer monitors.

2.4 Data Analysis

Data used in the analysis of monitors is based on a snap shot of models available in the market in July 2012. The analysis examines the performance, energy and market related properties outlined in Table 9. It also details the number of models for which data was available for each product property.

In addition to the generic cautions provided in the report's introductory section on Approach and Methodology, readers should note that not all performance and other parameters are available for all models identified. The specific number of models where each product property was known, and hence included in the analysis, is indicated in Table 9. However, it has not been possible to estimate the bias this has introduced into the analysis for any given parameter.

Table 9: Overview of the data used for the analysis of PC monitors

Data type	Notes
Models	760
Screen size	Range: 12 - 30
Energy efficiency Tier	Range: 1 - 2
Energy efficiency performance (cd/W)	Range: 0.85 - 1.80
On mode power (W)	Range: 10 - 80
Standby power (W)	Range: 0 - 1
Price (RMB)	Range: 500 - 3500

2.4.1 Product distribution

As noted above, although the GB 21520-2008 standard sets the requirements for CRT monitors, there are almost no CRT monitors on the market. For LCD monitors, the standard does not differentiate between the two main backlighting technologies, i.e. CCFL and LED.

CCFL and LED backlit monitors currently have an almost equal share of the market as illustrated in Figure 14. Due to developments in technology and manufacturing, international experience (and anecdotal information from China) suggests the cost of the LED monitors is decreasing significantly and their market share is anticipated to increase.

Figure 14: Market share of LCD monitors by backlighting technology (July 2012)

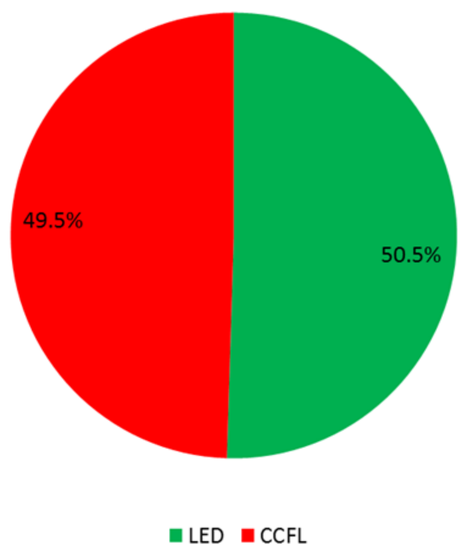
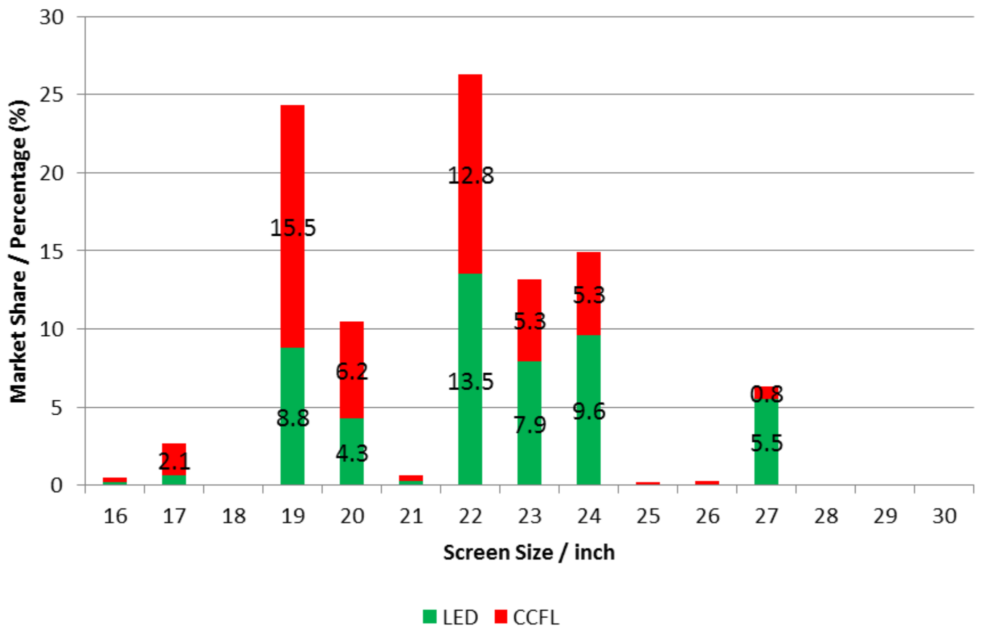


Figure 15 illustrates, of the models available in the market, screen sizes concentrate between 19 and 24 inches (noting the analysis is limited to units with screen size of 30 inches or less). For the monitors with screen size below 20 inches, CCFL backlighting technologies have a higher penetration than LEDs. The reverse is true for monitors with screen sizes above 22 inches. The relative proportion of each technology increases as the monitors get smaller and larger respectively.

Figure 15: Market share of monitors by screen size and backlighting technology (July 2012)



2.4.2 Energy Consumption

Generally, the on-mode power consumption of monitors has a close relationship with the monitor screen size, with power consumption increasing along with screen sizes[42]. However, for all but the 27 inch screen size, the on-mode power consumption of LED monitors is typically 40-60% lower than that of CCFL monitors, (see Figure 16).

Off-mode power has no correlation with the screen size, but again, the off-mode power of the LED monitors is still lower than that of CCFL monitors, typically around 30% less (see Figure 17).

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[42] Note that that this trend breaks down at the 22-24inch screen range for both LEDs and CCFL units. There is insufficient data to establish why this is the case, but it may be due to the popularity of this product size and the desire for manufacturers to initial bring new products to market in this size range before expanding into other size ranges. Hence models in this size range may be the newest designs with improved power management systems. There seems value in investigating this anomaly further to establish if this is the case as, if so, closely following the market trends in this screen size may lead to indications of how the market will develop for all other screen sizes in the future. This information would I be particularly helpful in the future development of EES thresholds.

Figure 16: Average on-mode power consumption of monitors by screen size and backlighting technology (July 2012)

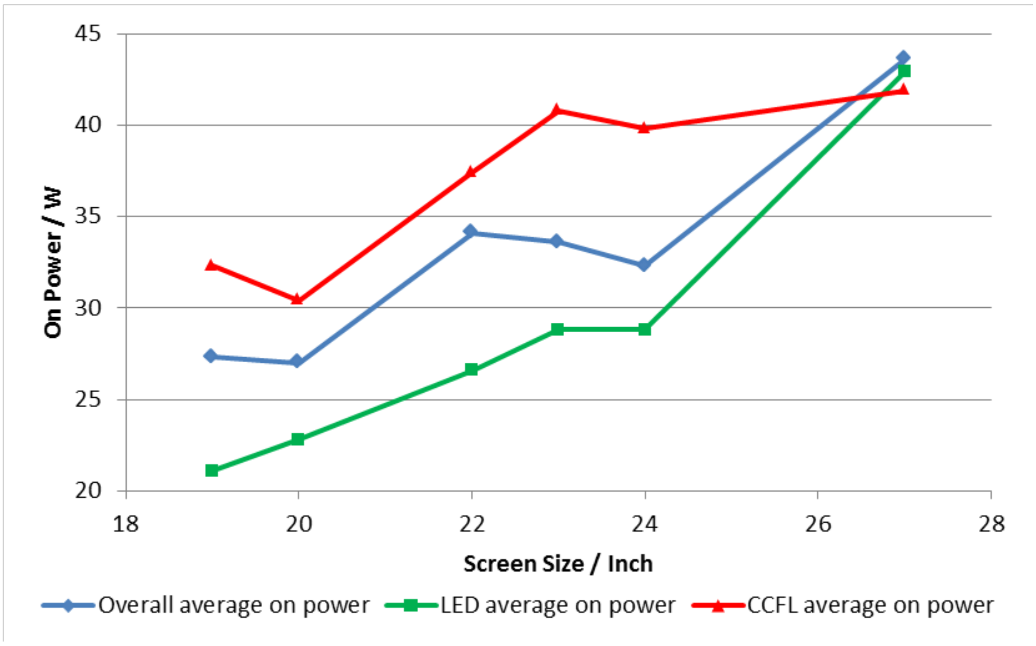
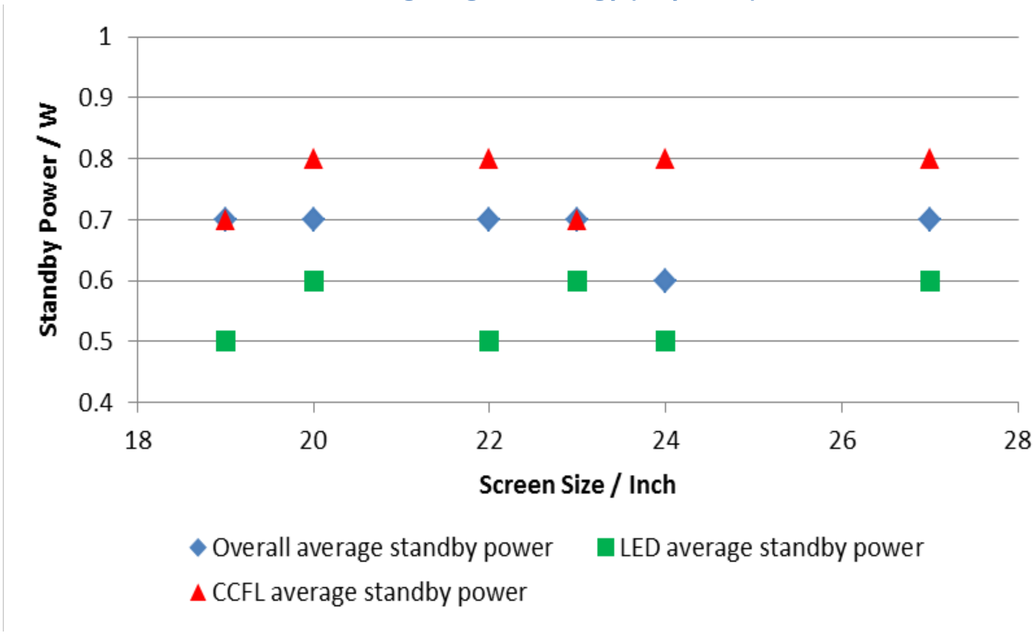


Figure 17: Average off-mode power consumption of monitors by screen size and backlighting technology (July 2012)



2.4.3 Energy Efficiency

2.4.3.1 Energy efficiency Tier distribution

As noted previously, the METR level introduced in 2011 restricts the sale of monitors to EET levels 1 and 2 only (the lower limit of Tier 2 being the METR level). In July 2012, the share of Tier 2 products available in the market was approximately 10% higher than available Tier 1 products, although the Tier 1 products still constitute approximately 45% of the market. The majority of the Tier 2 products are CCFLs, while approximately 70% of Tier 1 products are LEDs (see Figure 18). When looking at the most popular screen sizes (19-27 inches), the proportion of Tier 1 and Tier 2 products remains broadly similar to the 55:45 ratio for all products (see Figure 19).

Hence, the current distribution of products does not align with the stated policy objective of Tier 1 and 2 products denoting the most efficient products on the market, in this case Tier 1 and 2 cover *all* products on the market. Further, as noted in section 2.2.2, there is a need to revise the labeling thresholds to allow consumers more choice to preferentially select the most efficient products by having products in all three performance Tiers shown on the label.

Figure 18: Distribution of monitors by energy efficiency Tiers (July 2012)

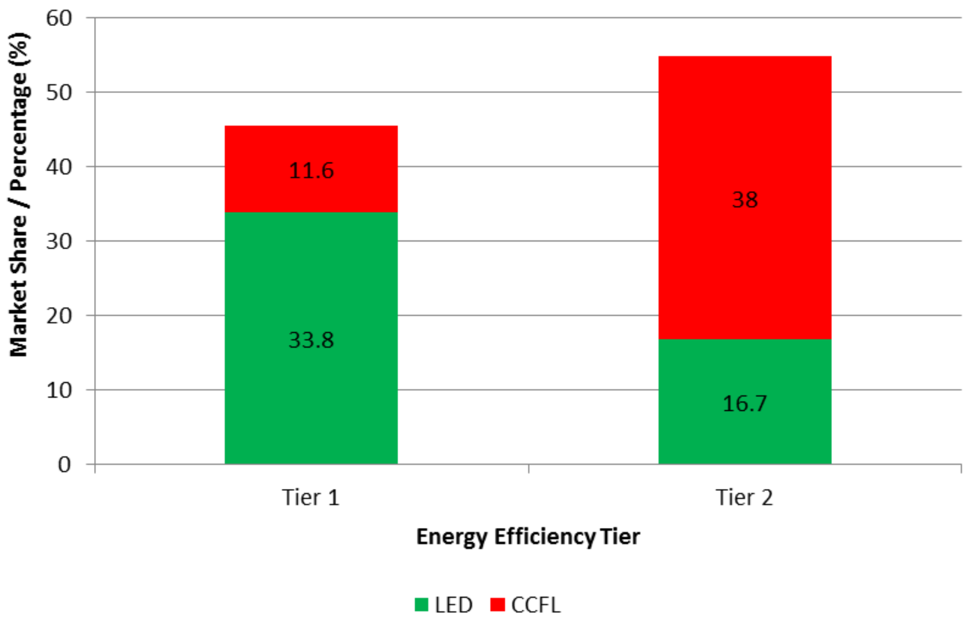
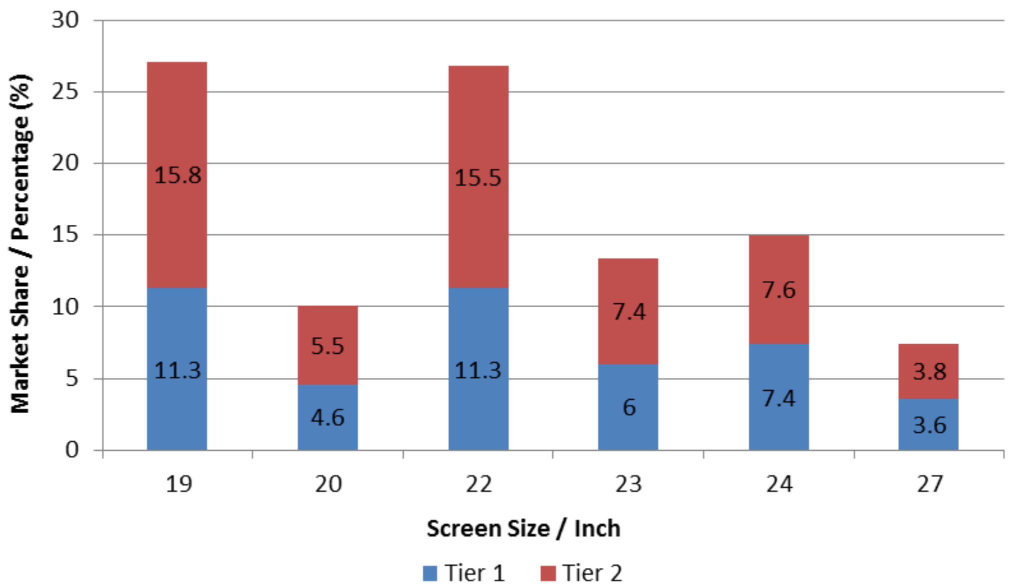


Figure 19: Distribution of monitor by energy efficiency Tier and screen sizes (July 2012)



The fact that 45% of products are currently Tier 1 clearly demonstrates the opportunity to revise the labeling thresholds to introduce a further band above the current Tier 1 threshold (i.e. revising the EET requirements such that current Tier 1 and 2 thresholds become the thresholds for Tiers 2 and 3 respectively, with new premium performance level created for Tier 1). Such action will create more transparent choice for consumers. The action will also create incentives for manufacturers to remove products from lowest Tier 3 level so their products do not appear to be inferior, and increase the likelihood of new product introductions being of higher efficiency.

2.4.3.2 Energy efficiency performance and (off-mode) standby power declarations

As Figure 20 illustrates, most of values for EFF declared on the monitor energy labels concentrate at two points, 0.85 and 1.05. These levels exactly match the EET thresholds for Tier 1 and Tier 2. A similar predominance of models have declared (off-mode) standby power at the Tier 1 and Tier 2 EET threshold values (0.5W and 1W respectively) as illustrated in Figure 21.

This implies either:

- Manufacturers have very accurate control of the design and production of televisions and can deliver products that are just at the boundary conditions.
- Manufacturers are over reporting the performance of products, for example declaring the lowest value of the EET Tier above that which their products qualify to appear more efficient.
- Manufacturers are under reporting the performance of products, for example declaring the lowest value within the EET Tier to which their products qualify to ensure their products pass any verification testing undertaken by the regulator.

Figure 20: Distribution of monitor by energy efficiency and backlighting technology (July 2012)

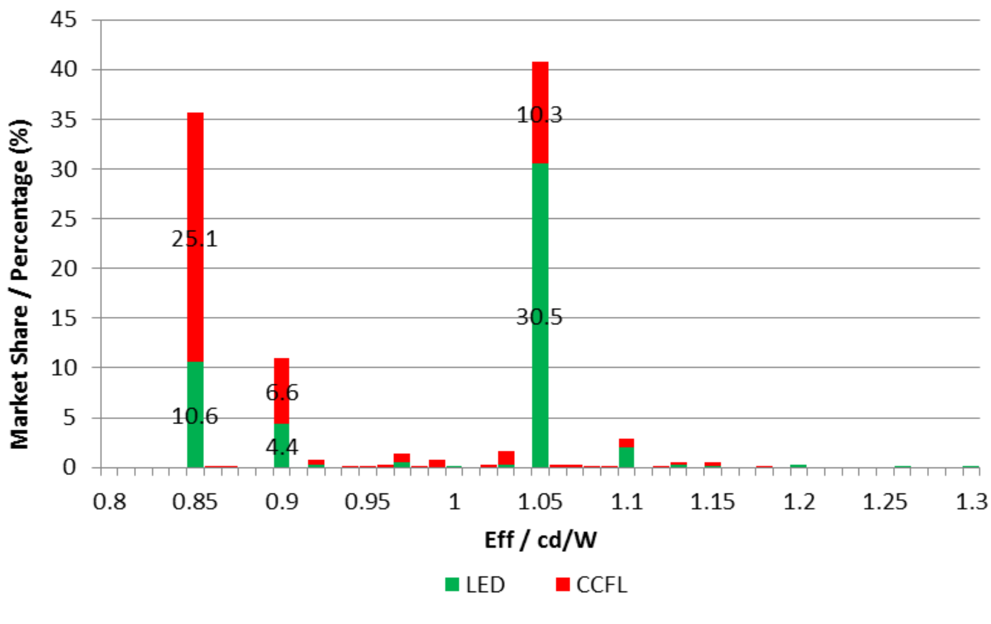
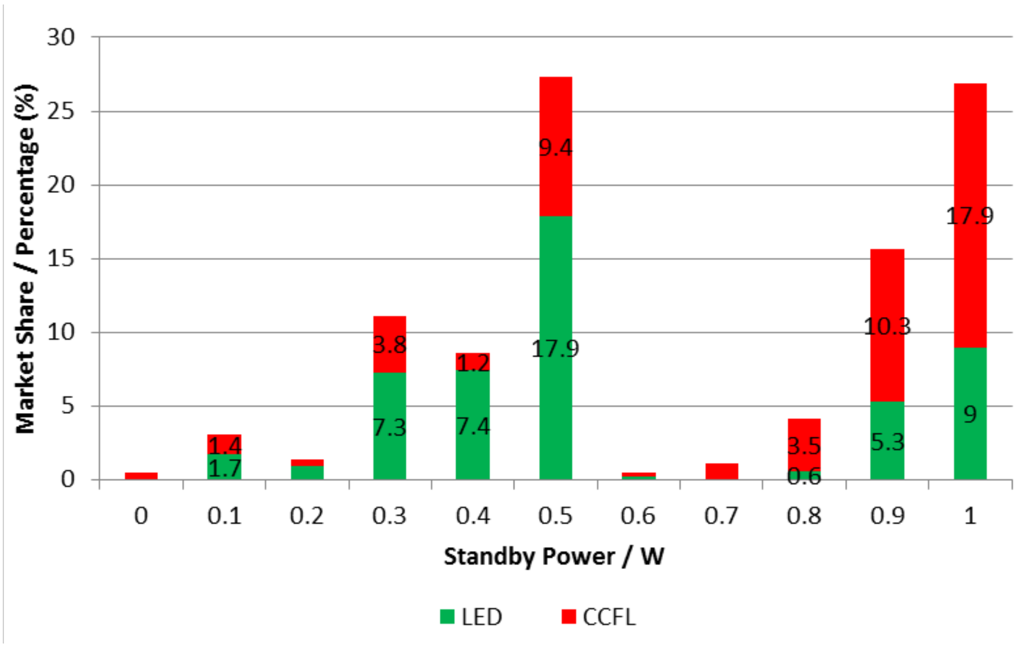


Figure 21: Distribution of monitor by (off mode) standby power and backlighting technology (July 2012)



Until relatively recently, there was limited evidence to give an indication of which of these reasons has led to the declaration of monitor performance at levels just above the threshold limits. However, in 2009 Top10[43] sampled 10 monitors from the market, all with labeled EFF value of 1.05 cd/W, i.e. just meeting the minimum requirements of EET Tier 1. The samples were then independently tested for EEF and standby power consumption[44]. The labeled and tested EFF values for each monitor tested are shown Figure 21.

In all cases the tested EFF values are higher than 1.05cd/W, in some cases significantly so with the highest EFF test value of the models tested at 1.8 cd/W, i.e. 70% more efficient than the value claimed. A similar situation of test values being significantly below declared values is found when in (off-mode) standby power (Figure 23) although fewer of the declared values are on the Tier 1 and Tier 2 boundary levels.

Hence, within the samples tested, it is very clear that the manufacturers are under-declaring product efficiencies. There is strong anecdotal evidence to suggest such under-declaration is repeated for a large percentage of models that are registered at the Tier 1 and Tier 2 boundary points. As noted above, this is denying consumers the opportunity to see true product performance, and potentially hampering the development of future EES and subsidy strategies.

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[43] See www.top10.cn/?page=English

[44] Tests were conducted by an independent laboratory, China Household Electrical Appliance Research Center (CHEARI), following the GB 21520-2008 test procedure.

Figure 22: Labeled and tested values for efficiency (EFF cd/W) for 10 monitors (Top10 tests 2009)

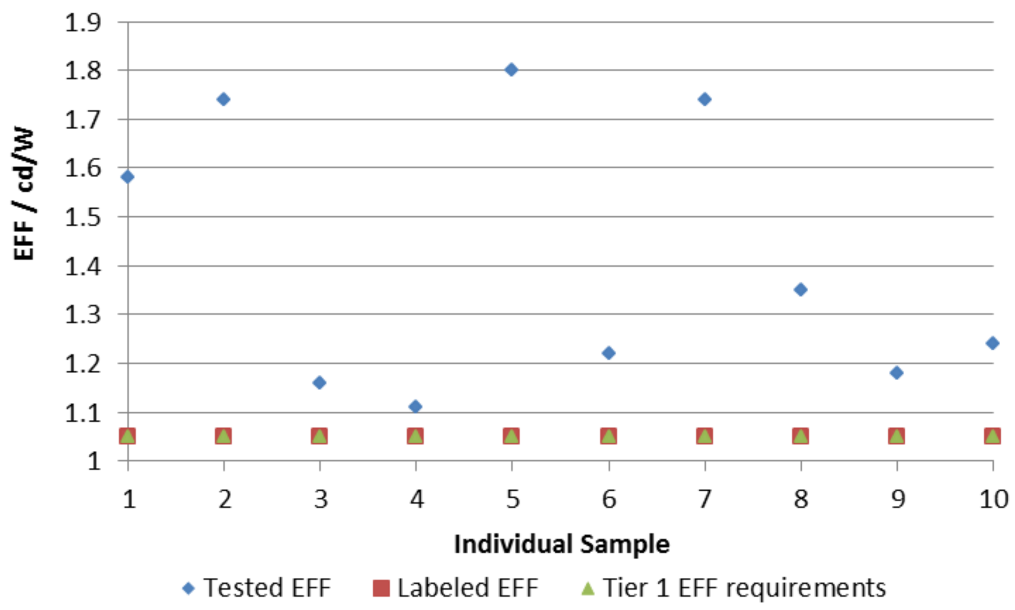
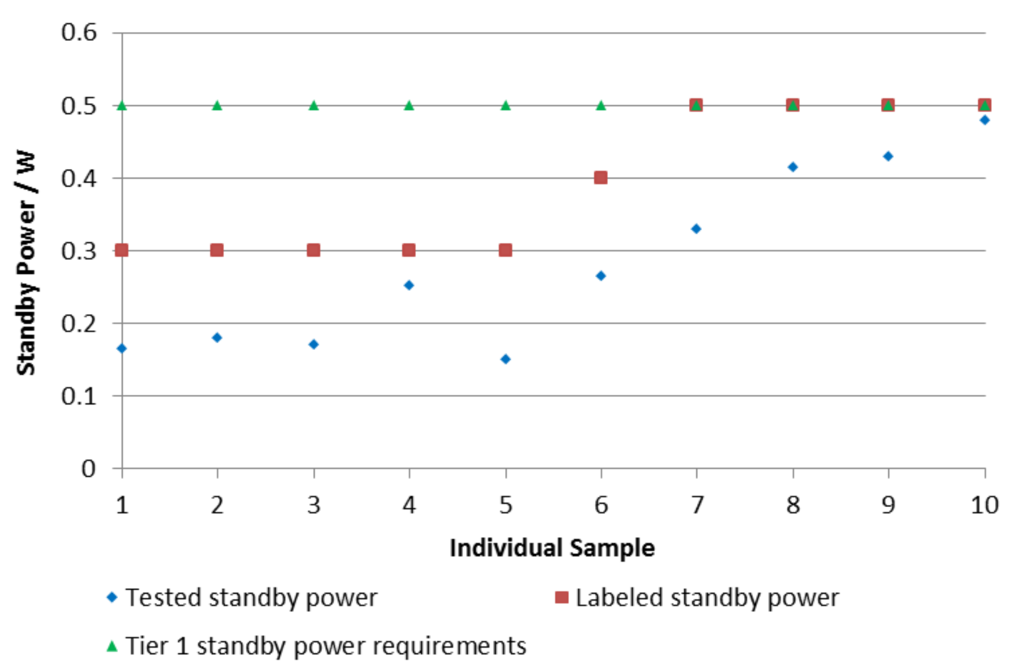


Figure 23: Labeled and tested values for (off-mode) standby power for 10 monitors (Top10 tests 2009)



This evidence leads us to two conclusions and associated recommendations:

- The current information declared on monitor labels is misleading to consumers, and not allowing reasonable comparison of product performance. Hence, it is recommended that policy makers insist claims made on product labeling must align with actual testing reports submitted in support labeling registration applications, and that these reports must represent the performance of typical products. Such action will allow consumers more accurate information on the product performance and thus facilitate more informed choice, and provide more accurate information to policy makers on which to develop future EES and subsidy requirements.

- The Top10 data shows that 4 out of 10 products tested had EEF values in excess of 1.5cd/W. Further, although only based on a 10 product sample, this sampling and testing was undertaken in 2009 and there is probability that newer products introduced since this time have efficiencies similar to, or better than, these values. Therefore, it is provisionally recommended that the new EET Tier one boundary proposed in 2.4.3.1 is set at 1.5cd/W. Further, the evidence from the Top10 standby tests indicates that the associated Tier 1 standby threshold should be 0.3W. Clearly, before finalizing these threshold values, policy makers should review the test reports submitted for products currently registered to ensure these values are appropriate, and that products will still be available in the Tier 1 category as suggested by the Top10 study.

2.4.3.3 Relationship between energy efficiency performance, monitor screen size and backlighting technology

Figure 24 shows the relationship between monitor screen size, energy consumption and energy efficiency split by screen backlighting technology (based on declared values). It confirms the picture shown in Figure 16 Figure 16that LED backlit monitors typically consumer 30-50% less energy than CCFL monitors of the same screen size. However, from this figure it is also clear that EFF levels of LED units are only 5-10% higher than CCFL. As the EFF metric is simply unit of luminance per unit of power consumed, then it is easily deduced that the LED units are providing much higher levels of luminance from a given screen size and power, and hence higher levels of service.

Thus, when considering future revisions to the EES, policy makers may wish to consider only the performance of LED units when setting new performance requirements as these products have the lowest power consumption, are the most efficient, and appear to be giving the highest level of service to consumers[45]. Further, given the average efficiency levels of LED backlit monitors already available are at least 5% better than average CCFL equivalents (even based on current declared performance values which may substantially underestimate the difference), it would be possible to raise the current Tier 1 and 2 thresholds[46] by at least 5% immediately. There is also the potential for significantly greater revisions to the threshold levels in

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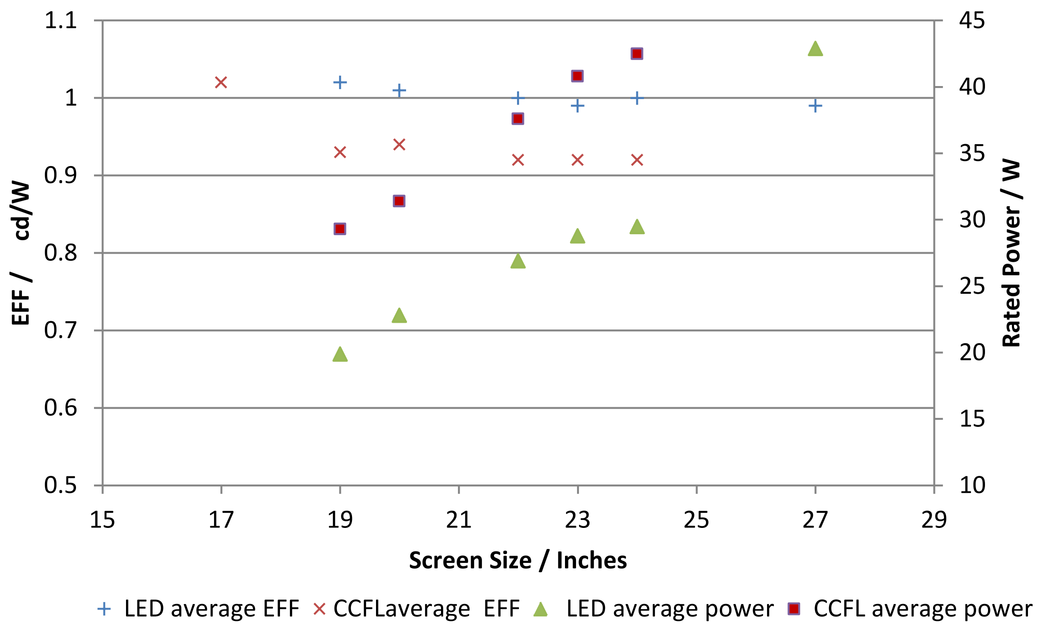
[45] Note that this proposal does not imply CCFL products should be banned from the market. The recommendation is simply performance levels should be set based the LED's better efficiency levels. Should new CCFL units enter the market that meet these higher efficiency requirements, and provide sufficient levels of consumer satisfaction, they should be allowed to enter the market with no additional restrictions.

[46] These would be EET 2 and 3 thresholds if a new Tier 1 threshold was introduced as proposed in section 2.4.3.2.

the future when full product performance declarations are made, and the potential for improvement is more transparent.

Figure 24: Relationship between monitor screen-size, energy consumption and efficiency values by monitor backlighting technology (July 2012)



2.4.4 Relationship between monitor price, screen size, energy efficiency and backlighting technology

As Figure 25 illustrates, on average, the price of monitors' increases with increasing screen size for both CCFL and LED backlit monitors, with the average price being similar for both CCFL and LED products at any particular screen size. However, as established in section 2.4.3.1, for a given screen size, the energy efficiency of LED backlit monitors is generally higher (and energy consumptions lower) than CCFLs. This seems to imply that the price is not strongly affected by the higher energy efficiency of LEDs. This proposition is supported when looking at the distribution of the price of all monitors of a single screen size (22 inches) for each declared EFF value (Figure 26). As can be seen, for 22 inch monitors, the average price across all EFF values varies relatively little compared with the variation in price within each individual EFF value (in some cases the there is a 250% difference in the lowest and highest price for 22inch monitors of the same EFF). Thus the product price is clearly driven by other factors such as screen size, brand, design, functionality, and so on, but not product efficiency.

Figure 25: Relationship between monitor price, screen size and backlighting technology (July 2012)

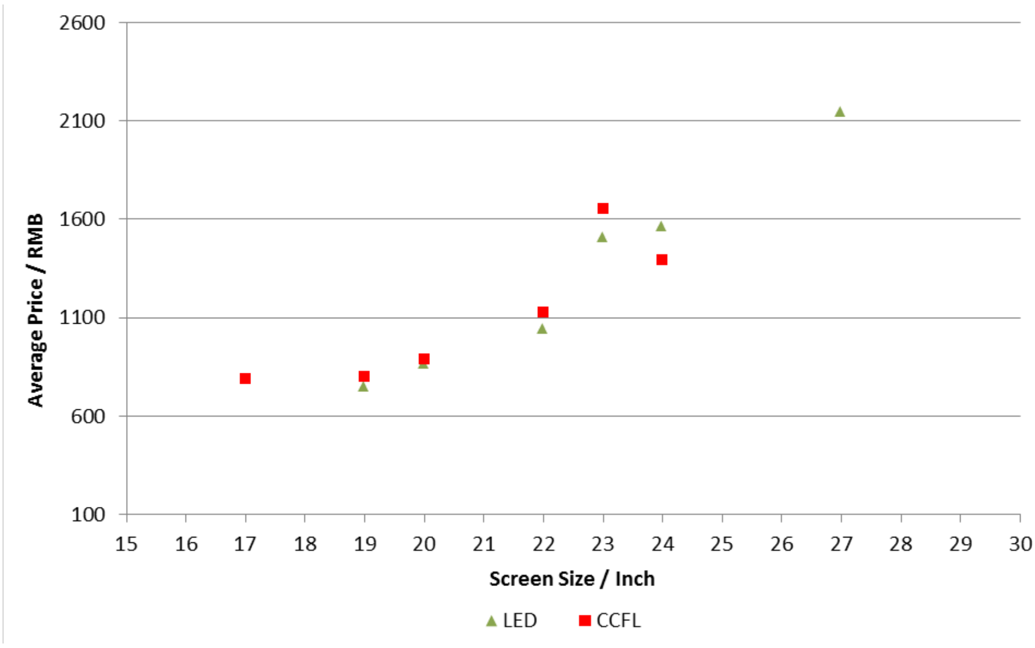
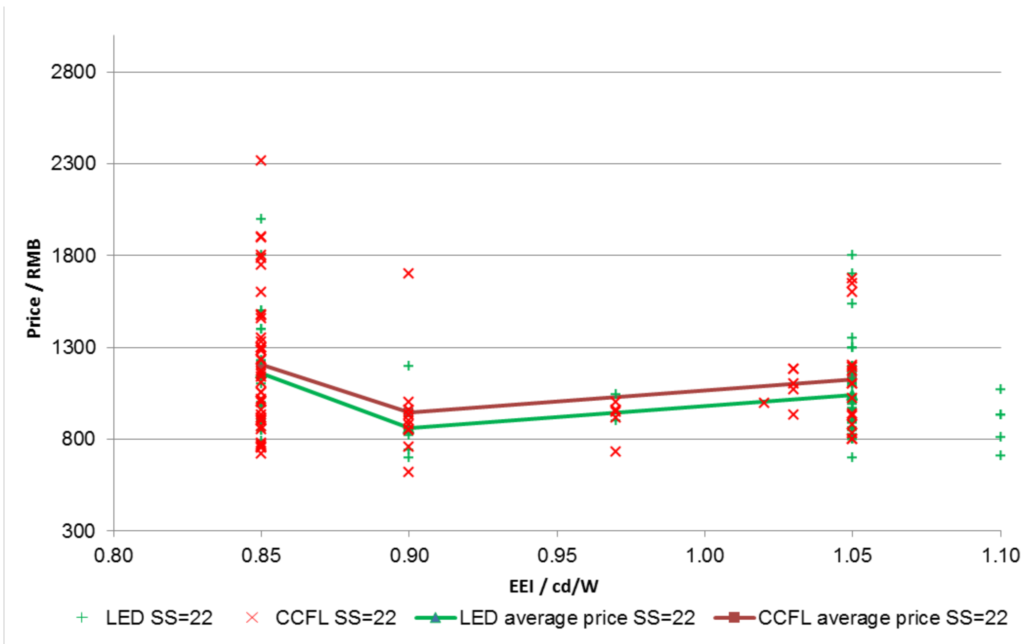


Figure 26: Distribution of the price of 22inch monitors for each declared Energy efficiency level (July 2012) (note *SS=Screen Size)*



This evidence leads us to two further conclusions and associated recommendations:

- The recommendation in section 2.4.3.1 that future EES performance requirements are based on LED backlighting technology can be endorsed as it appears unlikely that this will adversely affect product price.
- Should monitors be considered as one of the products to receive stimulus subsidy support in the future, such subsidies should only be considered as a mechanism to bring new, ultra efficient products to market (ie significantly

higher than the new proposed Tier 1 level) rather than to support purchase of existing models. The rational for this recommendation is that energy efficiency is clearly not a major driver on product price and therefore the marginal subsidy on higher efficiency products is unlikely to make a significant difference to the purchase decision, and may simply be absorbed by manufacturers/retailers as increased profit. However, there is likely to be an additional cost associated with the design and manufacture of new premium efficiency products and thus a subsidy for such products may offset these costs and bring new premium efficiency products to the market with the associated longer term benefit.

2.5 Conclusion and recommendation:

The conclusions and recommendations drawn from the analysis of the computer monitors are as follows:

Revision of Energy Efficiency Standard

1. Currently approximately 45% of monitors on sale are achieving Tier 1 levels of performance. This does not align with the publically stated policy objective of Tier 1 and 2 products demonstrating to the consumer the most efficient products on the market (in fact, Tier 1 and Tier 2 products together current represent the entire market). Therefore, to better align with stated policy goals and to improve the ability of consumers to preferentially select lower energy consuming products at the time of purchase, policy makers may wish to consider the introduction of an additional, higher energy efficiency Tier at the earliest opportunity. It is recommended that this is achieved by:

   - Setting a new EET Tier EFF 1 threshold at 1.5cd/W, with an associated Tier 1 standby threshold of 0.3W. Data from limited number of tests undertaken by Top10 indicate that, even in 2009, products which attained these proposed thresholds levels were already available in the market and therefore there is a high probability that a number of products will be very quickly be registered in this new performance Tier (a review of existing test reports supplied during the labeling registration process would quickly confirm to policy makers if this would be the case). Further, there is very little evidence to suggest these new Tier 1 products would be substantially more expensive than existing products.

   - Revising the existing Tier 1 and tier 2 thresholds to become Tier 2 and Tier 3 thresholds respectively. However, given the average efficiency levels of LED backlit monitors already available in the market are at least 5% better than average CCFL equivalents for almost all screen sizes (even based on current declared performance values), both of these Tier threshold, and hence the MEPR, should be raised by at least 5%.

   Such action will create more transparent choice for consumers by once more creating three Tiers of product efficiency from which to select products. Further, the action will also create incentives for manufacturers to remove products from lowest Tier 3 level so their products do not appear to be inferior, and increase the likelihood of new product introductions being of higher efficiency by enabling manufactures to differentiate their products in the new premium Tier 1.

2. There is very strong evidence to suggest that LED backlight monitors have the lowest power consumption, are the most efficient, and appear to be giving the highest level of service to consumers. Thus, when considering future revisions to the EES, policy makers may wish to consider only the performance of LED units when setting new performance requirements. This will encourage the improvement in performance of CCFL backlit products, or cause the worst performing of these products to leave the market (noting that policy makers may wish to offer support to manufacturers of CCFL backlit monitors as they attempt to transform production to higher efficiency alternatives).
3. There is a very high coincidence of computer monitors with declared performance values that *just* exceed EET threshold limits. However, there is strong evidence to suggest this is the result of manufacturers' under-declaring the actual performance of products. This is denying consumers the opportunity to see true product performance, and potentially hampering the development of future EES and subsidy policies. Therefore, it is recommended policy makers insist that claims made on product registration and labeling must align with actual testing reports submitted during the label application process, and that the test reports represent typical product performance. Once declarations are accurate, this will provide better decision making information to the consumer and better base data on which policy makers may develop future policy.
4. There is some evidence to suggest that monitors with screen sizes in the 22-24inch may be a good indicator of future market trends and represent the newest designs with improved power management systems. There seems value in investigating this possibility further to establish if this is the case as, if so, closely following the market trends in this screen size may lead to indications of how the market will develop for all other screen sizes in the future, hence enabling more informed EES development.

Research into consumer usage patterns

5. At present there appears to be very little publically available information on consumer usage of monitors. However, the projection of future energy consumption under different regulatory conditions is highly dependent on the specific consumer usage patterns. As these projections are critical in the development of appropriate energy efficiency standards, it is recommended that policy makers initiate research to establish true consumer usage patterns to enable more informed standards development in the future.

Energy Labeling of Monitors

6. The aim on the China energy label is to provide consumers with information that will allow them to preferentially select higher efficiency, lower energy consuming products. However, currently consumers may be misled into thinking that products labeled as Tier 2 are of reasonable performance, when in fact they are the worst products in the market. Therefore, the reintroduction of three EET thresholds is strongly recommended as outlined above.

   Further, there is little evidence to suggest the consumers currently understand the significance of the EFF value, nor the standby power value for the monitor as currently declared on the label. In addition, at present there is currently no indication of the *actual energy* consumption of the monitor. Therefore a consumer may choose a high efficiency monitor, but that monitor may still use substantially more energy than an alternative of smaller screen size. However, the consumer would be unaware of this. Therefore it is recommended that slight revisions are made to the information declared on the label by:

- In the short term: replacement of the declaration of the monitor's EFF value with the (to consumers) more useful power consumption of the product. While still not giving the consumer full information on the energy consumption, it will at least provide consumers with a measure of the comparative power (and hence probable energy) consumption of the monitor.
- In the longer term, should the research on consumer usage patterns be undertaken as recommended above, power measurement could actually be replaced with a typical daily, weekly or annual energy consumption of the monitor which is likely to be of significant value to the consumer.

Such revisions would provide more useful decision making information for the consumer by more accurately reflecting the real difference in power demand/energy consumption between models.

Section 3: Analysis of the Market and Product Performance of Office Copier Machines

3.1 Product Background

As in many other parts of the world, traditionally copiers in China had the single function of reproduction (referred to in this report as simple copiers). However, more recently, the copying function is increasingly being integrated into multi-functional devices (MFD) which deliver other services such as faxing, scanning and printing. Very few simple copiers were found to be on sale during data collection for this analysis (refer to section 3.4.1.1). Hence, within this report, the term “copiers” will be used to encompass both simple copiers and MFDs where the primary function is copying.

Copiers are normally categorized by their integrated functions, color capabilities, paper size and copying speed. Monochrome copiers still dominate the market, with color copiers regarded as premium products. Most copiers for office use are designed for paper sizes no bigger than A3, but A4 paper is more typical. The speed of most monochrome machines is between 16ppm (pages per minute) and 40ppm, while the speed of most color machines is between 20ppm and 50ppm.

Products considered in this report are those with reproductions speed below 70ppm that are capable of processing paper of standardize size format[47] and that work under normal electrical supply conditions, i.e. 220V and 50Hz. Hence copiers powered by battery or digital interfaces like USB or IEEE1394, or those with digital front equipment (DFE), are excluded.

3.1.1 Production, sales and stock level

China produced 6.54 million copiers in 2011 , of which 0.58 million were sold domestically (increases of 16.8% and 5.5% respectively from 2010 levels). It is estimated that the installed stock of copiers was 3.8 million units at the end of 2011[48].

3.1.2 Usage pattern

Specific usage patterns for copiers vary markedly between offices and little publically available information could be found. However, the performance metric used in the evaluation of energy consumption is based on a typical weekly energy consumption (refer to section 3.4.2.1) and is hence assumed to be sufficiently representative of actual consumption for use in the projections and analysis undertaken in this report.

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[47] The scope of “copiers” in this report is identical to the new draft version of GB 21521, in which “standardize size format” is defined as for non-continuously paper-feeding products, the maximum width of media should be between 210.0mm to 297.0mm (e.g. A3, A4, B4 and letter paper), while for continuously paper-feeding products, between 210.0mm and 406.0mm.

[48] White Paper for the energy efficiency status of China energy-use products, 2012, CNIS

3.2 Regulation, Labeling and MEPS

3.2.1 Energy efficiency standard

The energy efficiency standard (EES) GB21521-2008 provides the test method and the performance requirement for both simple copiers and MFDs. The EES originally defines three energy efficiency tiers (EET) based on the TEC, unit functionality and copying speed.

When first introduced, the EES also defined the Minimum Energy Performance Requirement (MEPR) as the lower threshold limit for Tier 3 products, i.e. no product can enter the market with a TEC lower than the EES Tier 3 lower threshold. However, a revision in 2011 led to the MEPR value being revised to the lower limit of Tier 2 and hence Tier 3 products were no longer allowed to enter the market (refer to Table 10).

There is currently also an EES for printer/fax (GB25956-2010) which also covers MFDs. In their current form, the scope of the copier and printer EESs have significant overlap for units that are multi-functional. As the specific definition of whether a MFD is considered a copier or printer is based on the manufacturer declaration of the *primary* function of the unit, this leaves significant opportunity for manufacturers to classify units under the least stringent EES requirement and achieve the highest EET (i.e. to register the products under the "printer/fax" EES).

Recognizing this situation, a revised draft of GB 21521-2008 was issued in mid-2012 which integrates the regulation of all MFDs under a unified requirement (also shown in Table 10).

3.2.2 Energy labeling of copiers

Copiers became subject to compulsory energy labeling (as part of the China Energy Label program) in March 2009. The energy label for copiers currently has three EETs (see Figure 27). In addition to the indicator showing the energy efficiency Tier, the label also includes basic identification information of the product, and TEC in kWh and off-mode in W. However, under the revised draft of GB 21521-2008, off-mode standby will become part of the TEC. Therefore, as the off-mode standby is unlikely to be a major influence on purchasing patterns, policy makers may wish to consider removing the off-mode standby value from the label during future revisions.

3.2.3 Test Method

The test method used in China to measure the energy performance of copiers is GB21521-2008, introduced in 2008.

The energy efficiency indicator used for copiers is termed the Typical Energy Consumption (TEC). The TEC is the weekly power consumption of the unit based on a set of parameters defined in the test methodology that aim to mimic typical weekly use of the product, i.e. the energy consumed in producing a defined number of copies and the power during auto-off mode and off mode[49].

[49] "auto-off" is the state of the unit after a period of inactivity following completion of a task, and "off" is the state where the unit is switched off, but is still connected to the mains power supply.

Table 10: Comparison of Scope and Energy Efficiency Requirements of three MEPS

<table>
<tr><th></th><th>GB 25956-2010, MEPS for Printer/Fax</th><th>GB 21521-2008, MEPS for Copier</th><th>GB 21521 (new draft)</th></tr>
<tr><td>Scope</td><td>The Standard applies to printers, fax machines, and multi-functional machines with printing or faxing as basic functions. They should work under 220V and 50Hz and process standard image sizes, with printing speed slower than 70 pages per minute.</td><td>The Standard applies to static electric copiers for general services, which work under grid power and process A3 and smaller image sizes, and multi-functional machines (multi-functional digital copier, multi-functional printer-copier, color copier, etc) with copying as a basic function.</td><td>The Standard applies to copiers and multi-functional machines with copying as basic functions. The equipment shall work under 220V and 50Hz and process standard image sizes, with copying speed slower than 70 pages per minute. For equipment with printing function, use printing speed as copying speed.</td></tr>
<tr><td>Energy Efficiency Levels</td><td>
<table>
<tr><th>Product Type</th><th>Copying Speed (ppm)</th><th colspan="3">TEC (kWh/week)</th></tr>
<tr><th></th><th></th><th>Tier 1</th><th>Tier 2</th><th>Tier 3 (MEPR)</th></tr>
<tr><td>Mono-chrome, Printer/Fax</td><td>p<=15</td><td>0.6</td><td>1.0</td><td>1.5</td></tr>
<tr><td></td><td>15<p<=40</td><td>0.06*p-0.3</td><td>0.10*p-0.5</td><td>0.20*p-0.9</td></tr>
<tr><td></td><td>P>40</td><td>0.21*p-6.2</td><td>0.35*p-10.3</td><td>0.61*p-17.8</td></tr>
<tr><td>Color, Printer/Fax</td><td>p<=32</td><td>0.06*p+2.0</td><td>0.10*p+2.8</td><td>0.14*p+4.0</td></tr>
<tr><td></td><td>32<p<=58</td><td>0.30*p-5.8</td><td>0.35*p-5.2</td><td>0.39*p-4.2</td></tr>
<tr><td></td><td>P>58</td><td>0.60*p-23.5</td><td>0.70*p-26.0</td><td>0.80*p-28.0</td></tr>
<tr><td>Monochrome, MFD</td><td>P<=10</td><td>1.0</td><td>1.5</td><td>4.0</td></tr>
<tr><td></td><td>10<p<=26</td><td>0.06*p+0.4</td><td>0.10*p+0.5</td><td>0.30*p+0.9</td></tr>
<tr><td></td><td>p>26</td><td>0.31*p-6.3</td><td>0.35*p-6.0</td><td>0.44*p-2.8</td></tr>
<tr><td>Color, MFD</td><td>P<=26</td><td>0.06*p+1.9</td><td>0.10*p+3.5</td><td>0.20*p+5.0</td></tr>
<tr><td></td><td>26<p<=62</td><td>0.33*p-5.0</td><td>0.35*p-3.0</td><td>0.41*p-0.7</td></tr>
<tr><td></td><td>P>62</td><td>0.60*p-22.0</td><td>0.70*p-25</td><td>0.85*p-28</td></tr>
</table>
</td><td>
<table>
<tr><th>Product Type</th><th>Copying Speed (ppm)</th><th colspan="2">TEC (kWh/week)</th></tr>
<tr><th></th><th></th><th>Tier 1</th><th>Tier 2 (MEPR)</th></tr>
<tr><td>Mono-chrome, Copier</td><td>p<=12</td><td>1.2</td><td>1.5</td></tr>
<tr><td></td><td>12<p<=50</td><td>0.16*p-0.8</td><td>0.20*p-1</td></tr>
<tr><td></td><td>P>50</td><td>0.64*p-25</td><td>0.80*p-31</td></tr>
<tr><td>Color, Copier</td><td>P<=50</td><td>0.16*p+1.5</td><td>0.20*p+2</td></tr>
<tr><td></td><td>p>50</td><td>0.64*p-22.5</td><td>0.80*p-28</td></tr>
<tr><td>Monochrome, MFD</td><td>P<=20</td><td>0.16*p+1.6</td><td>0.20*p+2</td></tr>
<tr><td></td><td>20<p<=69</td><td>0.36*p-2.2</td><td>0.44*p-2.8</td></tr>
<tr><td></td><td>p>69</td><td>0.64*p-22.4</td><td>0.80*p-28</td></tr>
<tr><td>Color, MFD</td><td>P<=32</td><td>0.16*p+4.0</td><td>0.20*p+5</td></tr>
<tr><td></td><td>32<p<=61</td><td>0.36*p-2.2</td><td>0.44*p-2.8</td></tr>
<tr><td></td><td>P>61</td><td>0.64*p-20</td><td>0.80*p-25</td></tr>
</table>
NOTE: There were three Tiers originally, but the MEPS self-upgraded in 2011 setting Tier 2 the MEPR.
</td><td>Same as GB 25956-2010</td></tr>
<tr><td>NOTE</td><td colspan="3">Test method and calculation for TEC is the same for three MEPS, which makes the requirements for TEC comparable.</td></tr>
</table>

Figure 27 China Energy Label for Copiers

3.3 Subsidy program

To date, the national subsidy program has not applied to copiers.

3.4 Data Analysis

Data used in the analysis of copiers is limited to product models registered as Copiers under GB 21521-2008. Hence, as a number of MFD are registered under the Printer/Fax product grouping, the data analyzed may not be comprehensive in market coverage of MFD models, but is believed to be sufficiently representative of the range of models available in the market to enable robust analysis.

The analysis examines the performance, energy and market related properties outlined in Table 11. In addition to the generic cautions provided in the Approach and Methodology section of the report introdution, readers should note that not all performance and other parameters were available for all models identified as available in the market. Where not all products are included in a particular analysis, this is noted in the associated text. However, it has not been possible to estimate the bias this has introduced into the analysis for any given parameter.

Table 11 Overview of data used for Copiers analysis

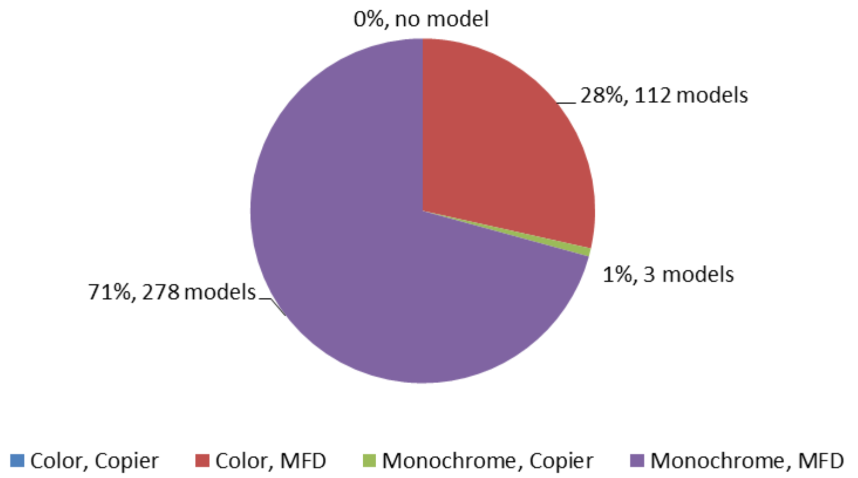
Data type	Note
Total Number of Models	393
Types	Monochrome Copier Color Copier Monochrome MFD Color MFD
Typical Energy Consumption (TEC, kWh/week)	Range 0.23 to 43.04
Price/RMB	Range 1,100 to 486,000
Copying speed /ppm	Range 4-135

3.4.1 Product distribution

3.4.1.1 Market distribution by product functionality

Figure 28 shows the distribution of copiers (categorized by type defined in the EES), available in the Chinese market in July 2012. This clearly shows simple copiers are disappearing from the market and are being replaced by MFDs (only 3 monochrome, and no color, simple copiers are available). The ratio of monochrome and color MDF copiers is approximately 70:30.

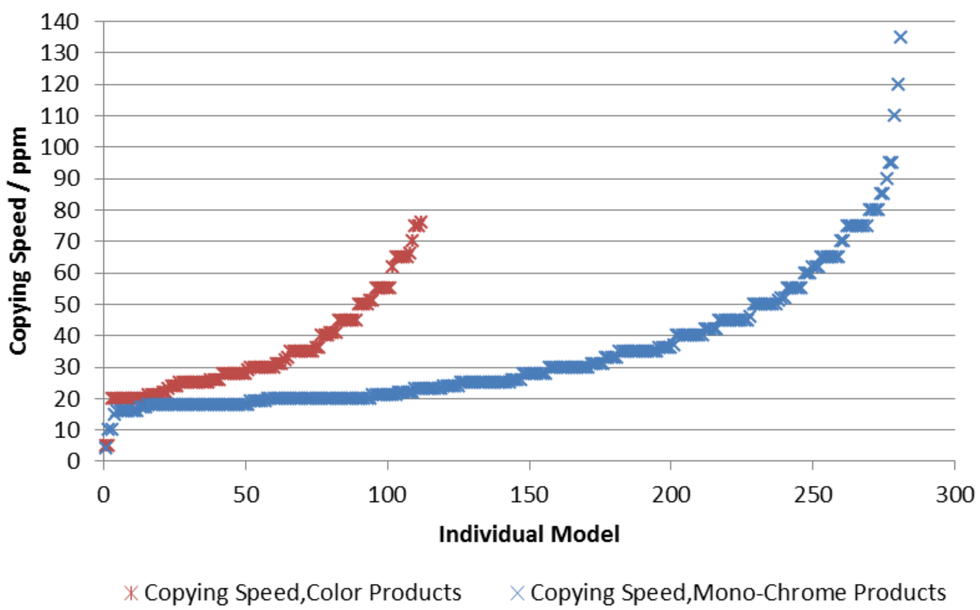
Figure 28: Market distribution of copiers by type (model based, July 2012)



3.4.1.2 Market distribution by copying speed

The requirements for the EET and MEPR set in the EES are primarily based on the copying speed; the faster the copying speed, the higher the TEC allowed. Figure 29 shows the distribution of copy speeds available for both monochrome and color units.

Figure 29 Distribution of copying speed (model based, July 2012)



The spread of copier speeds is broad, ranging from 4ppm to 135ppm. However, the most common copier speed available (for both monochrome and color) is 20-30ppm, although there are a significant number of models in the speed ranges just below and above this band, particularly for monochrome units

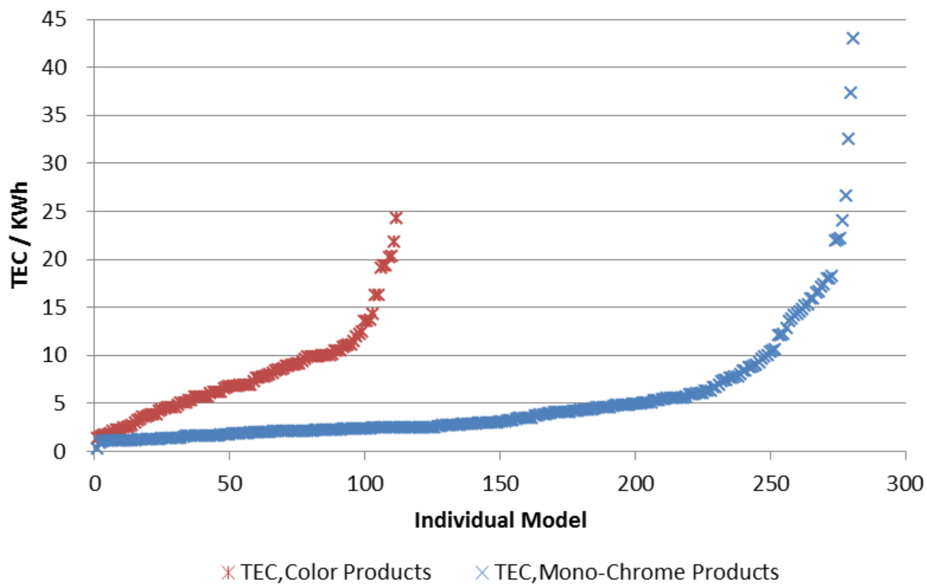
It is worth noting copiers with speeds faster than 69ppm will no longer be covered by the new EES if the revised product scope of GB 21521 is adopted as currently proposed. At the time of data collection, models with copier speeds above 69ppm represent 6.6% of models available (22 monochrome models, 4 color models). This is a relatively significant proportion of the market, and faster units are also the most energy consuming. Thus, leaving this market segment unregulated is risky as it fails to provide any consumer information on the highest energy consuming products and has the *potential* for less scrupulous manufacturers to shift production to copies above 69ppm to circumvent the regulations. Thus, it is recommended that policy makers reconsider the scope of the draft revised standards to ensure inclusion of copiers with higher reproduction speeds.

3.4.2 Energy Consumption

3.4.2.1 Distribution of Typical Energy Consumption (TEC, kWh)

As illustrated by Figure 30, 90 out of 112 models of color copiers (80.4%) have a TEC equal to or below 10kWh. The TEC of the other 22 models ranges from 10kWh to 24kWh. For monochrome products, 250 out of 281 models (89.0%) have a TEC equal to or below 10kWh. Of these, 211 models (75.1%) are below 5kWh. There are only 8 models with TECs higher than 20kWh[50].

Figure 30: Distribution of Typical Energy Consumption (TEC) (model based, July 2012)

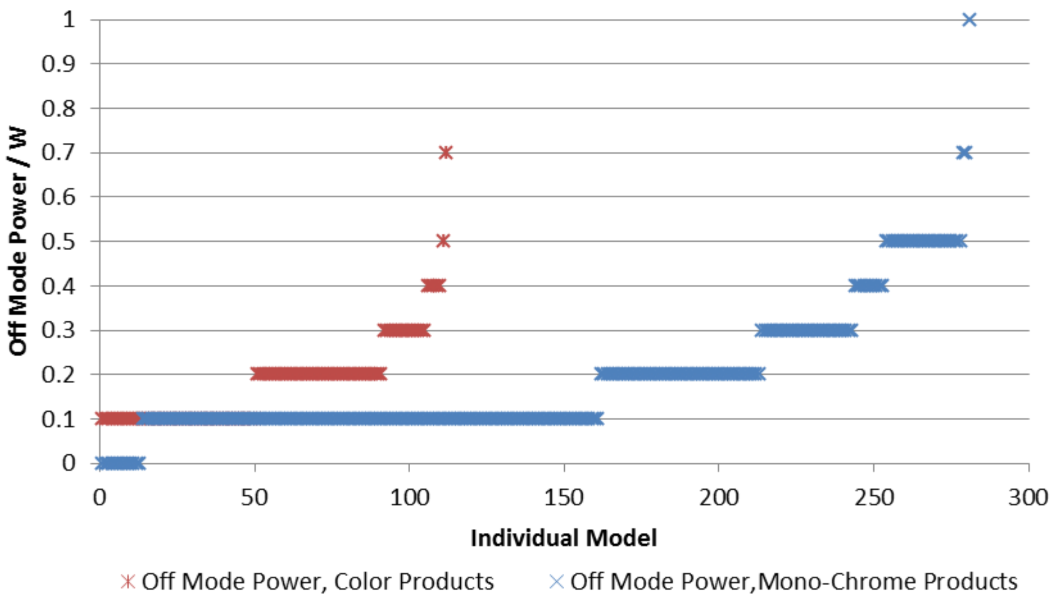


[50] While a TEC of 5kWh may sound insignificant within overall office consumption, the TEC represents a "typical" weekly power consumption. Thus a copier with a 5kWh TEC has a "typical" annual power consumption of over 250kWh which is clearly more significant. Further, copiers rated with TEC's of 20kWh have typical annual consumption in excess of 1,000kWh.

3.4.2.2 Off-Mode Power Consumption

The current copier EES (GB 21521-2008) requires off-mode power to be no higher than 2W. However, from the data collected, all but one model have off-mode power below 1W[51] (refer to Figure 31). Hence, the new draft version of GB 21521 sensibly does not have a specific requirement for Off-Mode Power Consumption, but instead incorporates it within the TEC calculation.

Figure 31: Distribution of Off-Mode power (model based, July 2012)



3.4.3 Energy Efficiency

The TEC is used as the indicator of copiers' energy efficiency. In order to be registered as qualifying for a particular EET, the TEC must not exceed the lower threshold level for the Tier defined in the EES. As the draft revision of copier EES has been published, it is worthwhile to compare the existing and new EET and MEPR requirements[52].

Figure 32 to Figure 35 illustrates the current and proposed EET levels for monochrome and color MFDs, over laid with the TEC performance of actual product found to be available in the market (noting only 3 monochrome and no color simple copiers were found in the market).

Note that in the analysis of TEC of the models on the market, all models with copying speed equal to or higher than 70ppm are eliminated since the new excludes these products.

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[51] The remaining product has a declared off-mode power of exactly 1W.

[52] The test method and calculation of TEC remained identical and so EET thresholds and individual product performance are directly compatible. However, under the draft revision, the copying speeds by which the EET of copiers are categorized have been revised (see Table 10**Error! Reference source not found.**)

Figure 32: Comparison of the Tier thresholds for the current and proposed simple monochrome copiers energy efficiency standard, overlaid with product available in the market in July 2012

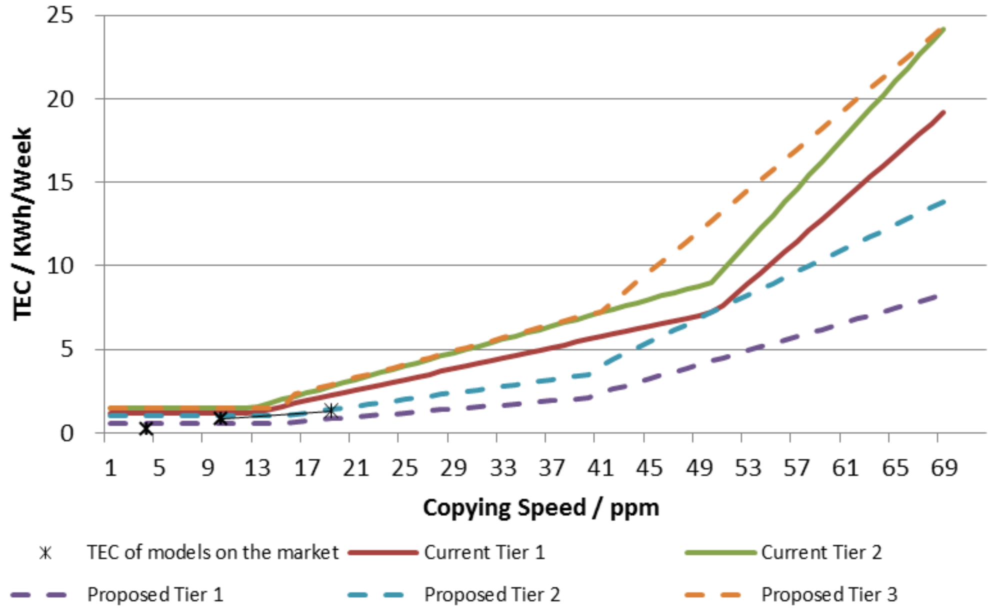


Figure 33: Comparison of the Tier thresholds for the current and proposed monochrome MFDs energy efficiency standard, overlaid with product available in the market in July 2012

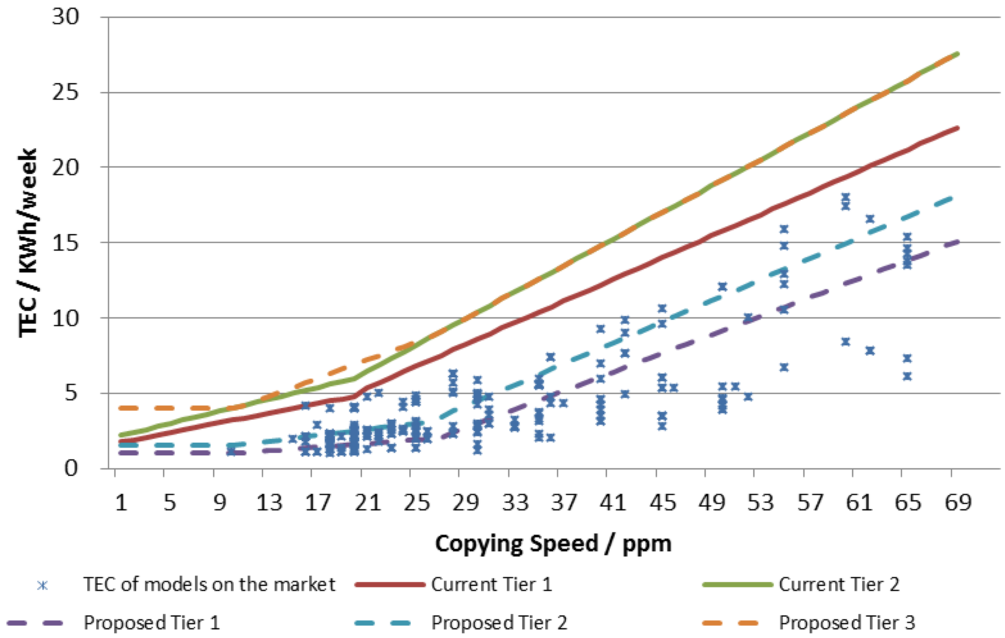
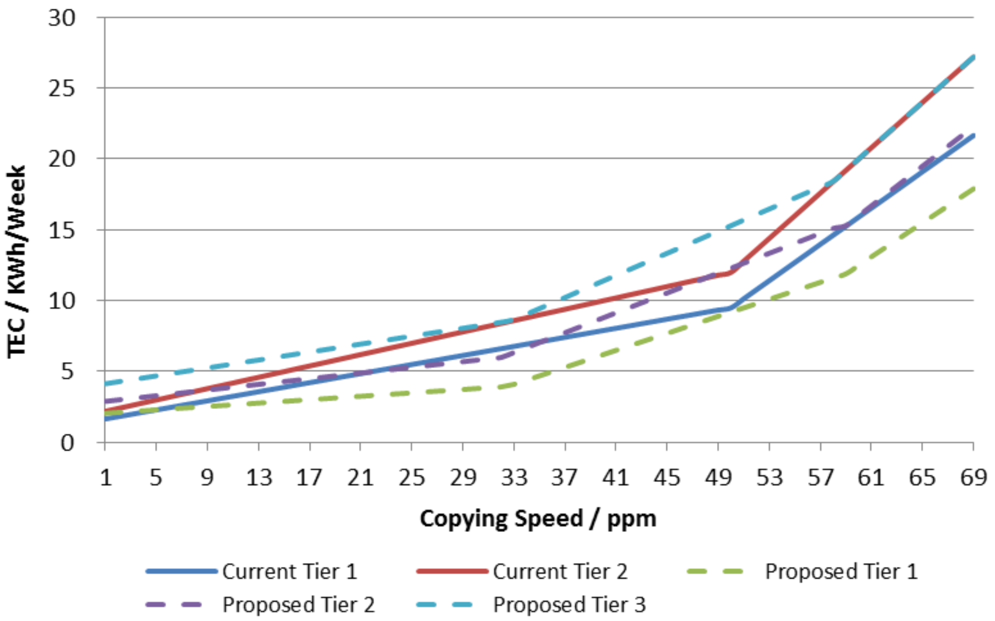


Figure 34: Comparison of the Tier thresholds for the current and proposed color copier energy efficiency standard*



**Note: no such type of product found on the Chinese market through this study.*

Figure 35: Comparison of the Tier thresholds for the current and proposed color MFD energy efficiency standard, overlaid with product available in the market in July 2012

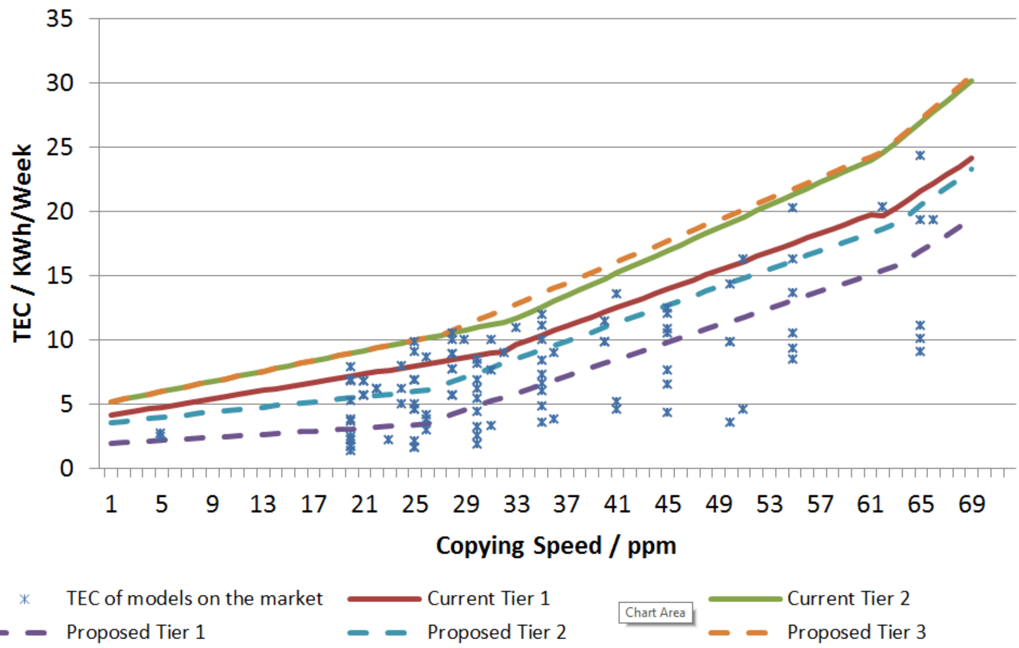


Figure 32 to Figure 35 clearly show that, for almost all products, the proposed revisions to Tier 1 and Tier 2 thresholds considerably increases the stringency even over the current Tier 1 requirements. This is applauded as it will significantly increase transparency of choice for the consumer as products are now much more clearly differentiated (Figure 36 and Figure 37 show the proportion of products currently available that would qualify under the existing and revised EET levels). However, there remains concern with two issues:

1) Even with the enhanced Tier 1 proposals, a significant number of products already achieve the Tier 1 performance level (37% monochrome and 32% color). If the proposed Tier 2 levels are also included, the percentage of products that *are currently* available that qualify for the top two Tiers is 80% monochrome and 63% color. This indicates that there is potential to raise the Tier 1 and Tier 2 thresholds still further to encourage market innovation.

2) As noted previously, the proposed EES revisions do not increase the stringency of current MEPR levels. In fact for a range of copier speeds, the MEPR is actually slightly lower. This failure to increase stringency levels potentially sends the wrong signals to the market place by indicating current levels are consider acceptable into the future.

Nevertheless, as noted earlier, the current round of MEPS is integrating the copier and printer/fax EES and it is possible that the printer fax MFD units do not perform as well as copier MFDs. Therefore, it *may* be appropriate to proceed with the EES as currently proposed, but once all products are categorized and registered in a similar manner, to initiate an immediate review of the resulting spread of products with a view to revising the both the MEPR and EET levels to present more challenging targets to the market and to maximize energy savings to the consumer and the nation.

Figure 36: Distribution of average efficiency Tiers (EET) of monochrome MFD copiers available in July 2012 based on the existing and proposed energy efficiency Tier (EET) requirements

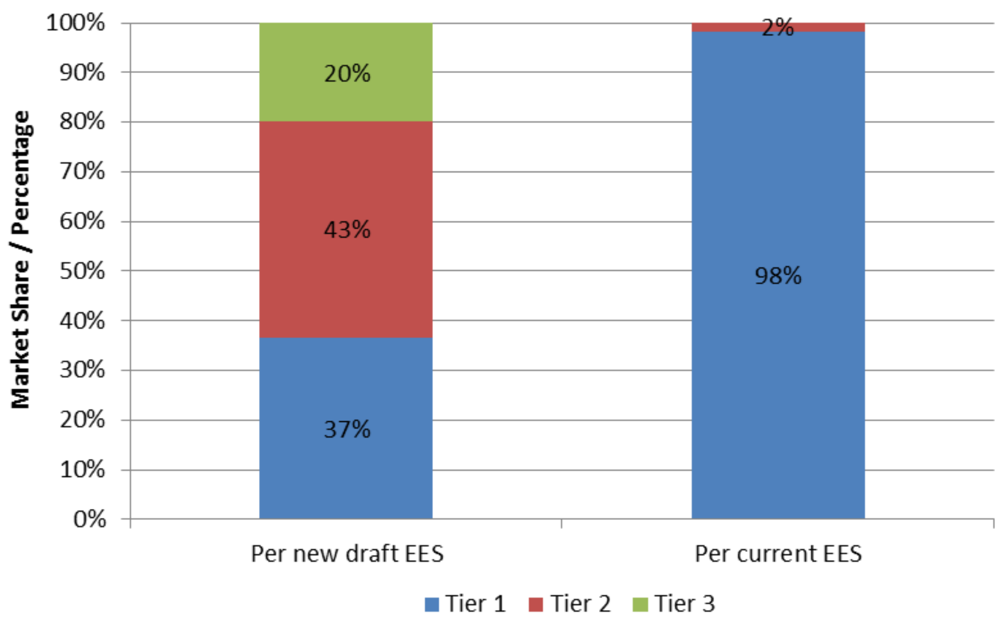
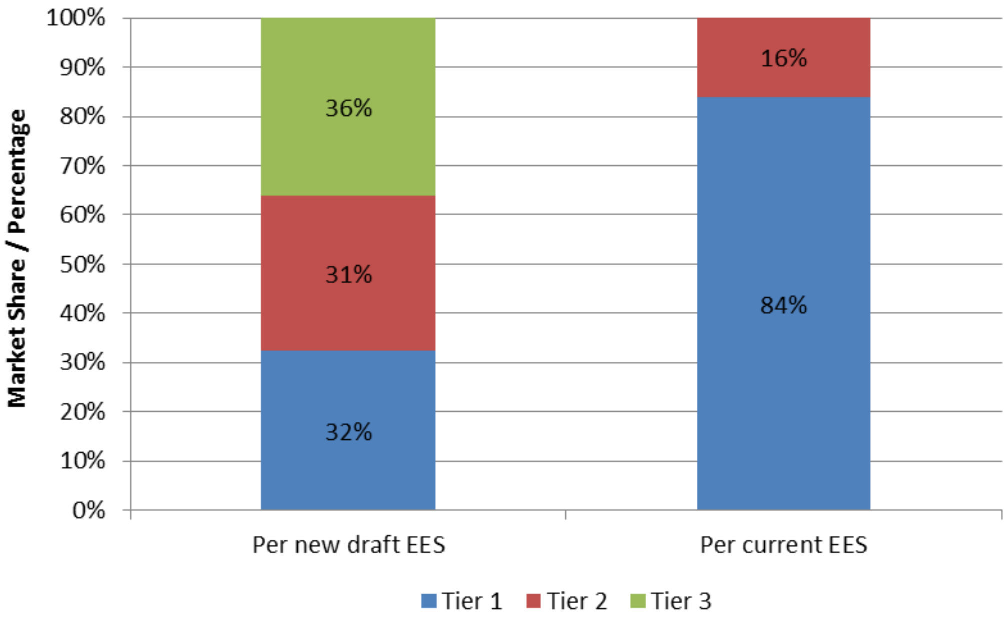


Figure 37: Distribution of average efficiency Tiers (EET) of color MFD copiers available in July 2012 based on the existing and proposed energy efficiency Tier (EET) requirements



3.5 Price

Copier prices are closely correlated to their functions, such as speed, capacity, color, network, multi-functionality, double-side copying, etc. Consequently, it is very difficult to eliminate the influence of these factors when attempting to analyze the impact on price of increasing levels of product energy efficiency. Therefore this study is not able to conclude if copier price is correlated to energy efficiency. However, further in-depth research on cost for energy efficiency of copiers may provide a solid result.

3.6 Conclusions and Recommendation

The conclusions and recommendations drawn for copiers are:

Energy Efficiency Standard

The markets for copier and printer/fax units are converging due to the market demand for multi-functional devices which integrate the reproduction, printing and communication features. Currently these products are regulated separately and have differing minimum energy performance and labeling requirements. This issue has been recognized and is now being rectified through the issue of a draft standards revision which integrates the regulations into a single standard.

The proposed revised standard considerably increases the stringency of Tier 1 and Tier 2 performance requirements, both of which are now higher than the previous Tier 1 requirements for almost all product types. This is applauded as it will significantly increase transparency of choice for the consumer as products are now much more clearly differentiated

However, a number of concerns exist with the draft standard revisions as they currently stand:

1. Even with the significantly enhanced Tier 1 proposals, over 30% of both color and monochrome copiers available in July 2012 already achieve the revised Tier 1 requirements. If Tier 2 is included, 80% of monochrome and 63% of color copies achieve one of the top two Tiers. This indicates that there is potential to raise the Tier 1 and Tier 2 thresholds still further to encourage market innovation.
2. The proposed energy efficiency standards revisions do not increase the stringency of current MEPR levels. In fact for a range of copier speeds, the MEPR is actually slightly lower. This failure to increase stringency levels potentially sends the wrong signals to the market place by indicating current energy performance levels are consider acceptable into the future. 80% of monochrome and 63% of color copies already achieve one of the top two Tiers, it is recommended that the MEPR is strengthened to current Tier 2 levels.
3. The proposed revisions to the standard remove high speed copiers (above 69ppm) from labeling and minimum performance requirements. At the time of data collection, models with copier speeds above 69ppm represent 6.6% of models available. Leaving this market segment unregulated fails to provide any consumer information on the energy consumption of units above 69ppm (the highest energy consuming product type) and has the potential for less scrupulous manufacturers to shift production to copies above 69ppm to circumvent the regulations. Thus, it is recommended that policy makers reconsider the scope of the draft revised standards to ensure inclusion of copiers with higher reproduction speeds.

Nevertheless, as noted earlier, the current round of MEPS is integrating the copier and printer/fax EES and it is possible that the printer fax MFD units do not perform as well as copier MFDs. Therefore, it may be appropriate to signal the intention to increase the MEPR level at some point in the near future (for example within 1 year of current proposals coming into force), but proceed with the EES as currently proposed with the extension of provisions to include copiers with speeds above 69ppm. Once all products are categorized and registered in a similar manner, initiate an immediate review of the resulting spread of products with a view to confirming the MEPR revision to current Tier 2 levels, and potential revising EET thresholds to present more challenging targets to the market, thus maximizing energy savings to the consumer and the nation. However, policy makers with access to both copier and printer data may be able to determine whether printer MDF units are indeed less efficient that copiers, and if not, then action to increase the stringency of both the minimum energy performance and efficiency Tier requirements may be appropriate before current draft proposals are finalized.

Additional research into price drivers for copiers

Copiers' prices are closely correlated to their functions, such as speed, capacity, color, network, multi-functionality, double-side copying, etc. Consequently it is very difficult to eliminate the influence of these factors and therefore to understand the impact of price on increasing levels of energy efficiency. Further research may be appropriate to understand this link better thus enabling more informed efficiency policy making in the future.

Section 4: Analysis of the Market and Product Performance of Domestic Refrigerated Appliances

This section of the report examines the market, product performance and regulatory framework for domestic refrigerated appliances.

Obviously refrigerated appliances are of importance due to their high levels of household penetration and their (typically) 24 hour running cycles. Even in rural areas, the penetration of refrigerators is rising rapidly in line with increasing incomes.

Based on the projections prepared as part of this analysis[53], approximately 340 million refrigerated appliances were installed across China by the end of 2012. This stock is expected to rise to just over one per household to 580 million in 2030, and under the business as usual scenario, these refrigerated appliances are estimated to consume approximately 24 TWh/yr of energy.

4.1 Product Background

This report examines refrigerator models available in Chinese retail market based on national classifications that are either by the appliance functionality and/or by the number and configurations of doors[54].

Based on functionality, refrigerators are classified in four ways:

- Fridge only for storing fresh food (abbreviated as BC);
- Freezer only for storing frozen food (BD);
- Fridge/freezer where the compartment can be switched to act as either a fridge or freezer but not both at the same time (BC/BD);
- Fridge freezer where there are two or more compartments, at least one of which is a fridge and at least one a freezer (BCD – BCDW if frost free).

The five door configurations used for classification are:

- single-door
- double-door
- three-door
- side-by-side
- multiple-door.

The Chinese regulatory framework broadly follows the IEC categorization of products with freezer units classified in 0, 1, 2 and 3 star levels. However, the IEC 4 star level is the default in China and does not receive specific categorization.

[53] Energy Saving Potential (ESP) Study for Nine Appliances in China, CLASP 2013

[54] Note that “doors” includes both doors and externally accessible draws.

For fridge freezers, there is no regulatory difference between the configuration of upright units (i.e. freezer at the top, bottom or side of the fridge).

Differentiation is made in stand-alone and integrated freezer units between those designed to simply store frozen food, and those capable of freezing and storing food. There is no regulatory difference between chest and upright freezers.

4.1.1 Production, sales and stock level

China is currently the world's largest refrigerator production base and the largest consumer market. There are more than 100 domestic refrigerator manufacturers, some of which have become the world's leading refrigerated appliance manufacturers with production capacity of four million refrigerators per year. In 2011, the overall Chinese refrigerator industry output was over 73 million units, of which more than 45 million units were sold in the domestic market[55].

By the end of 2011 Government sources estimated there are approximately 300 million domestic refrigerator appliances[56] being used in China[57].

With the rapid urbanization of China and its growing middle class population, more consumers are tending to buy larger refrigerators that consume more energy. It is estimated by GOME, one of the biggest electrical appliances retailers in China, that the market share of three-door and side-by-side door refrigerators (both of which typically use more energy than their two door vertical equivalent units) will increase from 50% to 65% in 2012.

4.1.2 Usage patterns

While there are likely to be a small number of cases where households have more than one refrigerated appliance with the second (or third) unit only used occasionally, and a limited number of cases where consumers turn off refrigerated appliances during, for example long vacations, the vast majority of refrigerated appliances in China are operated 24 hours a day throughout the year.

However, when the market matures and a significant proportion of consumers are at the point of purchasing replacements (for reasons other than products failure), policy makers may wish to monitor whether the original units are disposed of, or become secondary refrigerated appliances at home as is the case in the US. Such a situation would clearly lead to increase of electricity consumption associated with refrigerated appliances.

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[55] Source: China Home Electrical Appliances Association (CHEAA). Note that exports are recorded at 19 million units. Therefore the combination of domestic sales and exports are approximately 64-65million units. It is unclear if the remaining 8-9 million units are in manufacturer and retailer stock or sales have failed to be recorded in data.

[56] Source: Ministry of Finance of China, http://www.mof.gov.cn/zhengwuxinxi/zhengcejiedu/2012zcjd/201205/t20120530_655610.html (read in August 2012)

[57] As noted in the introduction to this section, with projections prepared as part of this analysis [The Energy Saving Potential (ESP) Study for Nine Appliances in China, CLASP 2013] estimate the number of installed appliances at 340 million by the end of 2012.

4.2 Regulation, Labeling and MEPS

4.2.1 Energy Efficiency Standard

In an effort to transform China's refrigerator market toward higher levels of energy efficiency, China first introduced an energy efficiency standard (EES) in 1989 (GB12021.2 "*The maximum allowable values of the energy consumption and energy efficiency grade for household refrigerators*"). This standard has since been revised three times in 1999, 2003 and 2008.

The performance requirements thresholds within the current EES are based on an energy efficiency index (EEI) calculated as the ratio of the measured energy consumption of the appliance during the 24 hour test to the baseline energy consumption. The calculation of EEI in GB 12021.2-2008 is as follows:

$$\eta = \frac{E_{test}}{(M \times V_{adj} + N + CH) \times S_r / 365} \times 100\%$$

Where

M and N values are shown in Table 12
CH = is 50kWh where refrigerators have a variable temperature compartment of less than 15 liters, otherwise 0.
*S_r = an adjustment factor of 1.1 if the unit has through the door ice-making capability **and/or** the total unit capacity is less that 100 liters or more than 400 liters*

and

$$V_{adj} = \sum_{c=1}^{n} V_c \times F_c \times W_c \times CC$$

where:

n = number of different types of compartments
Vc = measured storage volume of a specific type of compartment (Litres)
Fc = Constant, equal to 1.4 for forced air cooling or 1.0 for non-forced air.
CC = Climate type correction coefficient, (= 1 for N or SN, =1.1 for ST and = 1.2 for climate type T)
Wc = $\left(\frac{25-T_C}{20}\right)$ *where Tc is the compartment temperature.*

Table 12: M and N values used in the derivation of EEI in GB 12021.2-2008

Type	Description	M value	N value
Type 1	Refrigerator without star compartment	0.221	233
Type 2	Refrigerator with 1-star compartment	0.611	181
Type 3	Refrigerator with 2-star compartment	0.428	233
Type 4	Refrigerator with 3-star compartment	0.624	223
Type 5	Refrigerator-freezer	0.697	272
Type 6	Frozen-food storage appliances	0.530	190
Type 7	Freezer	0.567	205

The EES sets five energy efficiency Tiers (EET), with Tier 1 being the most efficient refrigerated appliances. Products above the Tier 2 lower threshold are eligible to apply for "energy-saving product" certification[58]. The lower Tier 5 threshold defines the minimum energy performance requirement (MEPR) below which appliances are considered too inefficient to be sold.

Table 13 compares the 2003 edition of the EES with the current, more stringent, 2008 version[59].

Table 13: Energy efficiency Tier requirements for refrigerated appliances (energy efficiency standards 2003 and 2008)

EET	Energy Efficiency Index (EEI) η		
	GB 12021.2-2003	GB 12021.2-2008	
	All types	Fridge Freezer	All other types
1	η ≤55%	η ≤40%	η ≤50%
2	55%< η ≤65%	40%< η ≤50%	50%< η ≤60%
3	65%< η ≤80%	50%< η ≤60%	60%< η ≤70%
4	80%< η ≤90%	60%< η ≤70%	70%< η ≤80%
5	90%< η ≤100%	70%< η ≤80%	80%< η ≤90%

Note: the 2008 standard added the correction coefficient for different climate types, the definition and the equation of base energy consumption and the new equation for calculating energy consumption of specified refrigerator types.

The current distribution of products within these energy efficiency Tiers is investigated in section 4.4.2. However, at this point it is important to note that EES

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[58] Energy Saving Certification is an endorsement regulation (allowing use of a label). However, in addition to the energy efficiency requirement other requirements must also be met (e.g. factory quality check, etc.) in order to register products for certification.

[59] Li Tao, Dai Hong (Hefei Meiling Co.,Ltd): Analysis of GB 12021.2 – 2008, Beijing, 2010

uses an EEI function that results in Tier threshold values that are linear *and* that are based on adjusted volumes. There are two significant problems with this approach:

- While the energy consumption of a refrigerated appliance tends to increase with increases in volume, this relationship is not linear. Therefore, larger refrigerated appliances are inherently more efficient than smaller equivalents. Thus, the use of a linear function to define the energy efficiency threshold limits for the EES means either smaller units are unnecessarily penalized, making them relatively more expensive than larger units to produce (and thus increasing price to the consumer); or larger units are allowed more leniency and claim higher efficiency Tiers than should be the case.
- Energy consumption of a refrigerator is not actually a function of adjusted volume. The energy consumption is a function of adjusted surface area. However, over small variations in volume the use of adjusted volumes as a proxy for adjusted surface area is acceptable as the variation in volume and surface area will be broadly similar. However, the range of product volumes is now extensive (in China unadjusted volumes of BCD products range from 150-500+ litres) and over such ranges adjusted volume ceases to be an appropriate proxy for adjusted surface area. Again, this will result in EES threshold values being unnecessarily severe for smaller appliances or lax for larger appliances which will either increase the price of smaller units and/or make larger units appear relatively more efficient[60].

Hence, this use of linear functions and adjusted volumes is increasing the price of smaller units, and/or the improving the apparent efficiency of larger units. Either (or worse both) of these outcomes is giving an incentive for consumers to purchase larger appliances which leads to higher overall energy consumption.

While the use of a linear function and adjusted volume is in line with practice in the majority of countries around the world at *present*, policy makers in China may wish to consider leading much of the world in:

- A move away from linear functions as a basis for EES performance Tier and MEPR thresholds and move towards a curved exponential function (Australia has already effectively done this for labeling thresholds).
- Changing the basis on which the MEPS and labeling thresholds are calculated by moving away from adjusted appliance volume and adopting adjusted surface area. Note, the suggestion is NOT that the adjusted surface area is included on the label; it should only be used for the calculation of regulatory requirements. The information on the label should remain simply the capacity of the compartment(s).

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[60] For a full description of the relationship of adjusted volume, adjusted surface area and the associated impact on energy consumption and regulations, refer to the IEA 4E **Benchmarking report for Domestic Refrigerated Appliances at** http://mappingandbenchmarking.iea-4e.org/matrix?type=product&id=13

Such an approach would more effectively responds to the inherent increase in efficiency as product sizes increase, and removes the potential for the perverse outcome of increased unit volumes improving apparent unit efficiency but increasing consumption.

4.2.2 Energy labeling of refrigerated appliances

The China Energy Label for household refrigerators became mandatory in March 2005 based on GB12021.2-2003. From May 2009, the label became based on the requirements laid out in GB12021.2-2008.

An example of the energy label is shown in Figure 38. The label has five Tiers aligning with the EETs. In addition to the indicator showing the specific energy efficiency Tier of the appliance, the label also includes basic identification information of the model, the 24 hour energy consumption under test conditions, and the volume of the individual compartments within the appliance.

Figure 38: Example of China Energy Label for Household Refrigerators

This declared information is broadly in line with other comparative labels used internationally. However, given desire to provide consumers with information to encourage their adoption of the lowest energy *consuming* product (even if this is not necessarily the most efficient), policy makers may wish to consider amending the label declaration to include *annual* rather than *daily* energy consumption. The rationale for this proposal is that, at the time to purchase, consumers are considering a range criteria not just related to energy (eg price, brand, capacities, etc). Therefore, performing the annual energy consumption calculation for a number of competing machines may not be at the forefront of their minds. Should they not perform the calculation, then competing machines with 0.4 kWh/24hrs and 0.9 kWh/24hrs may be considered to be *relatively* similar. However, over a full year, this would make approximately 180 kWh difference in consumption and 90 RMB additional energy cost to the consumer (based on electricity costs approximately 0.5RMB/kWh). Therefore, the presentation of annual consumption may have a more significant impact and increase the likelihood of consumers selected the lower energy consumption product.

4.2.3 Test Method

The Chinese test method for household refrigerators is GB/T 8059. The test method is very similar to ISO 15502 and IEC 62552 with consumption measured over 24 hours in steady state conditions (ambient temperature 25°C, average temperature in the fridge compartment 5°C and maximum temperature in the freezer compartment -18°C).

4.3 Subsidy Information

In May 2012, the government announced that refrigerated appliances would be included in the appliance subsidy programs for the first time. The subsidy became effective on June 4, 2012 with subsidies for energy-efficient refrigerators ranging from 70 RMB per unit to a maximum of 400 RMB per unit depending on efficiency level, appliance type and appliance volume. The details of the available subsidies are shown in Table 14.

Table 14: Levels of support under the 2012 subsidy program for refrigerated appliances of varying capacity and type

Refrigerator type	Total Storage Volume (TSV)[61]	Subsidy Applicable (RMB/Unit)	Energy Efficiency Requirement (η)
Freezer, Fridge/Freezer (BD, BC/BD)	(TSV) ≤ 120L	70	η ≤ 50%
	120L< TSV ≤ 300L	130	
	TSV > 300L	180	
Fridge Freezer, frost-free fridge freezer (BCD, BCDW)	TSV ≤ 240L	260	η ≤ 32%
	240L < TSV ≤ 300L	330	
	TSV > 300L	400	η ≤ 40%

In September 2012, the National Development and Reform Commission (NDRC), the Ministry of Finance (MOF) and the Ministry of Industry and Information Technology (MIIT) announced two groups of refrigerator manufactures and their product models qualified for the subsidy program with support for these models available until May 31, 2013 (about 50 manufacturers and 3,800 models in total).

4.4 Data Analysis

The analysis examines the performance, energy and market related properties outlined in Table 15. Table 15 also details the number of models for which data was available.

[61] The "Storage Volume" is tested according to the Chinese National Standard GB/T 8059.

The analysis of the recent national subsidy program for refrigerators is based on the publicized implementing rules and the registered refrigerator models covered by this subsidy program[62].

In addition to the generic cautions provided in section Approach and Methodology, readers should note that not all performance and other parameters were available for all models identified. Where all models are not included in a particular analysis, this is noted in the text. However, it has not been possible to estimate the bias this has introduced into the analysis for any given parameter.

Table 15: Summary of Data Captured on Domestic Refrigerated Appliances and Analyzed in this Report (Data captured July 2012)

Data type	Notes
Models	1,693
Types	BC, BD, BC/BD, BCD and BCDW
Number of Doors	Single, Double, Three, Side-by-Side, Multiple
Volume (L)	From 45 to 829
Energy Consumption (kWh/24h)	From 0.23 to 2.80
Price (RMB)	From 499 to 29999
Energy Efficiency Tier	1, 2, 3, 4, 5

4.4.1 Market distribution and relationship of refrigerated appliance product type, number of door, volume and energy consumption

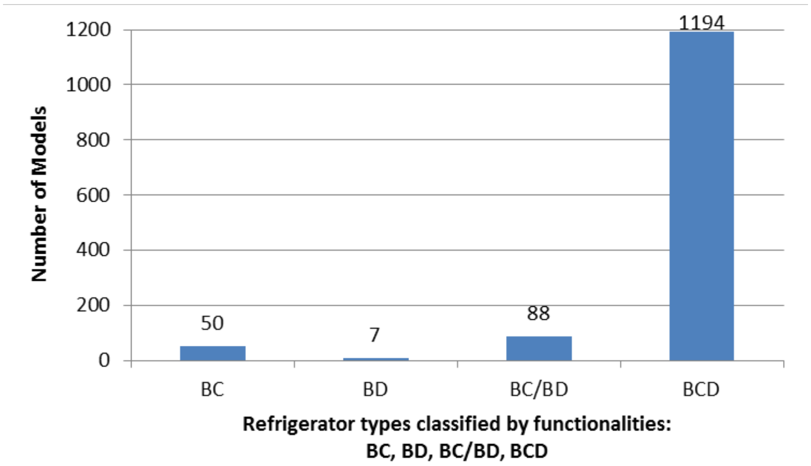
4.4.1.1 Market distribution by product type

Based on the 1,339 models for which classification of functional type was available, the market is dominated by BCD appliances (refrigerator freezers). These products constitute 89% of the Chinese market, with just 6.5% of models of the multifunctional BC/BD type, and a very small number of refrigerator only or freezer only models (refer to Figure 39)[63].

[62] Implementing rules (read in October 2012): http://www.sdpc.gov.cn/zcfb/zcfbqt/2012qt/t20120608_484887.htm
First round including 47 manufactures and 2,321 models: http://www.sdpc.gov.cn/zcfb/zcfbgg/2012gg/t20120619_486485.htm
Second round including 52 manufactures and 1,876 models: http://www.sdpc.gov.cn/zcfb/zcfbgg/2012gg/t20120914_505227.htm

[63] Note that the large percentage of BCD models has the potential to indicate that the rest of the analysis should be based purely on this product type. However, the actual market share (based on sales) of each product type is unknown and other categories may have significantly higher market share that indicated by product availability. Therefore all products are included in the analysis unless otherwise specified.

Figure 39: Distribution of available refrigerated appliance by functional type* (July 2012)

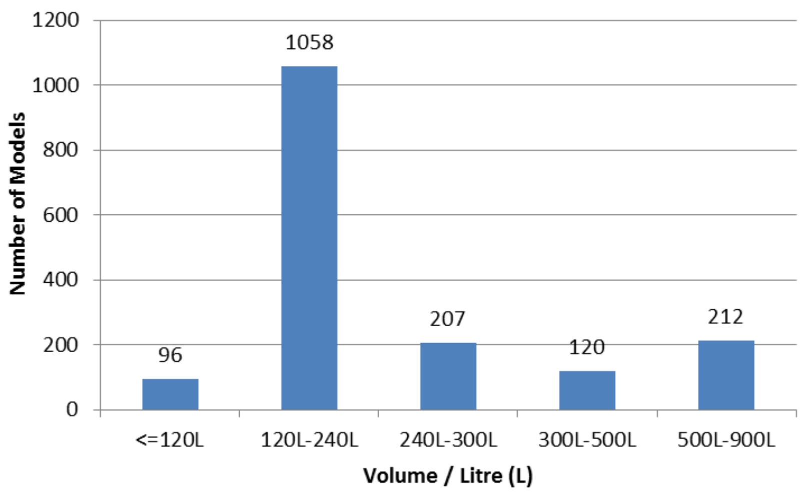


** Due to limitations on data available only 1339 models analyzed.*

4.4.1.2 Market distribution total unadjusted volume

Figure 40 uses the total (unadjusted) refrigerator compartment volumes used in the 2012 subsidy programs to show the distribution of available products by volume. There is a clear market dominance of products in the 120-240 liter range (62%), with smaller products taking just 6% of the market and 12% and 20% having volumes or 240-300 liters and greater than 300 liters respectively (of which 212 models have volume more than 500 liters).

Figure 40: Refrigerator model distribution by total unadjusted volume used in the 2012 subsidy program ((July 2012)

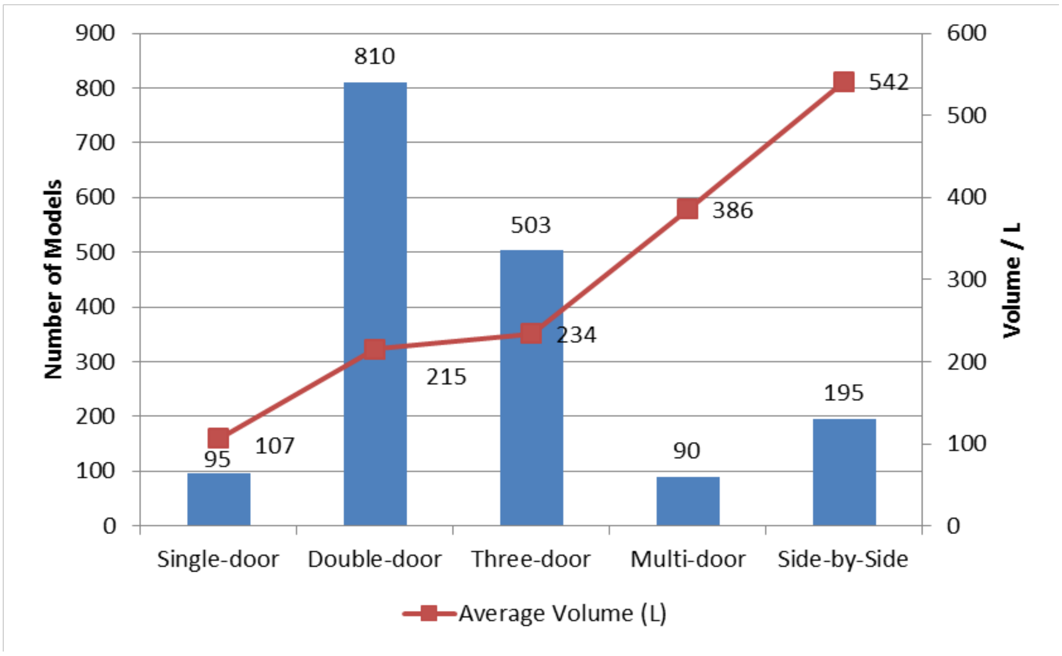


4.4.1.3 Market distribution by number of door and relationship to unadjusted volume

Figure 41 shows a breakdown of available appliances by number of doors and combines this information with the average unadjusted volume of products for each door configuration. Double and three-door upright refrigerated appliance dominate the market and together currently account for 78% of all models available. Side-by-side and multi-door models account for the majority of the remaining units.

As would be expected, the number of doors is a reasonable proxy for the relative volume of units with 1, 2 3 and multi-door units having average volumes of 107L, 215L, 234L and 386L respectively. However, side-by-side refrigerators (currently 11.5% of the market) have the largest average volume at 542L. It is estimated by GOME, one of the biggest electrical appliances retailers in China, that the market share of three-door and side-by-side door refrigerators (both of which typically use more energy than their two door vertical equivalent units) will increase from 50% to 65% in 2012. Clearly larger size refrigerators are rapidly becoming widely used in China, market change which is highly likely to result in more energy consumption in future.

Figure 41: Distribution of available refrigerated appliance by configuration of doors (July 2012)

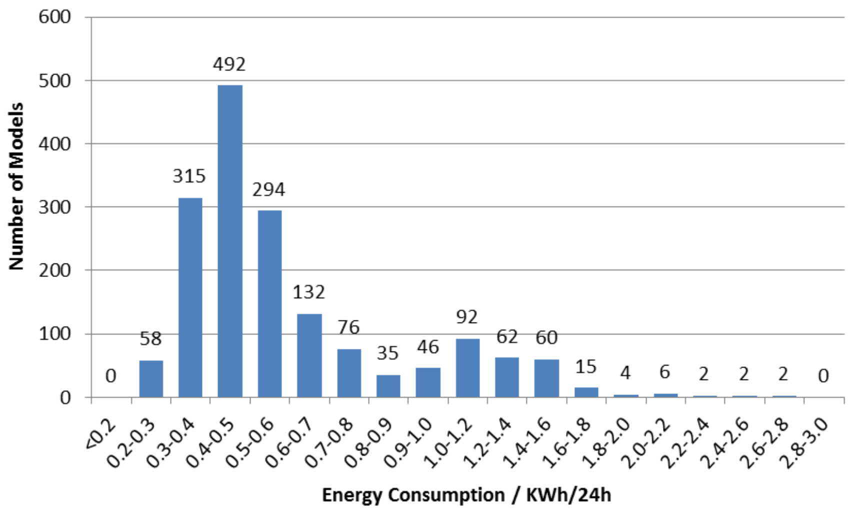


** Due to limitations on data available only 1339 models analyzed.*

4.4.1.4 Market distribution by energy consumption and relationship to unadjusted volume

Figure 42 examines the breakdown of refrigerated appliance by their declared energy consumption over 24 hours under test conditions. The majority of products are in the 0.3-0.6 kWh/24 hour consumption range (equivalent to an energy consumption of 110-220kWh/year). Specifically, 18.6% of the models have the energy consumption in the range 0.3-0.4 kWh/24h, 29% in the range 0.4-0.5 kWh/24h, and 17.4% in the range 0.5-0.6 kWh/24h and 0.6kWh/24h. 14.5% of the models have the energy consumption more than 1.0kWh/24h, and a small number of models have the energy consumption more than 2.0kWh/24h (equivalent to over 720kWh/year).

Figure 42: Distribution of available refrigerated appliance by energy consumption (July 2012)



Again using the same total unadjusted volume categories used in the 2012 subsidy program, it is possible to investigate the relationship between average unadjusted volume and average energy consumption as shown in Figure 43[64]. As would be expected, the larger the refrigerator, the more energy it consumes.

This underlines the importance to policy makers that the consumer selects an appropriate size refrigerator to minimize overall energy consumption, and highlights the concern that consumers are increasingly purchasing larger products as noted in section 4.4.1.3. This issue is investigated further in section 4.4.4 on subsidy support for refrigerated appliances.

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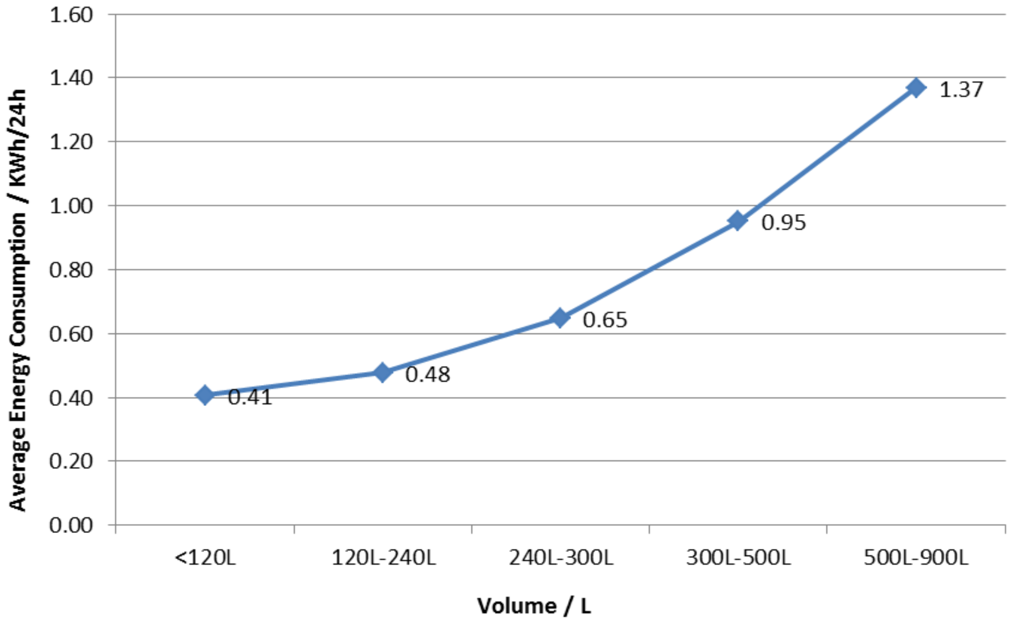
[64] Note volume categories are based on the total (unadjusted) refrigerator compartment volumes used in the 2012 subsidy program and are not of equal size. Therefore it appears energy consumption is increasing faster as volume increases (the curve is getting progressively steeper). This is not actually the case and although energy consumption is increasing with volume, this increase is at a proportionately slower rate.

Figure 43: Relationship between unadjusted refrigerator appliance volume and average energy consumption (July 2012)*



** Note volume categories are based on the total (unadjusted) refrigerator compartment volumes used in the 2012 subsidy program and are not of equal size*

4.4.2 Market distribution of refrigerated appliance efficiency and energy efficiency standard Tiers

The distribution of refrigerated appliances available in the market by EES Tier is shown in Figure 44. As can be seen, 73% of the models are labeled Tier 1 and 23% are Tier 2, i.e. models that can apply to be certified as energy-efficient refrigerators account for 96% of all available models.

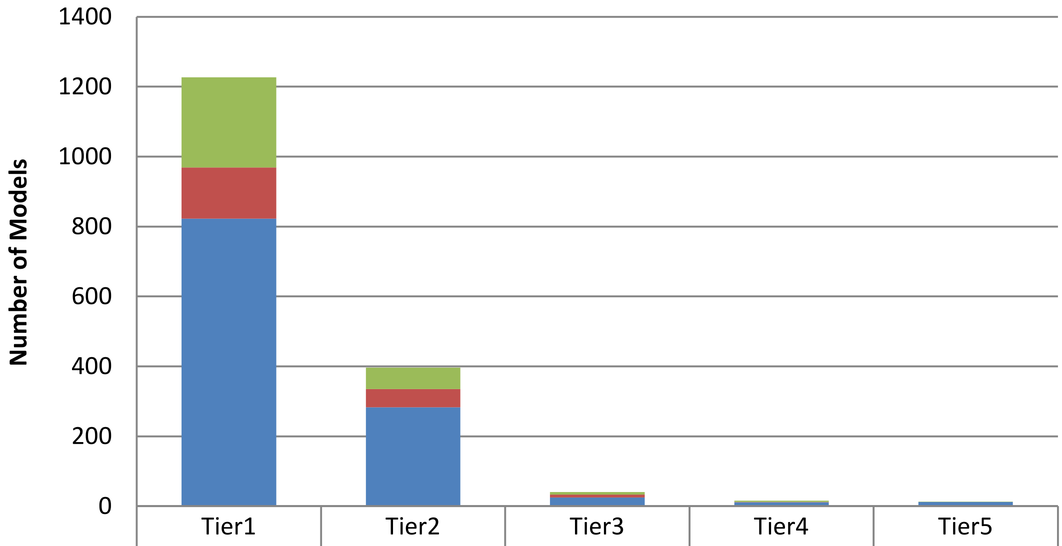
This skewed distribution to Tier 1 and 2 present's policy makers with two problems:

- It is removing choice for the consumer. As almost all products are "high-efficiency", it is not possible for the consumer to preferentially select the best performing products at time of purchase;
- It is limiting appropriate policy actions. It is not possible for policy makers to focus support (e.g. subsidy) on the best performing products as there is very little apparent differentiation in product performance.

This suggests the thresholds within the EES should be revised. The simple solution would be to remove the current Tiers 3-5 and use the current Tier 2 thresholds to become a new lower Tier 5 threshold and METR limit. The remainder of the Tier 1 products could then be redistributed to new Tier levels.

While partially addressing the problem, typically the introduction of a revised METR level would aim to remove approximately 20% of the worst performing products from the market. However, setting the current Tier 2 as the new METR would remove only approximately 5% of the worst products from the market. Therefore, there is value in reviewing the actual distribution of declared EEI levels of refrigerated products to establish if alternative Tier thresholds may be appropriate.

Figure 44: Distribution of available refrigerator models by energy efficiency Tier (July 2012)

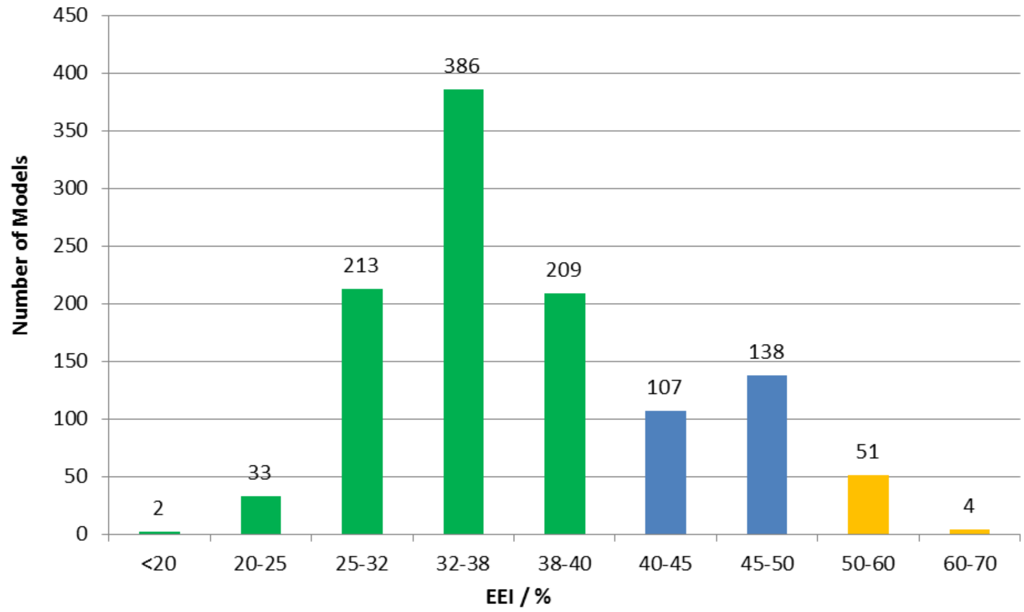


	Tier1	Tier2	Tier3	Tier4	Tier5
>300L	258	61	8	4	1
240-300L	146	52	8	1	0
<=240L	823	283	25	11	12

Figure 45 shows the distribution of the 1143 refrigerator freezer (BCD) models for which EEI values are available. Clearly the spread of EEI values of models on the market is much more extensive than the current EET distribution suggests. In particular, the distribution of current Tier 2 products splits into two equal halves, with broadly equal numbers of models above and below the 45% EEI midpoint. By setting a new Tier 5 threshold at this 45% midpoint, it would remove approximately 20% of the worst performing products from the market in line with the typical target when setting new MEPR levels. Further, setting the Tier 1 thresholds at EEI=25 and the Tier 2 threshold at EEI=32 would also ensure a small number of products would be identifiable as premium Tier 1 products, and approximately 20% of products would achieve the "high efficiency" designation for Tier 1 and 2 products. The remaining products could then be distributed between the remaining three Tiers. Proposals are made in Table 16 for potential energy efficiency Tier requirements for refrigerated appliances based on the 2008 EEI calculation methodology[65].

[65] Note the proposed Tier requirements are based on the analysis of BCD products and the previous approach taken by policy makers to allow 10% higher EEI allowances for other products. With limited further analysis it may be possible to revise the Tier thresholds for other products to more stringent levels.

Figure 45: Distribution of available refrigerator freezer models by energy efficiency index (July 2012)



** Note distribution based on only 1143 BCD models for which data was available.. Also note EEI ranges on x-axis are of different sizes. Dark green columns are EET Tier 1 products, light green EET Tier 2 products and yellow EET Tier 3 products.*

Table 16: Potential energy efficiency Tier requirements for BCD refrigerated appliances based on the 2008 EEI calculation methodology

EET	Energy Efficiency Index (EEI) η *(based on GB 12021.2-2008)*	
	Fridge Freezer (BCD)	**Other Products**
1	η ≤25%	η ≤35%
2	25%< η ≤32%	35%< η ≤42%
3	32%< η ≤38%	42%< η ≤48%
4	38%< η ≤40%	48%< η ≤50%
5	40%< η ≤45%	50%< η ≤55%

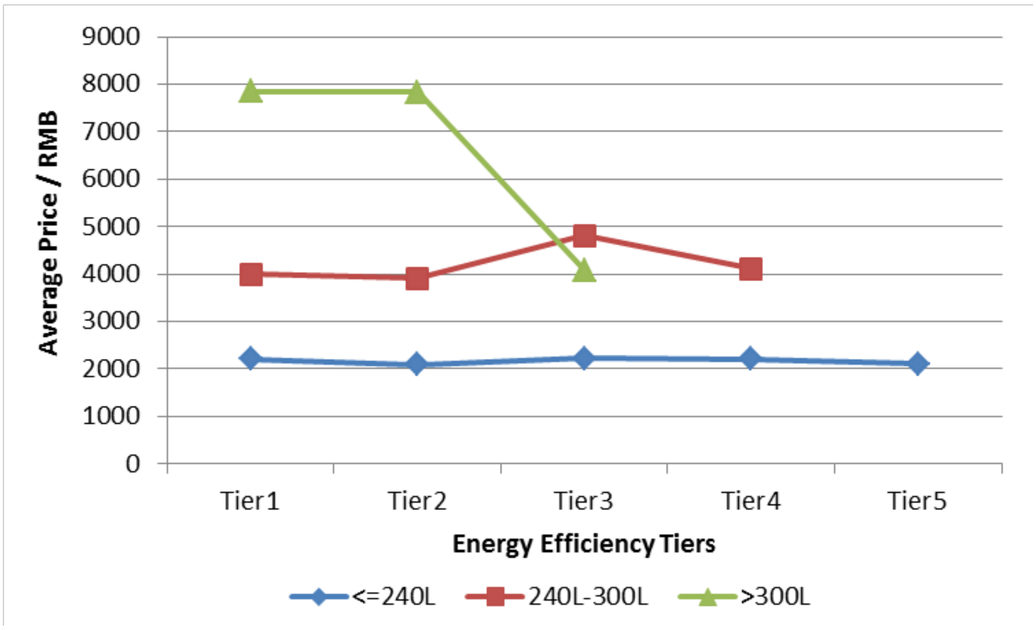
Such an approach would:

- Remove the very worst performing products from the market.
- Provide consumers with more product differentiation based on the comparative efficiency of the products allowing them to preferentially choose the more efficient units at the time of purchase.
- Incentivize manufacturers whose products have now been categorized as Tier 4 and 5 to improve their product performance so as not to appear “inferior” compared with competitive models.
- Allow policy makers to more appropriately focus other policy support measures on only the most efficient products.

4.4.3 Relationship of appliance price to volume and energy efficiency Tier

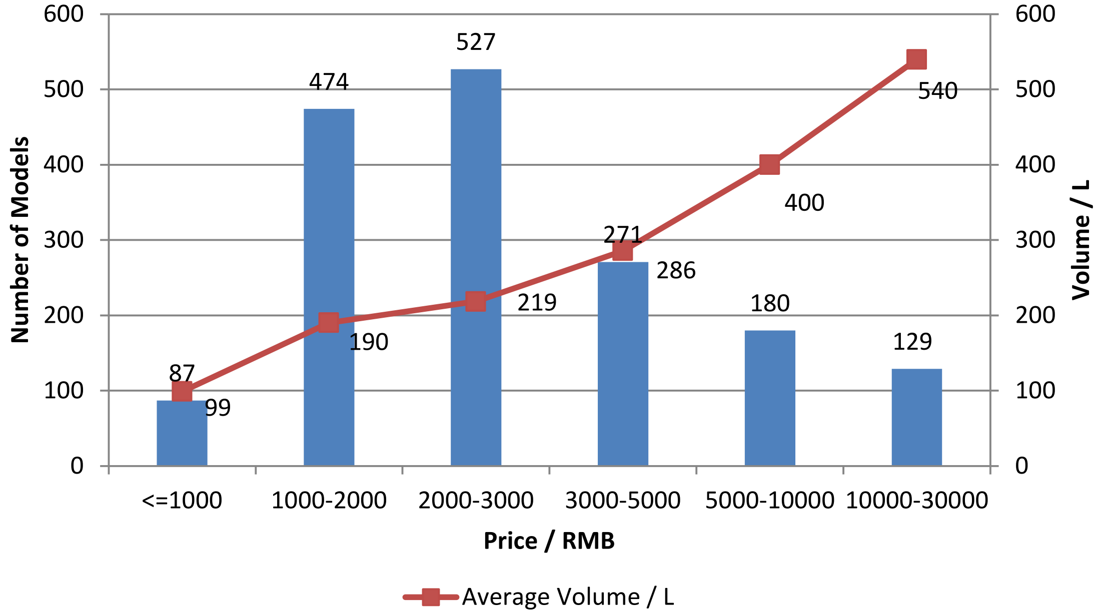
There are a large number of factors that affect the price of refrigerated appliances such as brand, design, market position, etc. However, as Figure 46 illustrates, the average price of refrigerators of similar volumes does not seem to rise with increasing efficiency Tier, if anything the reverse (with the exception of products over 300 liters which are influenced unduly by the very large spread of volumes). Hence, at present policy makers may be reassured that revisions to the EES suggested in section 4.4.2 are unlikely to result in significant price increases to the consumer.

Figure 46: Relationship of refrigerated appliance price to energy efficiency Tier (July 2012)



However, as might be expected, products of larger volume are on average more expensive than smaller products. Figure 47 examines the distribution of products by price range, and the average volumes in those price ranges. As can be seen, 60% of the refrigerator models available are in the price 1,000-3,000 RMB and 16% in the range 3,000-5,000 RMB. 19% of available models are in the high-end market with prices over 5,000RMB (it is worth noting that this is over 300 models, of which 129 models have a price over 10,000RMB). This indicates that there are consumers in China who tend to buy large size refrigerators as a luxury rather than for pure practical use which has a strong energy penalty given the strong relationship between increased product size and energy consumption shown in section 4.4.1.4.

Figure 47: Distribution of number of refrigerated appliances available and average volume by price range (July 2012)



4.4.4 Application of the subsidy program to refrigerated appliances

By the end of November 2012, 4197 refrigerator models were registered as eligible for the national subsidy programs (although not all may have been placed on the market). For those products where data was available, **Error! Reference source not found.** Figure 48 and Figure 49**Error! Reference source not found.** show the number of products of different types registered to receive subsidies in the first two batches of registration.

Figure 48: Distribution of BD and BC/BD refrigerated appliances registered during the first two rounds of subsidy in 2012

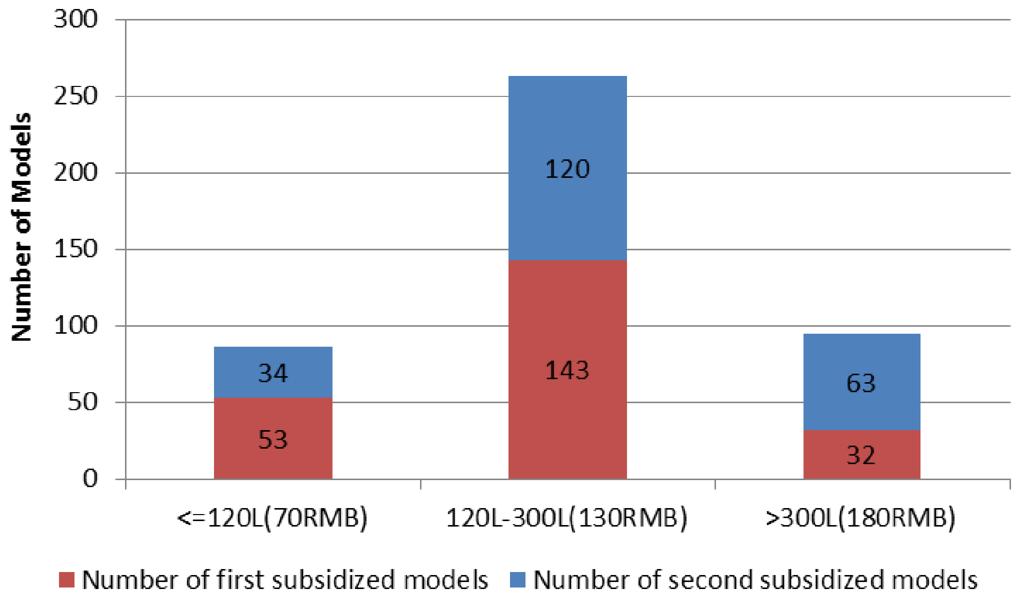
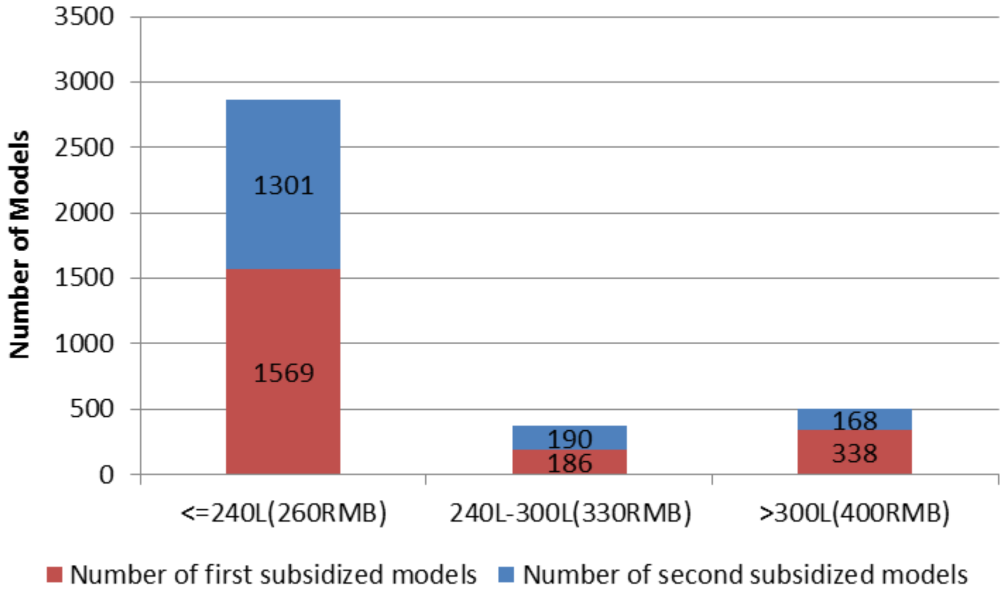


Figure 49: Distribution of BCD and BCDW refrigerated appliances registered during the first two rounds of subsidy in 2012



While it is possible that the subsidy has fulfilled its primary focus of stimulating demand for products, it appears the secondary goal of driving higher product efficiency has not been fulfilled for two reasons:

- It appears the program was designed based on outdated product performance information from the 2008 EES and thus a very high proportion of refrigerators where eligible for the subsidy rather than restricted to the higher efficiency products. Should the revision of EET thresholds suggested in section 4.4.2 be adopted by policy makers, and future subsidy programs targeted at only products qualifying for the revised Tier 1 and Tier 2 products, this situation would be resolved.
- The current subsidy scheme is primarily determined by the energy efficiency index of the product which reflects only how efficient the refrigerator is, and makes no consideration of the absolute energy consumption. However, if an assumption is made that 70 liters[66] of storage volume is an appropriate size for a person, and the average Chinese family size is 3-5 (3.10 in the year 2011), then a refrigerator with a volume between 210L and 350L should be sufficient for a typical family group. So from the perspective of energy conservation, giving subsidies to those refrigerators with volumes larger than 350 liters will encourage consumers to buy refrigerators that are bigger than necessary for their families and will result in unnecessary energy consumption. Based on the distribution of products registered for subsidy shown in **Error! Reference source not found.**Figure 48 and Figure 49**Error! Reference source not found.**, 9.1% of products have a volume over 350L.

[66] The 70 litre volume per person is a European guide for appropriate refrigerator capacity per person: http://www.iee-promotion.eu/docs/1725/Microsoft_Word_-_D3_3_Energysaving_tipps_en_short_version_final.pdf

However, actual sales figures for these models are unknown but the information from GOME provided in section 4.1.1 suggests that larger units are taking an increasing proportion of the market.

Thus, it is recommended that future subsidy support is not only limited to revised EET Tier 1 and Tier 2 products, but also is capped at product volumes no larger than 350 litres. This will have an additional benefit of targeting the subsidy support at the "typical" consumers rather than payment of subsidies for higher end products where the relatively limited subsidy (typically less than 5-10% of higher end products) is *likely* to have marginal impact on the purchasing decision of consumers that are inherently less sensitive to price.

4.5 Conclusions and recommendations

The conclusions and recommendations drawn from the analysis of refrigerated appliances are as follows[67]:

Proposed revisions to the energy efficiency standard and energy efficiency Tier thresholds

The current EES is based on a linear function and adjusted appliance volume to derive the energy efficiency performance Tiers and the associated METR. However, the use of such a linear function *and* adjusted volumes has the effect of increasing the price of smaller units and/or improving the apparent efficiency of larger appliances. Either (or worse both) of these outcomes is giving an incentive for consumers to purchase larger appliances which leads to higher overall energy consumption.

While the use of liner function and adjusted volume is in line with practice in the majority of countries around the world at *present*, policy makers in China may wish to consider taking a world lead and:

1. Moving away from linear functions as a basis for EES performance Tier and MEPR thresholds and towards a curved exponential function (Australia has already effectively done this for labelling thresholds).
2. Changing the basis on which the MEPS and labelling thresholds are calculated by moving away from adjusted appliance volume and adopting adjusted surface area.

   Such an approach would more effectively responds to the inherent increase in efficiency as product sizes increase and removes the potential for the perverse outcome of increased unit volumes improving apparent unit efficiency yet leading to increasing energy consumption.

However, such a transition will take some time to implement and the current distribution of refrigerated appliances is very skewed (73% of the models are labeled Tier 1 and 23% are Tier 2, i.e. models that can apply to be certified as energy-

[67] A separate study was taken by CLASP to benchmark Chinese refrigerator standards against a number of other countries (Benchmarking of Refrigerated Appliances, CLASP 2013). This report contains complementary recommendations, which policy makers may wish to review.

efficient refrigerators account for 96% of all available models). This skewed distribution to Tier 1 and 2 present's policy makers with two problems:

- It is removing choice for the consumer. As almost all products are "high-efficiency", it is not possible for the consumer to preferentially select the best performing products at time of purchase;
- It is limiting appropriate policy actions. It is not possible for policy makers to focus support (eg subsidy) on the best performing products as there is very little product differentiation.

3. This suggests the thresholds within the EES should be revised. Therefore, specific proposals for revised EES threshold levels and a new METR are made in section 4.4.2. If adopted, such a revision to the EES would:
    - Remove the 20% of very worst performing products from the market.
    - Provide consumers with more product differentiation based on the comparative efficiency of the products allowing them to preferentially choose the more efficient units at the time of purchase.
    - Incentivize manufacturers whose products have now been categorized as Tier 4 and 5 to improve their product performance so as not to appear "inferior" compared with competitive models.
    - Allow policy makers to more appropriately focus other policy support measures on only the most efficient products.

Analysis suggests that policy makers may be reassured that product prices are unlikely to rise due to the proposed increases in efficiency requirements.

Proposed revisions to the energy efficiency label

The information declared on the Chinese refrigerated appliance label is broadly in line with other comparative labels used internationally and in general seems highly appropriate to the market need. However:

4. Given desire of policy makers to provide consumers with information to encourage adoption of the lowest energy *consuming* product (even if this is not necessarily the most efficient) policy makers may wish to consider amending the label declaration to include *annual* rather than *daily* energy consumption. The rationale for this proposal is that, at the time to purchase, consumers are considering a range criteria not just related to energy (eg price, brand, capacities, etc). Therefore, performing the annual energy consumption calculation for a number of competing machines may not be at the forefront of their minds. Should they not perform the calculation, then competing machines with 0.4 kWh/24hrs and 0.9 kWh/24hrs may be considered to be *relatively* similar. However, over a full year, this would make approximately 180 kWh difference in consumption and 90 RMB additional energy cost to the consumer (based on electricity costs approximately 0.5RMB/kWh). Therefore, the presentation of annual consumption may have a more significant impact and increase the likelihood of consumers selected the lower energy consumption product.

Proposed revisions to the energy efficiency label

It is likely the subsidy has fulfilled its primary focus of stimulating demand for products, but the secondary goal of driving higher product efficiency appear has not to have been as successful. The subsidy was designed based on outdated product performance information from the 2008 EES and thus a very high proportion of refrigerators where eligible for the subsidy rather than restricted to the higher efficiency products. Should the revision of EET thresholds suggested in section 4.4.2 be adopted by policy makers, and future subsidy programs targeted at only products qualifying for the revised Tier 1 and Tier 2 products, this situation would be resolved.

However, the current subsidy scheme is mainly determined by the energy efficiency index of the product which only reflects how efficient the refrigerator is and makes no consideration of the absolute energy consumption. Analysis indicates that a 210L and 350L refrigerator should be sufficient for the typical family group in China. So from the perspective of energy conservation, giving subsidies to those refrigerators with volumes larger than 350 liters will encourage consumers to buy refrigerators that are bigger than necessary for their families and this will result in unnecessary energy consumption. Thus, it is recommended that:

5. Future subsidy support is not only limited to revised EET Tier 1 and Tier 2 products, but also is capped at product volumes no larger than 350 liters. Such an approach would not only limit overall consumption, but will have an additional benefit of targeting the subsidy support at the “typical” consumers rather than payment of subsidies for higher end products where the relatively limited subsidy (typically less than 5-10% of higher end products) is *likely* to have marginal impact on the purchasing decision of consumers that are inherently less sensitive to price.

Section 5: Analysis of the Market and Product Performance of Automatic Rice Cookers

Rice is the primary staple food for much of the Chinese population. As such, rice cookers are one of the most regularly used residential appliances. The energy saving projections made as part of this analysis[68] indicate that the number of rice cookers installed will rise from approximately 243 million in 2012 to 354 million in 2020, especially as penetration rises in rural households. Under the business as usual scenario projection, by 2020 the stock of induction cookers would consume approximately 62 TWh per year of energy. Such projections clearly demonstrate the need to examine and potentially address the energy efficiency and overall energy consumption of automatic rice cookers.

5.1 Product Background

Electric rice cookers turn electricity into heat. This heat is then passed into the cooking water via an inner container (often called a pot) in which the rice or other food items are cooked (the cooking of other items is possible in most automatic rice cookers).

Originally rice cookers were all mechanically controlled. However, as cooker technology has advanced, electronic control has increasingly been used and is now typical in all but the lower end products. Similarly, rice cookers were all traditionally heated via electrical resistance. More recently, units heated through induction have been introduced to the market, although at present their penetration is still low at 2%[69]. In line with the national energy efficiency standard, this analysis examines only rice cookers with rated power of up to 2000W.

Aside from the differences in heating method, rice cookers are also categorized by inner pot material (e.g. metallic vs. non-metallic).

5.1.1 Production, sales and stock level

Rice cookers started to enter the Chinese market in the 1990's. With the rapid development of the national economy and electrification, their household penetration increased swiftly. By 2011, 186 million rice cookers were produced in China, with annual domestic sales of 51 million[70]. By the end of 2011, it was estimated that 226 million rice cookers were in use in Chinese homes[70], rising to approximately 243 million in 2012. This represents approximately one rice cooker in every two households in China, though the predominance is currently in urban households.

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[68] Energy Saving Potential (ESP) Study for Nine Appliances in China, CLASP 2013
[69] Based on the information of models available from the on-line dealers of ZOL and 360buy in January 2013. Websites: www.zol.com.cn, www.360buy.com.
[70] CNIS White Paper, 2012

5.1.2 Usage Patterns

Rice cookers have three main energy-using states:

- *Cooking*: the period in which the water is heated and maintained at a relatively high temperature to cook rice or other foodstuffs;
- *Keep-warm*: maintaining the food temperature once the cooking process is complete; and
- *Standby*: when the appliance is not actually in use but is still plugged in to the main supply.

Unfortunately, little public information can be found on actual usage patterns of rice cookers in China – i.e. how often rice cookers are used to prepare food, how much food is actually prepared, how long this food is kept in the rice cooker in keep-warm mode, and how much time the rice cooker is in standby rather than being unplugged and stored.

The projection of future energy consumption under different regulatory conditions is highly dependent on these specific consumer usage patterns, and these projections are critical in the development of appropriate energy efficiency standards. For example, the test method described in section 5.2.3 assumes the rice cooker will be operated at full volume. However, it appears that consumers tend to buy rice cookers that are larger than their normal usage requirements (refer to section 5.4.3), and therefore operation will typically be at less than full capacity. Thus, projections of energy consumption based purely on the declared values under the test would exaggerate actual appliance energy consumption and thus potential savings from improved rice cooker efficiency.

Therefore, we recommend that policymakers initiate consumer research to establish true consumer usage patterns including frequency of use and hours of operations in cooking, keep warm, and standby modes, plus the typical load factor of the rice cooker (i.e. how much rice or water is typically cooked relative to the capacity of the cooker). We also recommend conducting a technical study to establish the impact of part load cooking on the efficiency of the rice cooker.

As this information is not currently available, we have developed estimates of usage patterns based on the little data available , to allow for the energy consumption and other projections made in this report[71].

5.2 Regulation, labeling and MEPS

5.2.1 Energy efficiency standard

The first mandatory energy efficiency standard (EES) for rice cookers was introduced in 1989. However, the rice cooker market evolved over the following two decades and a revised version of the EES (GB 12021.6-2008) was issued in 2008, coming into force in 2009. The EES is applicable to rice cookers with rated power less than

[71] Refer to the Energy Saving Potential (ESP) Study for Nine Appliances in China, CLASP 2013

2000W operating under atmospheric (not high) pressure, and which are heated by electrical energy, i.e., including both resistance and induction-heated rice cookers.

The regulatory requirements of the 2008 EES are summarized in Table 17. The EES categorizes rice cooker into five rated power ranges. Within each power range, five energy efficiency Tiers (EETs) are defined based on the thermal efficiency of the rice cooker. For each rated power range specified there is also maximum keep-warm energy consumption. A maximum standby requirement is also set at 1.6W for products in Tiers 1, 2, and 3, and 2W for products in Tiers 4 and 5. Rice cookers are defined as “high efficiency” in Tiers 1-3 if the inner pot is non-metallic, and in Tiers 1-2 if the inner pot is metallic.

Table 17: Energy efficiency, keep-warm mode energy consumption and standby power requirements for rice cookers

Rated Power, P (W)	Energy Efficiency (Thermal efficiency, η (%)) Energy Efficiency Tiers 1	2	3	4	5	Keep-warm mode energy consumption (Wh)
P<=400	85	81	76	72	60	40
400<P<=600	86	82	77	73	61	50
600<P<=800	87	83	78	74	62	60
800<P<=1000	88	84	79	75	63	70
1000<P<2000	89	85	80	76	64	80
Standby Power (W)	1.6			2		-

However, all five EETs only apply to rice cookers with non-metallic inner pots, with the lower threshold of Tier 5 defining the minimum energy performance requirement (MEPR) for this product type. For cookers with metallic inner pots, only the top four EETs apply, with the lower threshold of Tier 4 defining the MEPR. The direct implication of this differentiation is that rice cookers with metallic inner pots are inherently more efficient than rice cookers with non-metallic inner pots.

It is also clear from Table 17 that in order to be grouped into the same EET, rice cookers with higher power have to be more efficient than lower power units. However, as noted in section 5.1.2, is seems probable that consumers are not typically using rice cookers at rated capacity. Additionally, the test method requires the rice cookers to be tested using their typical cooking function, which may not correspond to the rated power (although it must be within the range 90-105% of rated power). As these issues have direct impact on the development of the EES, the need for the consumer and technical research proposed in section 5.1.2 is clear.

Finally, it should be noted that the current EES sets energy efficiency requirements based on power. However, it seems reasonable to speculate consumers are likely to select rice cookers primarily based on volumes. Therefore policymakers may wish to consider a switch from power-based energy efficiency requirements to the related but more understandable (to consumers) volume-based requirements. This would also assist with the revisions to labeling information proposed below.

5.2.2 Energy labeling of rice cookers

In October 2009, the Chinese government announced that rice cookers would join a number of other products and be covered by the China Energy Label Scheme, with labeling becoming mandatory from March 2010.

The energy label for rice cookers, shown in Figure 50, has five Tiers aligning with those in the EES[72]. In addition to showing the specific energy efficiency Tier of the rice cooker, the label also includes the basic identification information of the model, thermal efficiency, keep-warm energy consumption per hour, standby energy consumption per hour, and the material of inner pot (metallic or non-metallic).

Figure 50: China Energy Label for Rice Cookers

The aim the of the energy labels is to guide the consumer to better energy performing products. Unfortunately, there is no indication on the label of the *actual cooking energy* consumption. This can be misleading for the consumer. For example, a consumer may purchase a larger-volume rice cooker over a smaller volume alternative simply due to the larger product having a higher efficiency Tier rating. As mentioned in section 5.1.2, this will result in partial-load cooking for much of the time, which will have a significant impact on energy consumption, and may have an impact on unit efficiency.

Therefore, to improve comprehension, policymakers may wish to consider slightly revising the information on the label to replace the thermal efficiency value with the more useful (to consumers) value of energy consumed by the product during a typical cook/keep-warm cycle. In the longer term, the label would ideally be

[72] Note that the labels for rice cookers with non-metallic inner pots still have five Tiers on the label despite only four EETs being applicable in the EES.

amended to display energy consumption at partial-load that aligns with typical usage[73]. This energy consumption value could also incorporate typical keep-warm and on- and off-mode standby power consumption.

Such revisions would provide more useful decision making information for the consumer at the point of purchase.

5.2.3 Test Method

The test method for measuring the energy efficiency of rice cookers is described in the energy efficiency standard issued in 2008 (GB 12021.6-2008). The test is conducted with the appliance set to the “normal rice cooking function.” Where the rice cooker is multi-functional, the test is performed using the most efficient function as indicated in the instruction manual. Water is added to fill 80% of the inner cooking vessel[74] (the pot) with the total mass of the water and water temperature measured. The cooking cycle is then initiated until the water temperature reaches exactly 90°C, at which time the power is switched off. The temperature of the water continues to rise for a short period due to the delay in heat transfer from the heating plate to the inner pot/water. The maximum temperature reached by the water is recorded. The theoretical energy consumed by the mass of water within the cooker is calculated based on the temperature rise. The thermal (energy) efficiency (η) of the rice cooker is calculated by dividing the theoretical energy used to heat the water by the input power which is measured directly during the water heating process.

To measure keep-warm energy consumption, the water is brought to 90 °C in the same manner as the cooking test, but the rice cooker is then switched to the keep-warm function. Energy consumption is measured from this point with the water temperature measured after 4 hours, 4.5, and 5 hours. The average of the three measured temperatures is used as the keep-warm temperature. During the test, the keep-warm temperature should be within 60 °C to 80 °C. The energy consumption in standby is the average energy consumption over the first 4 hours when rice cooker is in standby mode.

5.3 Subsidy program

To date, the national subsidy program has not applied to rice cookers.

5.4 Data Analysis

The analysis examines the energy performance and price-related properties of rice cookers outlined in Table 18. In addition to the generic cautions provided in Approach and Methodology, readers should note that not all performance and other parameters were available for all models identified as available in the market. Where analysis is based on less than the full data set, this is stated. Where a full data set is

[73] For example, either energy consumption at full and half capacity, or possibly energy consumption when cooking incrementally larger quantities such as 1 liter, 2 liter, and 3 liter up to the rated capacity of the rice cooker.

[74] The 80% fill volume of the inner container is used to simulate the approximately 20% volume left by most consumers to allow for the expansion of the rice during cooking, although no rice is used in the test.

not available, it has not been possible to estimate the bias this has introduced into the analysis for any given parameter.

Table 18: Overview of the data used for rice cooker analysis

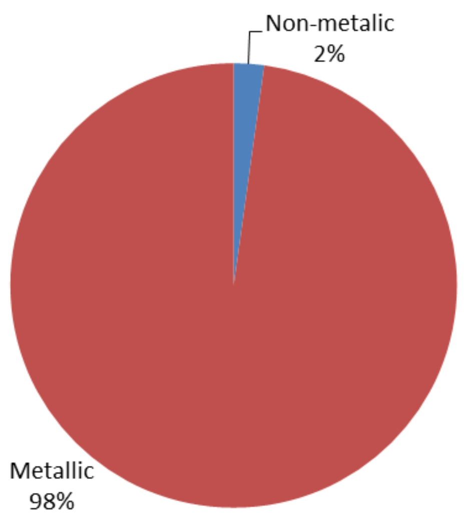
Data type/parameter	Note
Total number of models	1,276. All these models are used for the analysis in this report unless otherwise noted.
Types	Inner pot: metallic and non-metallic. Heating type: electric resistance and induction heating.
Thermal Efficiency (η)	Range 60-89
Power (W)	Range 200-2000
Price (RMB)	Range 75-6799
Volume (L)	Range 0.7-16
Standby Power (W)	Range 0.5-2

5.4.1 Rice cooker types and functionality

5.4.1.1 Distribution of rice cookers by inner container (pot) type

Figure 51 illustrates the market dominance of rice cookers with metallic inner pots. Note, only 2% of models on sale (28 models) have non-metallic inner pots.

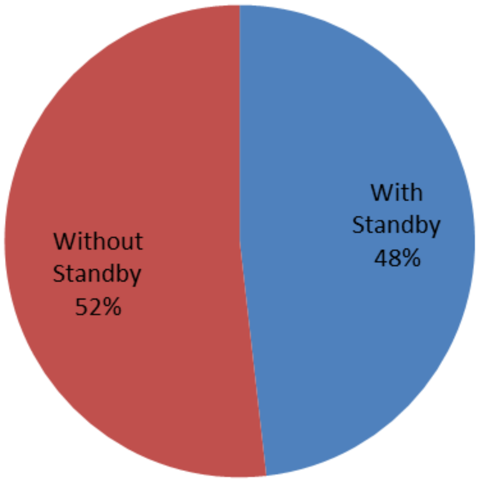
Figure 51: Market distribution of rice cookers by material of inner pot (July 2012)



5.4.1.2 Proportion of rice cookers with standby power consumption

With the development of electronic control, standby energy consumption is increasingly common in rice cookers. Figure 52 shows that of the rice cooker models available in July 2012. Almost 50% had some level of standby energy consumption.

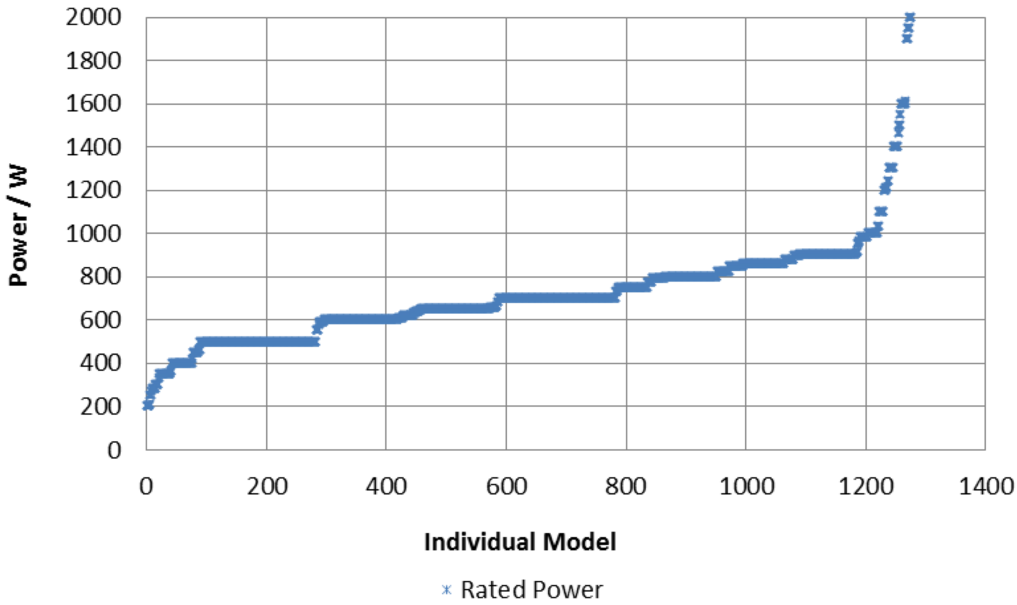
Figure 52: Market distribution of rice cookers with and without on-mode standby power functionality (July 2012)



5.4.2 Distribution of rice cookers by rated power

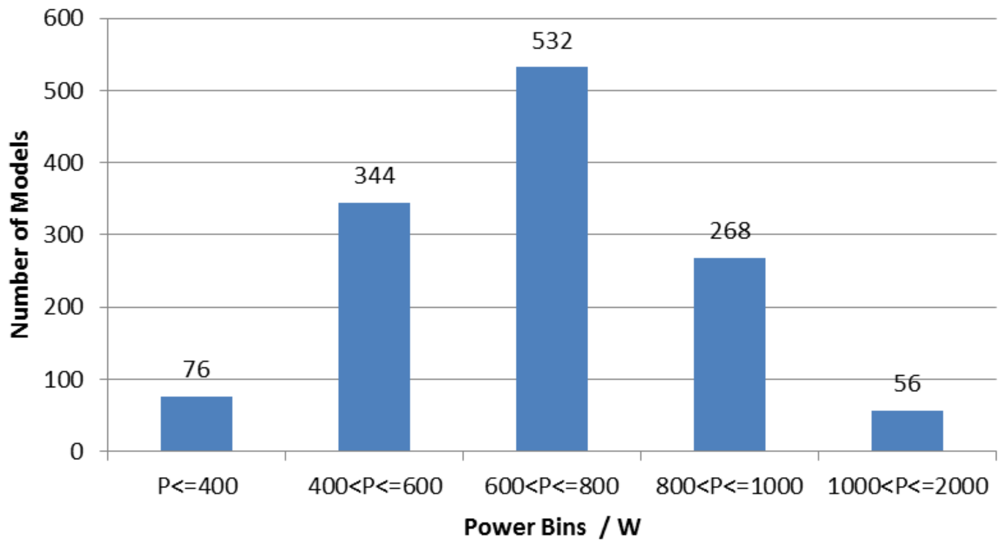
Figure 53 shows the detailed distribution of rice cookers by rated power. It is clear there are relatively few products rated at less than 400W and greater than 1000W.

Figure 53: Market distribution of rice cooker models by rated power (July 2012)



Looking at the market distribution based on the same power ranges used in the EES (Figure 54), it is clear that the majority of products fall into the 600-800W range, followed by 400-600W, and 800-1000W.

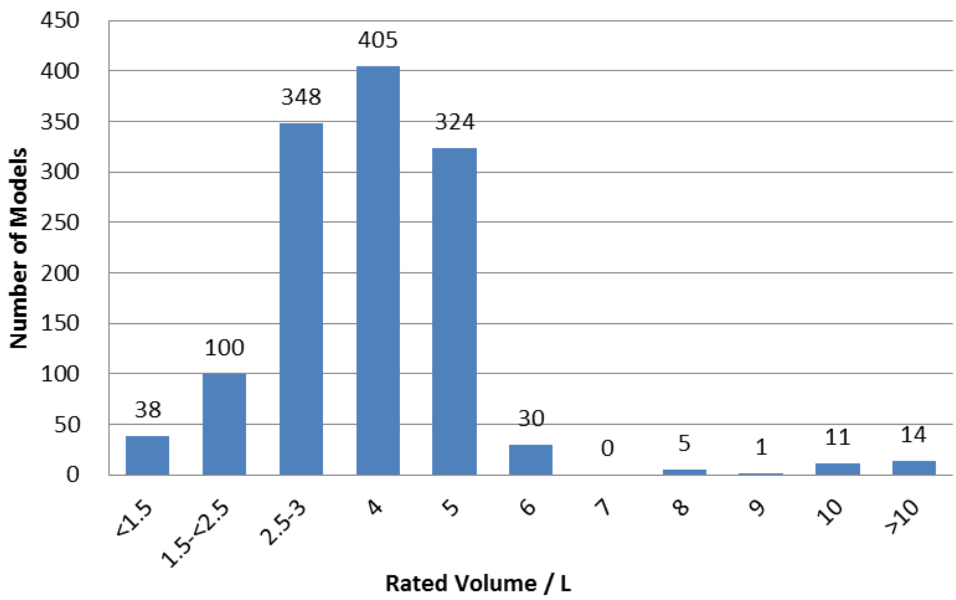
Figure 54 Distribution of rice cooker models by energy efficiency standard power ranges (July 2012)



5.4.3 Distribution of rice cookers by rated capacity

While the EES requirements are primarily based on the rated power, it is likely the key criteria for consumers during the purchase process is the capacity of the rice cookers. Figure 55 shows that 92% of available rice cooker models fall into the 2-5 litre range.

Figure 55: Distribution of rice cookers by volume* (July 2012)



**Rated capacities with non-integer volumes only occur for rice cookers with capacity below 3 liters.*

As part of the development of this report, estimates have been made for the number of people that rice cookers of various capacities are able to serve. These estimates are shown in Table 19.

Table 19: Estimate of serving capacities of rice cookers

Rated Volume (liters)	Estimated Capacity (number of people that could be served)
1	2
2	4
3	6
4	8
5	10
6	12

According to the Bureau of Statistics of China, Chinese families in 2011 had an average of 2.87 and 3.90 members in urban and rural areas, respectively.[75] Based on our estimates in Table 19, a two-liter rice cooker would sufficient for an average family except for when friends or relatives are being entertained. On the further assumption that the distribution of models available on the market shown in Figure 55 reflects the most popular volumes purchased, consumers are understandably purchasing rice cookers that are of a larger capacity than is typically required for normal use to allow flexibility to cater to intermittent demands when visitors are present.

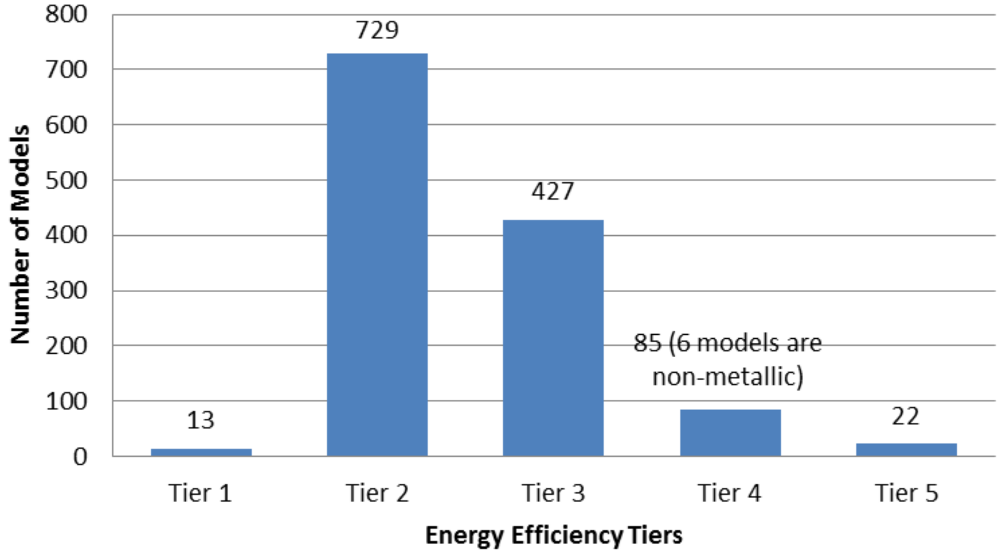
Hence, it appears that, under typical operating conditions, consumers may be using rice cookers at a range of capacities below their rating. If this is the case, then it may be appropriate to revise the test procedure to include tests with the rice cooker filled to (for example) 50% capacity to more accurately reflect actual usage. This information could be added to the energy label, as proposed above. However, the research into consumer usage patterns and the technical research into partial-load cooking proposed in section 5.1.2 should first be completed to inform the revisions that may be needed to the test methodology.

5.4.4 Distribution of rice cookers by energy efficiency Tier

The distribution of available rice cookers by EET is shown in Figure 56. Tier 2 products alone constitute over 57% of rice cookers available on the market in July 2012. When the small number of products in Tier 1 is added, this means 58% of the rice cookers available in the market are considered “energy efficient products.” Therefore, there would be clear benefit in restructuring the current EES to better align with the policy goal of less than 25% of products classified as efficient. Further, the predominance of products in Tiers 2 and 3 indicates a revision of the EES is necessary to more clearly distribute products across Tiers and to take the opportunity to implement a new MEPR.

[75] National Statistics Year Book of 2012.

Figure 56: Distribution of rice cookers by energy efficiency Tier (July 2012)



Consequently, policy makers may wish to consider revising the current EES as follows:

- Based on the assumption that the new EES should eliminate the least efficient 15%-20% products from the market, the MEPR value for metallic-type of rice cookers could be raised to 1% higher than the current Tier 3 lower boundary value, and that the EET thresholds could be revised such that this new MEPR becomes the lower threshold of Tier 4.
- Although the number of products currently available in Tier 1 is just 1% of available models, when taking into consideration the concept and advantages of Top Runner, and to encourage manufacturer innovation, the Tier 1 threshold could also be increased by 4%. The Tier 2 and Tier 3 thresholds could then be evenly distributed, with the proposed new Tier 2 threshold set at the current the Tier 1 threshold value.
- As there may be non-energy/efficiency reasons for maintaining a range of non-metallic inner pot rice cookers in the market (e.g., quality of rice cooking), policymakers may wish to consider maintaining a secondary MEPR level only for non-metallic rice cookers. However, there is still the opportunity to exclude the least efficient units and therefore raise the current Tier 5 threshold by 2%.

Table 20 provides an example of potential thresholds that policymakers may consider adopting in revisions to the EES.

Such revisions would enable policymakers to achieve a number of their objectives. They would result in less than 25% of products in the market qualifying for Tiers 1 and 2 (hence considered “energy efficient products”) and would motivate manufacturers of products now classified in Tiers 3 and 4 to increase the efficiency of their rice cookers so as to appear more “energy efficient” than other alternatives in the market.

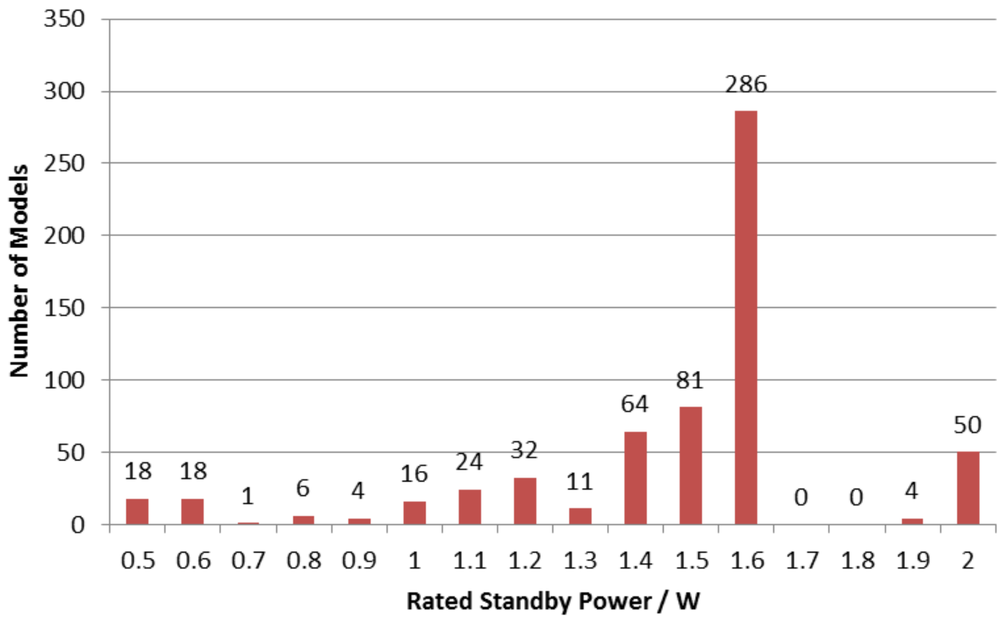
Table 20: Potential revised energy efficiency Tier thresholds for rice cookers

	Energy Efficiency (thermal efficiency, η (%)) *Potential new* energy efficiency Tier thresholds				
Rated Power, P (W)	**1**	**2**	**3**	**4**	**5**
P<=400	89	85	81	77	62
400<P<=600	90	86	82	78	63
600<P<=800	91	87	83	79	64
800<P<=1000	92	88	84	80	65
1000<P<2000	93	89	85	81	66

5.4.5 Distribution of rice cookers by standby power

The distribution of the declared standby power for rice cookers available in the market is shown in Figure 57.

Figure 57: Distribution of rice cookers based on declared standby power values (July 2012)



**Note that not all cookers have standby. Refer to section 5.4.1.2.*

The figure clearly shows that a very large proportion of products are only just complying with the 2W and 1.6W EES Tier thresholds. This seems to imply one of the following:

- Manufacturers have very accurate control of the design and production of rice cookers and can deliver products that are just at the boundary conditions; or,
- Manufacturers are understating the performance of products; for example, declaring the lowest value within the EET Tier for which their products qualify to ensure their products pass any verification testing undertaken by the regulator.

There was limited evidence as to which of these possible reasons was the cause of suppliers declaring rice cooker performance to be just above the threshold limits. However, we must bear in mind that standby power consumption is providing no useful function as the rice cooker is switched off. Therefore, if manufacturers have the degree of design and production control suggested, then there is a high likelihood that their designs could be made to accommodate stricter standby requirements. Similarly, if suppliers are under-reporting values, then increased stringency of standby should also not be a problem.

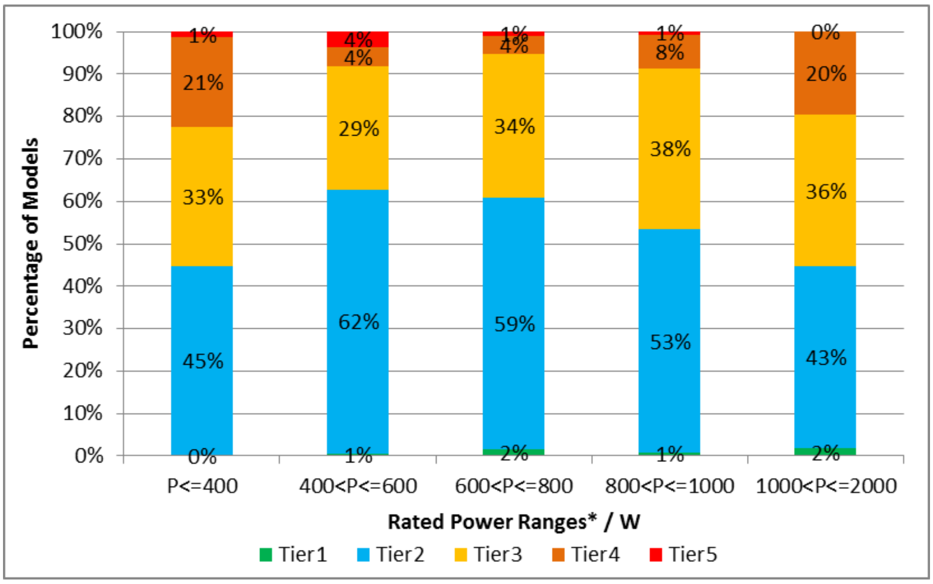
Thus, we recommend that policymakers aggressively target this standby energy consumption by increasing the stringency of the EES. Firstly, we propose that standby power in Tiers 1-4 be reduced to 1W. For Tier 5, some allowance may be given, e.g. 1.6W, considering that this more lax requirement would only apply to the small number of non-metallic rice cookers still in the market. Additionally, we recommend that policymakers require manufacturers to declare the actual standby (and other performance) values recorded on the test report supporting the labeling application.

Together, these recommendations should lead to an immediate and long term reduction in standby energy consumption, and present policymakers with better information on the true distribution of standby power between products. Based on this more realistic distribution of actual standby requirements, this may allow a future further revision of the standby requirements to, for example, 0.5W for EETs 1 and 2.

5.4.6 Distribution of rice cooker energy efficiency Tier by power

The EES sets increasingly stringent efficiency thresholds as the rated power of the rice cooker increases. Figure 58 examines the proportion of rice cookers that are registered within each EET for the power range specified in the EES.

Figure 58: Distribution of rice cookers by energy efficiency Tier within each energy efficiency standard power range (July 2012)



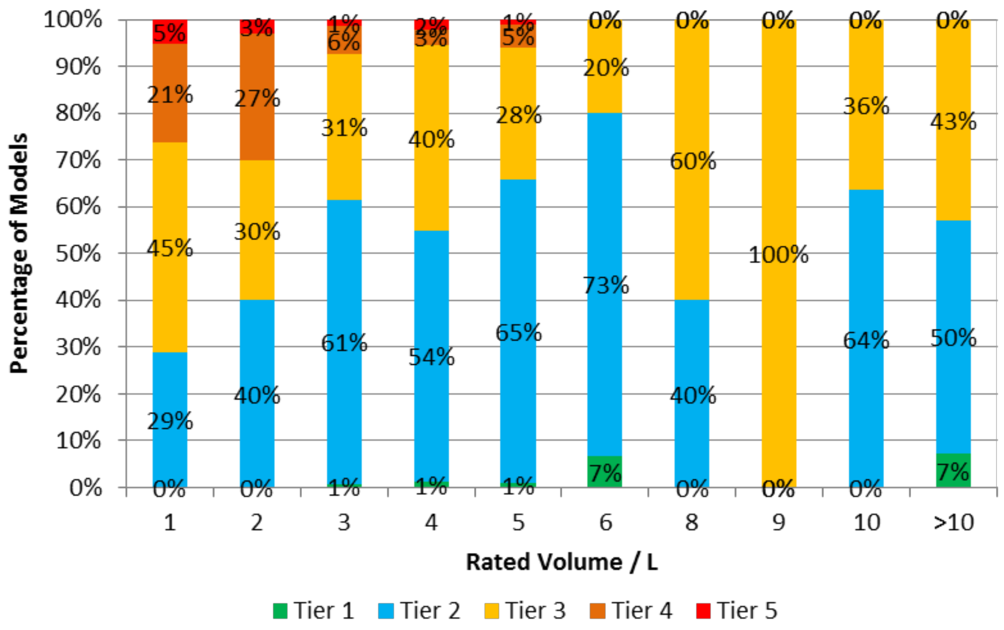
* *Note that the proportion of products with power below 400W and above 1000W is small compared with other power ranges.*

As can be seen, the distribution of products across the EETs is very similar for all power ranges. This implies, although does not guarantee, that the current grading of efficiencies by power range, and the degree of increase in stringency between power ranges, are both appropriate.

5.4.7 Distribution of rice cooker energy efficiency Tier by volume

As established in section 5.4.3, volume is an important factor in the consumer purchase decision. Therefore, to ensure a significant proportion of the products with better efficiency are available in the most popular volume ranges, there is value in examining the distribution of rice cookers that are registered as complying with each EET based on their volume (Figure 59).

Figure 59: Distribution of rice cooker energy efficiency Tier by volume (July 2012)



** Note that: the proportion of products with volumes below 3 liters and above 5 liters very little compared with the number of products with volumes within the 3-5 liter range and there is no product rated as 7L.*

Assuming consumer purchase patterns align with the availability of models in the market, then rice cookers with volumes of 3-5 liters are the most popular. Within this volume range, there is a reasonably even distribution of products, although it is significantly biased toward the Tier 2 efficiency level, which is not ideal.[76] Outside these most popular ranges, there is also appears to be a reasonable spread of products across the various EET levels, although this interpretation should be treated with caution given the limited number of products in some volumes.

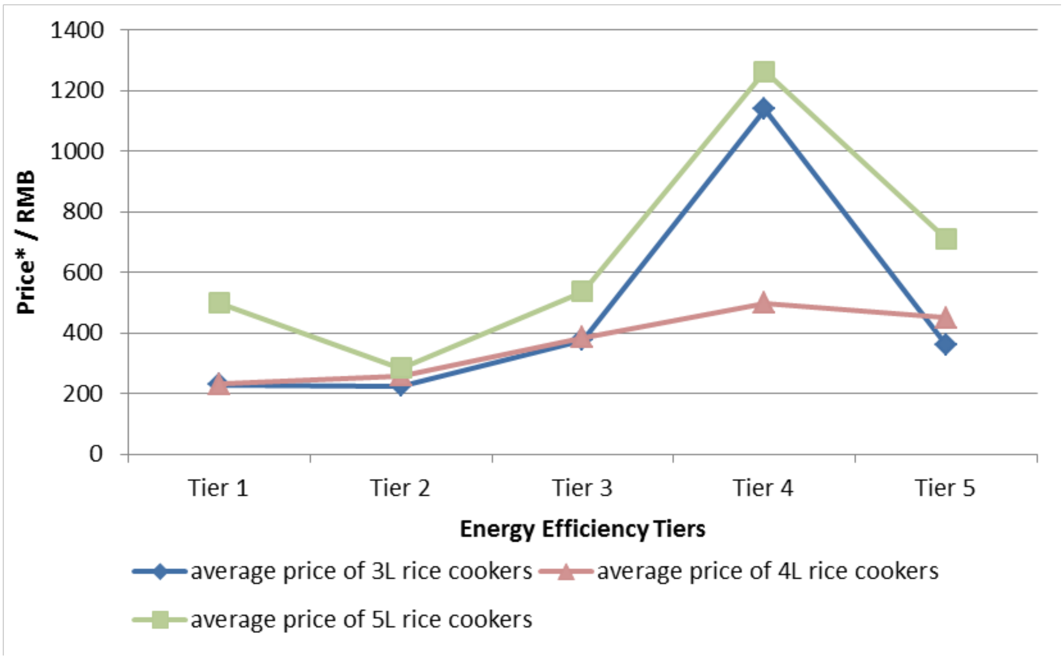
5.4.8 Relationship of rice cooker energy efficiency to purchase price

The relationship of rice cooker price to the appliance energy efficiency is difficult to measure if all products are grouped. For example, a 10-liter rice cooker is almost

[76] However, this would be addressed if the proposals for revising the EET thresholds proposed in section 5.4.4 were adopted.

inevitably going to be more expensive than a 2-liter rice cooker, irrespective of the efficiency levels. However, as established in section 5.4.3, volume is an important factor in the consumer purchase decision, and 3-, 4- and 5-litre products are the most prevalent in the market. Therefore, by looking separately at these three volumes, it will be should be possible to establish any relationship between price and efficiency from the most popular products. Figure 60 attempts to do exactly this by showing the average price of 3-, 4-, and 5-liter rice cookers registered in each efficiency Tier.

Figure 60: Relationship of average rice cooker purchase price to energy efficiency Tier for 3, 4 and 5 liter appliances (July 2012)



** Note that the proportion of products with volumes below 3 liters and above 5 liters very small compared with the number of products with volumes within the 3-5 liter range.*

*** Note that the number of Tier 1, 4, and 5 products are limited compared with Tier 2 and 3 products, which may lead to a degree of distortion in the averages shown.*

Two primary observations may be drawn from Figure 60:

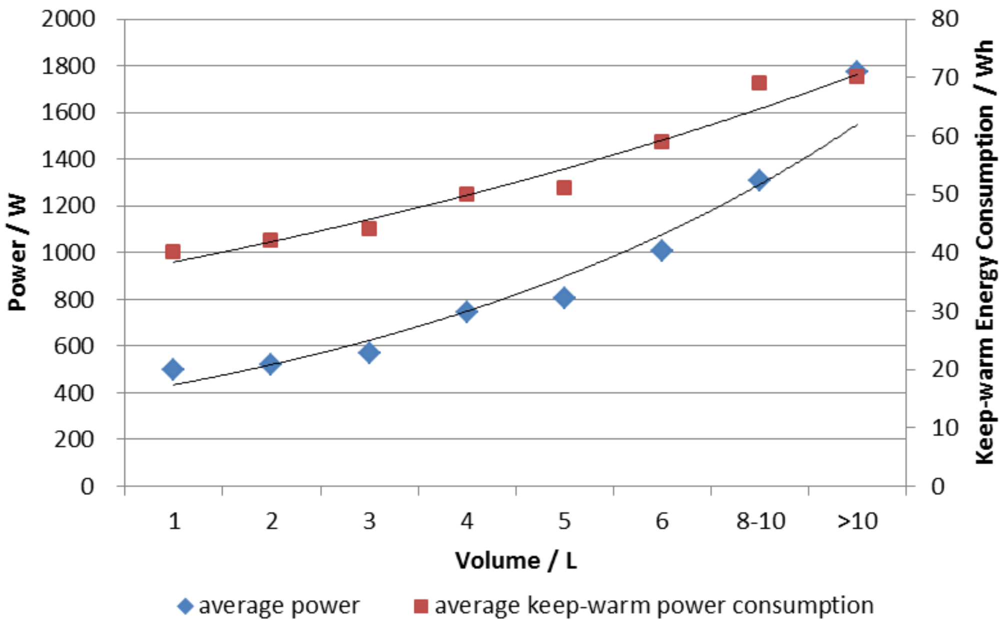
- Typically, there is an inverse relationship between rice cooker price and efficiency (as defined by higher Tier levels), i.e., for a given volume the average price of a rice cooker typically falls as efficiency increases (noting this is not true in all instances). However, for Tiers 2 and 3, the trend is clear for all volumes shown and it is these Tiers which contain the highest number of products, and hence are most likely to be representative;
- There is no strong relationship between average price and volume. While clearly 5-liter products are more expensive in all energy efficiency Tiers, 3-liter appliances are of a very similar price to 4-liter appliances, and significantly more expensive in the Tier4 range.

While the degree of confidence in either of these statements may be limited by the relatively small number of Tiers 1, 4 and 5 products which may be distorting the average values, there is still a relatively strong indication that price is not related to product volume, and is therefore more likely to be dictated by other criteria such as brand, additional functionality, etc. Therefore, it appears policymakers can be reassured the proposals made in section 5.4.4 to revise the energy efficiency Tier thresholds should not adversely affect product price.

5.4.9 Relationship of rice cooker volume, cooking power and keep-warm energy consumption

Figure 61 shows that rice cooker volume is closely correlated to the rated power and the energy consumed by the appliance in keep-warm mode, although in both cases this relationship is not linear.

Figure 61: Relationship between rice cooker volume, power and keep-warm energy consumption (July 2012)



**Note: there is no product rated as 7L.*

5.5 Conclusions and Recommendations

The conclusions and recommendations drawn from the analysis of rice cookers are as follows:

Revise of the Energy Efficiency Tier Thresholds

In July 2012, most rice cookers on the market were registered in Tier 2 (57%) and Tier 3 (33%). Such a distribution of products suggests the EES should be revised to:

- Better align with the policy goal of less than 25% of products classified as efficient;
- More clearly distribute the range of product efficiencies across Tiers; and
- Take the opportunity to implement a new MEPR.

Further, there is strong evidence to suggest that the standby power requirements for rice cookers could be further strengthened. Therefore, policymakers may wish to consider:

1. Revising the current energy efficiency Tier thresholds (as proposed in Table 20 in section 5.4.4 to) eliminate the least efficient 15%-20% of metallic rice cookers from the market through raising the MEPR to 1% higher than the current Tier 3 lower boundary value. EET thresholds should be revised such that this new MEPR becomes the lower threshold of Tier 4;
    - Increase the Tier 1 threshold by 4% to take advantage of the Top Runner concept and encourage manufacturer innovation; and
    - Evenly distribute Tier 2 and Tier 3 thresholds with the proposed new Tier 2 thresholds set at the current the Tier 1 threshold values.

    As there may be non-energy/efficiency reasons for maintaining a range of non-metallic inner pot rice cookers in the market (e.g. quality of rice cooking), policymakers may wish to consider maintaining a secondary MEPR level only for non-metallic rice cookers. However, there is still the opportunity to exclude the least efficient units and therefore raise the current Tier 5 threshold by 2%.
2. Reducing the standby power MEPR for tiers 1-4 to 1W. For tier 5, some allowance may be given, e.g. 1.6W, remembering this more lax requirement would only apply to the small number of non-metallic rice cookers still in the market.

From the evidence within the analysis, policymakers can be reassured the proposals to revise the EET thresholds for thermal efficiency and standby power are unlikely to affect price.

Conduct Research into consumer usage patterns

Little public information can be found on actual usage patterns of rice cookers in China, i.e. how often the rice cookers are used to prepare food, how much food is actually prepared, how long this food is kept in the rice cooker in keep-warm mode, and how much time the rice cooker is in standby. However, this information is critical in developing appropriate test methods that are broadly representative of consumer usage patterns, and for the development of energy efficiency standards that rely on accurate projections of the likely energy impact of the various regulatory options.

3. It is therefore recommended policymakers initiate research to establish true consumer usage patterns to enable the development of more representative testing methods and enable better-informed Energy Efficiency Standards development in the future.

Revise the rice cooker energy consumption test method and related EES metric

Should the research suggested above identify consumers as typically using rice cookers at partial capacity, then policymakers should consider:

4. Initiating a technical research study to establish if cooking at partial capacity significantly affects unit efficiency, and if so, consider development of a test that reflects typical consumer operation.
5. Should the test method be revised, the energy efficiency standard EETs should also be revised to reflect appropriate cooking, keep-warm, and standby consumer use.

6. Further, when amending the EES, policymakers should switch from power-based energy efficiency requirements to the related but more understandable (to consumers) volume-based requirements. This would also assist with the proposed revisions to labeling information proposed below.

Revise information on the rice cooker energy label and requirements for the registration process

The aim the of the energy labels is to guide the consumer to better (energy) performing products. Unfortunately, currently there is no indication on the label of the *actual cooking energy* consumption. This can be misleading for the consumer. For example, a consumer may purchase a larger volume rice cooker over a smaller volume alternative simply due to the larger product having a higher efficiency Tier rating. However, while having higher efficiency, there is a likelihood the larger volume product actually consumes more energy. Hence there is unclear messages reaching the consumer and no incentive to buy a smaller capacity (and energy consuming) cooker. Further, there is little evidence to suggest the consumer will understand the significance of the thermal efficiency value quoted on the label. Hence this information on the label is not likely to impact the consumer choice as desired. Therefore, to improve transparency to the consumer and improve their ability to preferentially select lower energy consuming products at the time of purchase, policymakers may wish to consider:

7. An immediate slight revision to the information declared on the label to replacement the declaration of the thermal efficiency value with the (to consumers) more useful energy consumption of the product during a typical cook/keep warm cycle.
8. In the longer term, policymakers should amend the label to show energy consumption at part load that aligns with typical usage (for example, either energy consumption at full and half capacity; or possibly energy consumption when cooking incrementally larger quantities such as 1 liter, 2 liter, 3 liter, up to the rated capacity of the rice cooker). Note that this energy consumption could also incorporate typical keep-warm and on and off mode-standby power consumption.

Such revision would not only provide more useful decision making information for the consumer, but would more accurate reflect the real difference in power demand/energy consumption between rice cooker which may be useful to policymakers in future policy development.

Further, there is some evidence that suppliers are under reporting equipment performance levels on the label declarations. This is limiting the consumer's ability to preferentially select more efficient appliances, and may be hampering the development of future energy efficiency standards. Therefore, it is strongly recommended policymakers:

9. Require the energy label declarations of energy efficiency, energy consumption, standby power and other performance to accurately reflect the true performance values reported in the test certificate submitted in support of the label application.

Section 6: Analysis of the Market and Product Performance of Flat Panel Televisions

This section examines the market, product performance, and regulatory framework for flat panel televisions. While there is likely to still be a small number of Cathode Ray Tube televisions on sale in the Chinese market, the proportion of such products is now very small. Therefore, unless otherwise specified, throughout this report the term “television” will be used to mean flat panel televisions

Household penetration of televisions in China is already high and still rising. The number of units per household is also growing, as a result of increasing disposable incomes. Projections[77] made in support of this analysis indicate that the number of televisions installed in homes or similar applications will rise from approximately 579 million in 2012 to 735 million in 2030. Under the business as usual scenario prepared as part of this study, the projected stock of televisions would consume approximately 154 TWh of energy per year by 2030. This clearly demonstrates the need to address the energy efficiency and overall consumption of televisions.

6.1 Product Background

Historically, as elsewhere, the Chinese television market was dominated by cathode ray tube (CRT) televisions. More recently, however, there has been a fundamental market shift to flat panel televisions. Currently, there are two basic types of flat panel technologies that dominate the television market, plasma display panels (PDPs) and liquid crystal displays (LCDs). It is reasonable to assume these will remain the dominant products for at least the next decade.

LCD televisions break down further into two sub-types, differentiated by the backlighting source. These are cold cathode fluorescent lamps (CCFLs) or light emitting diodes (LEDs). Currently, the LCD television market is undergoing a transition from CCFL to LED backlighting as LEDs consume less energy, have a thinner profile, and are more durable.[78]

There are a number of technological differences between PDP and LCD televisions, and for some models this may result in differences in picture quality or other performance metrics. However, our analysis focuses on comparisons from an energy use perspective only and assumes that, in general, television performance between technologies is similar.

6.1.1 Production, Sales and Stock Level

As noted above, the Chinese television market was traditionally dominated by CRT televisions. By 2006, however, about 10% of television sales were flat panel models, and flat panel sales rose again to over 20% the following year[79]. By 2011, the annual

[77] Energy Saving Potential (ESP) Study for Nine Appliances in China, CLASP 2013
[78] There is no information to suggest PDP televisions are experiencing any technological change similar to the transition being experienced in LCD televisions.
[79] Raw data is from www.hc360.com.

sales of flat panel televisions in China had reached 39.7 million, accounting for 94.8% of all color TVs sold that year[80].

According to the 2011 Year Book by the National Bureau of Statistics, the ownership of color televisions was 137.4 units per one hundred urban families and 111.8 units per one hundred rural families by the end of 2010. Given current trends in the indicators, it is anticipated that these ownership levels (and associated sales) are likely to rise continuously in the foreseeable future due to China's continued economic development and increasing household disposable incomes. Sales of flat panel televisions will be further boosted by consumers' desire to replace existing CRT units[81].

6.1.2 Usage patterns

There is limited reliable public data available on usage patterns of televisions in China. However, the projection of future energy consumption under different regulatory conditions is highly dependent on the specific consumer usage patterns of the primary, and other televisions, within households. To support the energy consumption estimates and other projections made in this report[82], usage patterns are based on what little data available. The estimates separate energy use into two types, on-mode and standby, and the assumed average hours of energy consumption are shown in Table 21

Table 21: Average use of all televisions in a household (hours/day) in 2012

Operating mode	Rural (hours/day)	Urban (hours/day)
On-mode	6	6
Standby	2	10

6.2 Regulation, Labeling and MEPS

6.2.1 Energy Efficiency Tiers, MEPRs, and EEI

The EES for flat panel televisions, GB 24850-2010, was introduced in December 2010. It not only defines the television test methodology, but also three EETs denoting increasing levels of energy efficiency. The EES also specified a MEPR that all televisions must satisfy, equal to the lower boundary value of Tier 3. Table 22 shows the EEI threshold values for the EETs and consequently the MEPR. The associated standby power MEPR for televisions is depicted Table 23. Note that the derivation of EEI differs between LCD and PDP televisions (see Table 24).

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[80] CCID thinktank, www.ccidthinktank.com.

[81] However, it is unlikely the CRT televisions will actually be disposed of. Rather the CRT unit will be moved to other rooms to act as a second or additional television. Thus, as the estimated life of a CRT is 12 years (refer to the parallel "Energy Savings Potential: China" report), and Flat Panel televisions did not begin to make major penetrations into the market until 2007, CRTs will remain a significant element of the stock until into the 2020's.

[82] For a full list of the assumptions made in the energy projections related to televisions, please refer to the Energy Saving Potential (ESP) Study for Nine Appliances in China, CLASP 2013.

Due to the rapid development of TV technology and major policy incentives such as the national subsidy program (see section 6.3), the energy efficiency of televisions in the Chinese market has improved rapidly. Consequently, the 2010 EET and MEPR thresholds soon became outdated. An EES revision process was initiated in 2011, with a revised EES draft for comment released in August 2012[83]. Table 22 and Table 23 also detail the EET, MEPR, and standby power requirements proposed in this 2012 draft. Noting that the derivation of EEI values in the current EES differs significantly from that in the August 2012 proposal; thus they are not directly comparable.

Table 22: Energy efficiency requirements for televisions in the current (2010) energy efficiency standard, and revised (August 2012) draft

	Energy Efficiency Index (EEI) Tier Thresholds Requirements*					
	Current (2010) EES			Revised draft EES (August 2012)		
TV type	**Tier 1**	**Tier 2**	**Tier 3**	**Tier 1**	**Tier 2**	**Tier 3**
LCD	1.4	1.0	0.6	2.6	2.2	1.7
PDP	1.2	1.0	0.6	2.2	1.8	1.4
PDP (*normalized to LCD equivalent*) **	0.35	0.29	0.17	0.70	0.58	0.45

**Method of EEI derivation changes between 2010 and 2012 (refer Table 24) and differs between LCD and PDP televisions.*

*** The EEI thresholds defined in the EES for LCD and PDP televisions are not directly comparable. The "PDP (normalized to LCD equivalent)" shows EEIs for PDP televisions calculated on an equivalent basis to LCD televisions.*

Table 23: Standby power requirements for televisions in the current (2008) Energy Efficiency Standard, and revised (August 2012) draft

	Current (2010) EES Requirements		Requirements of draft EES revision (August 2012)
	Before Jan 1st, 2012	**After Jan 1st, 2012**	
Standby Power (W)	<=1.0	<=0.50	<=0.50

While the test method for LCD and PDP televisions is the same, the derivation of the EEI in the 2010 EES differs between LCD and PDP televisions. Further, the overall derivation of EEI values in the draft 2012 EES is amended in general from the derivation in 2010, and still retains a difference in the derivations between LCD and PDP televisions. Table 24 summarizes the derivation of EEI values in the 2010 EES and in the draft 2012 revision.

[83] Before this report was completed, a revised draft EES for televisions was published in March, 2013. An analysis of this revision is included as an Annex to the television analysis in Section 6.6.

Table 24: Comparison of the derivation of EEI values in the 2010 Energy Efficiency Standard (now) and in the draft August 2012 revision (new)

	EEI Derivation (2010 EES)		**EEI Derivation (August 2012 draft EES)**	
TV Type	**LCD**	**PDP**	**LCD**	**PDP**
EEI calculation	$EEI_{lcd\ now}=[L*S/(P_k-P_s)]/1.1$	$EEI_{pdp\ now}=[L*S/(P_k-P_s)]/0.32$	$EEI_{lcd\ new}=(L*S/P_k)/1$	$EEI_{pdp\ new}=(L*S/P_k)/0.32$
	Notes: *L: average screen luminance;* *S: area of the screen;* P_k: *power when TV is on and dynamic image is displayed* P_s: *power to process signal:* P_s*=6W, when* YP_bP_r *interface is used;* P_s*=10W, when Analog Radio Frequency interface is used***Error! ookmark not defined.***;* P_s*=17W, when Digital Radio Frequency interface is applied.* $EEI_{lcd\ ref} = 1.1$ $EEI_{pdp\ ref} = 0.32$		*Notes:* *All symbols mean the same as 2010 EES, except Pk.* *Pk=Pj if Pj varies more than 15% from Pd and Pj is higher than Pd otherwise Pk=Pd*[84]*.* *where:* *Pj: power when TV is on and static image is displayed;* *Pd: power when TV is on and dynamic image is displayed* $EEI_{lcd\ ref} = 1$ $EEI_{pdp\ ref} = 0.32$	
Conversion of EEI_{now} **and** EEI_{new}	*LCD:* $EEI_{lcd\ new}=[EEI_{lcd\ now}*1.1*(P_k-10W)]/P_k$, *PDP:* $EEI_{pdp\ new}= EEI_{pdp\ now}*(P_k-10W)/P_k$,			
Observation	*1. The new* $EEI_{lcd\ ref}$ *has changed from 1.1 to 1.* *2. The new draft has excluded* P_s *as a variable in the calculation of EEI.*			

[84] Because no evidence shows that Pk would necessarily change from Pd to Pj for testing samples, the analysis in this report assumes the new Pk remains the same as defined in the current EES.

The notation EEI_{ref} stands for the nominal reference value(s) defined in the EES for televisions and used in the calculation of a television's EEI. The EEI_{ref} specified in the EES for the derivation of EEIs are not the same for LCD and PDP televisions[85]. In the 2010 EES, the specified EEI_{ref} for LCD televisions ($EEI_{lcd\ ref}$) is 1.1, and 0.32 for PDP televisions ($EEI_{pdp\ ref}$).[86] Thus, if the EEI value is the same for an LCD television and a PDP television, the actual tested energy efficiency of the LCDs television will be almost 3.5 times higher than that of the PDP television.[87]

This differential falls slightly in the 2012 EES draft, as $EEI_{pdp\ ref}$ remains the same, but $EEI_{lcd\ ref}$ is reduced to 1.0. However, the efficiency of an LCD television would still be well over three times higher than that of an of a PDP television with a similar declared EEI. The bottom row of Table 22 provides a direct comparison, showing the EET threshold EEI values for PDP televisions calculated on an equivalent basis to LCD televisions.

Thus, as presently formulated, the information delivered to the consumer is misleading as the energy label (refer to section 6.2.2) only provides the consumer with the non-comparable EEI and EET values of LCD and PDP televisions. This gives the consumer no indication that that a PDP television is actually consuming more energy than an LCD model of equivalent size, and thus removes the consumer's ability to choose the fundamentally more efficient LCD television with the associated lower energy consumption. Therefore, it is strongly recommended that policymakers consider revising the current EEI derivation for PDP televisions to be *directly comparable* with LCD televisions, i.e. by making $EEI_{lcd\ ref} = EEI_{pdp\ ref}$, and adopting the LCD EET thresholds for all product types.

This action would create a technologically neutral energy performance benchmark to allow policymakers and consumers to source information on which to make rational policy and purchase decisions. Note that this may require the Tier 3 threshold and MEPR for PDP televisions to be temporarily lowered to the equivalent current EEI value to allow manufacturers to adjust to the revised requirements and to ensure that PDP televisions are not immediately removed from the market.

Additionally, policymakers should ensure that consumers have access to information that demonstrates the true comparative efficiency, preferably the energy consumption of LCD relative to PDP televisions, by including the directly comparable EETs, EEI values, or power, on the label.[88]

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[85] There is no technical explanation provided in the EES to clarify the difference in EEI_{ref} for LCDs and PDPs.

[86] There are two EEI_{ref} values for PDP's in the EES depending on screen resolution (for resolutions of 1920*1080 and higher an EEI_{ref} of 0.32 is to be used, with an EEI_{ref} of 0.45 applied to PDP televisions of lower resolutions). In this report, the PDP EEI_{ref} of 0.32 is used as the proportion of LED and CCFL products with resolution of 1920*1080 is similar to that of PDPs, and overall the market trend is increasingly towards high resolution televisions.

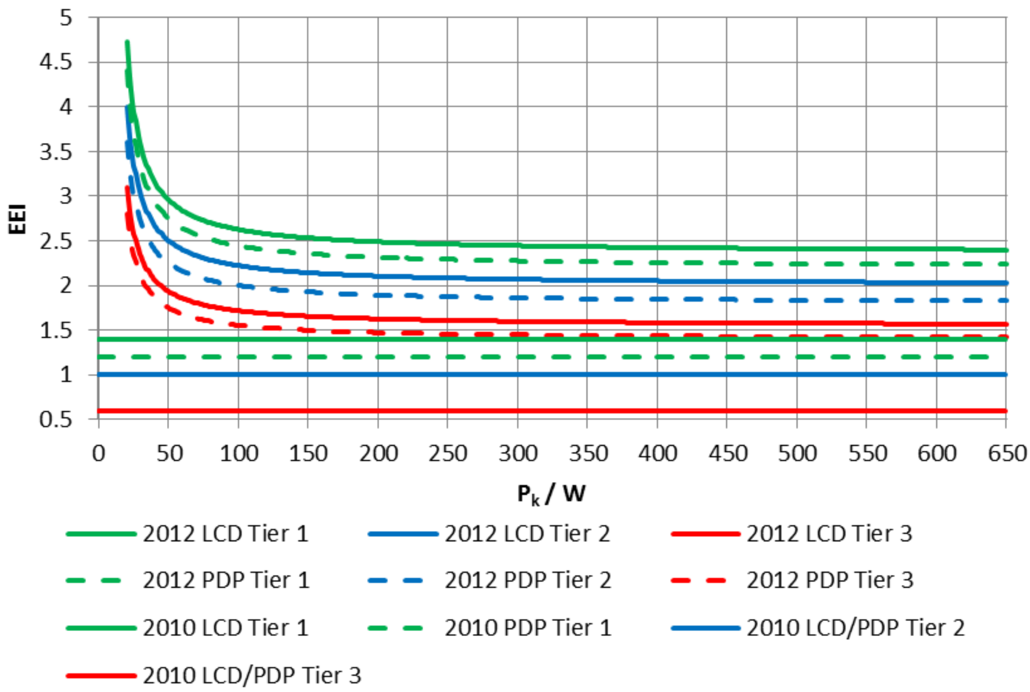
[87] Calculation: 1.1/0.32=3.4375. Note that we assume that LCD and PDP televisions provide equal levels of customer performance, e.g. picture quality.

[88] This assumes the overall content of the label is not revised as recommended in section 6.2.2. The revision recommended in section 6.2.2 to replace EEI declarations with annual energy consumption (or similar) is actually the preferred option as it provides consumers with additional information that

In addition to varying between different television models, the derivation of EEI has changed significantly between the 2010 EES and proposed 2012 revision (see Table 24). This has affected the stringency of the EETs. As shown in Table 22, the proposed EET threshold values in the 2012 draft EES are significantly higher than the 2010 EES thresholds. Superficially, this implies that efficiency requirements in the new draft are significantly more stringent than previously, as would be desired. However, because the EEI derivation has changed, the degree of increased stringency is unclear.

Fortunately, as shown in Table 24, it is possible to convert EEI values calculated using the 2010 EES methodology (EEI_{now}) to equivalent EEI values calculated using the draft August 2012 EES methodology (EEI_{new}), and vice versa, by making a limited number of relatively simple assumptions. Figure 62 shows the 2010 EES and draft 2012 EES thresholds for Tiers 1, 2, and 3 for both LCD and PDP televisions, with comparable EEI values based on the 2010 EES methodology.

Figure 62: Comparison of 2010 EES and draft August 2012 EES energy efficiency Tier threshold values comparable based on the 2010 EES methodology for derivation of EEI*



** EEI values are comparable for LCD and PDP threshold between years, the LCD and PDP EEI thresholds are not comparable between screen technology types as detailed in Table 24.*

Figure 62 clearly shows that the proposed August 2012 EET thresholds are significantly more stringent than the current 2010 thresholds. However, the relationship is not linear with the stringency for smaller televisions, having increased significantly more than the stringency for larger televisions. For example, for a particularly low energy-consuming LCD television using just 20W, the 2010 Tier 3

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will increase the likelihood of the consumer selecting the more efficient, and lower energy consuming, LCD television.

threshold/MEPR level is an EEI of 0.6. Under the proposed 2012 revision, the Tier 3 threshold for this model climbs to 3.09. For an LCD television drawing 110W, however, the current Tier 3 threshold is still an EEI of 0.6, but the under the 2012 revision it climbs to just 1.7.

The draft 2012 EES revision contains similar increases for small and large PDP televisions, though it should be noted that almost all PDP units are relatively high-power, and therefore the increased stringency levels are proportionately less challenging.

The outcome that the proposed 2012 EET thresholds are significantly more stringent for smaller televisions than larger televisions is controversial. It is counter to the typical policy maker desire to minimize energy consumption. In this case, the larger energy-consuming televisions are being allowed to consume proportionately more energy than their smaller equivalents. Hence, the message potentially being sent to manufacturers is “produce higher energy-consuming televisions because it will be easier to get a higher rank in energy efficiency Tiers.” This is surely counter to policymakers’ intentions[89].

Therefore, policymakers may wish to re-examine the proposed 2012 EET and potentially reduce the thresholds for lower power TVs.

6.2.2 Energy Labeling of Televisions

In March 2011, three months after the TV EES was implemented, the Chinese Government announced that televisions would join a number of other products in the China Energy Label scheme. Figure 63 shows the television label for both LCD and PDP televisions. The three performance levels shown align with the EETs in the EES, with the specific Tier at which the product performs clearly shown, in this case Tier 2. Absolute values for the EEI and standby power performance of the television are stated towards the bottom of the label. The label also includes the manufacturer’s name and product model number.

The current makeup of the TV label poses some problems. It is highly unlikely, for example, that a typical consumer will understand the meaning of EEI. Further, the information delivered to the consumer is misleading, as the LCD and PDP energy labels give no indication that the EEI and EET values are incompatible between product types, and that a PDP television is actually consuming more energy than an equivalent LCD model. This eliminates the consumer’s ability to choose the fundamentally more efficient, lower energy-consuming LCD televisions. Additionally, the label refers to energy efficiency Tier 1 as “low energy consumption” and Tier 3 as “high energy consumption” which may not actually be the case (the Tiers are based on EEI values, *not* consumption and therefore a very large television with high energy consumption could still achieve Tier 1 performance).

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[89] We recognize that there is a possibility that the 2010 EET thresholds were proportionately more stringent on larger televisions and that the August 2012 proposals have been specifically designed to redress this imbalance. However, there is no evidence suggesting that the 2010 EET thresholds were proportionately more stringent for larger televisions. See Section 6.4.2.2

Figure 63: China Energy Label for Flat Panel TVs

LCD Label

PDP Label

Therefore, to improve transparency to consumers, as well as their ability to preferentially select lower energy-consuming products at the time of purchase, policymakers should consider replacing the declaration of the television's EEI value with the power drawn by the product. While this will not give the consumer full information on the energy consumption of the television, it will at least provide a measure of the comparative power (and hence typical energy) consumption of different televisions.

If policymakers undertake research on consumer usage patterns, this power measurement could eventually be replaced with a value for the television's typical daily, weekly, or annual energy consumption, which is likely to be of significant value to the consumer. Such revisions would not only provide more useful decision-making information, but would more accurately reflect the real difference in power demand and energy consumption between LCD and PDP televisions.

6.2.3 Test Method

Televisions are globally traded products, and the test standard used to measure their performance has been harmonized in much of the world through full or partial adoption of the IEC 62087 test methodology. However, the test methodology used in China differs significantly.

The current Chinese flat panel television test method was first introduced in December 2010 as part of the EES GB 24850-2010. This standard requires televisions to be set to a standard viewing condition by adjusting brightness and contrast based on an eight-level grey pattern in a dark room. This pattern is an image consisting of different levels of brightness, with two rows of eight grey levels against a background of 50% grey level, as shown below.

Figure 64: Eight-level grey pattern used in Chinese TV test method

The first row consists of four levels: 0% (absolutely black), 5%, 10% and 15%. The second row contains 85%, 90%, 95%, and 100% (absolutely white). At first, brightness should be adjusted to the point when the two neighboring levels of 0% and 5% grey in the first row could be just differentiated by the test personnel. Then the contrast is adjusted from 100% to a lower level where the 95% and 100% levels in the second row could be just differentiated by the test personnel. Test personnel should repeat the adjustment procedure until both neighboring groups (0%-5% and 95%-100%) could be exactly distinguished at the same time. At that point, the brightness and contrast levels are deemed to have been set, and are used for the rest of the testing procedures. The test method also dictates that, "if such a condition cannot be achieved, adjust the image to the best quality possible and record the brightness and contrast levels." However, there is no description of how "best quality" is defined.

Once adjustment is complete, the luminance of the screen is calculated based on the average of nine values measured at points spaced across the screen, P_0 to P_8, in a pattern dependent upon the screen size and shape, as shown in Figure 65. The IEC standard "test clip" is then played, and the power consumed by the television is measured during the broadcast. The energy efficiency of the television is calculated as the average measured luminance multiplied by screen size divided by total power consumed. In other words:

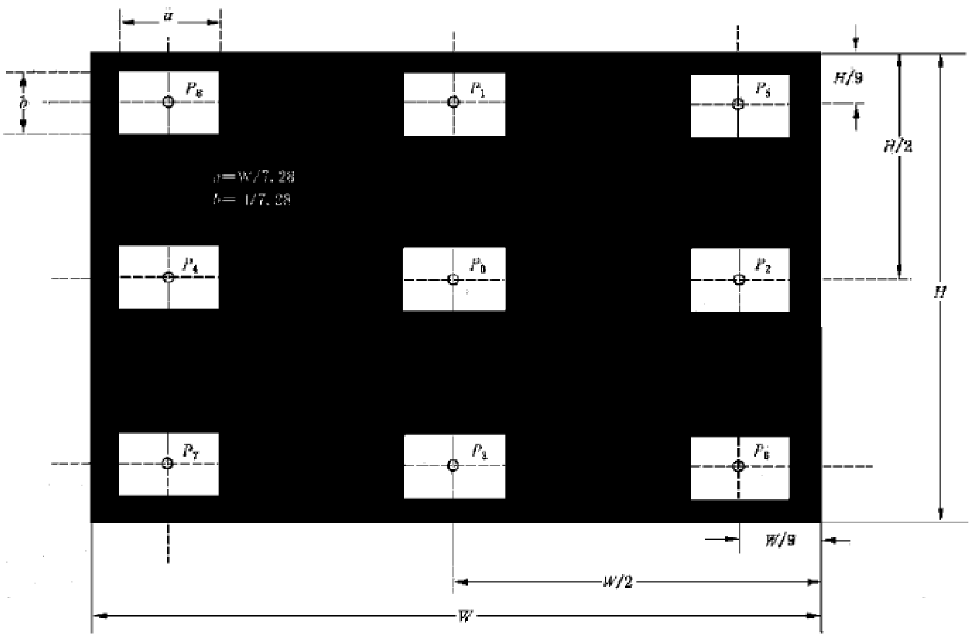
$$EEI=[(Luminance \times Screen\ Size)/(Power-10W)]/\ EEI_{ref}$$

Where,

EEI is the Energy Efficiency Index of TV
Luminance is the averaged luminance in cd of the nine points as mentioned above
Screen Size is the viewable size of TV screen in square meters (m^2)
Power is the tested on-mode power in W
10W is the power regarded for signal processing[90]
EEI_{ref} equals to 1.1 and 0.32[91] *for LCD and PDP respectively.*

[90] If a television has an Analog RF interface, it must be the system used in the test. Almost all TVs sold in the Chinese market have this interface, therefore, the analysis in this report uses 10W.

Figure 65: Nine-point layer used in Chinese TV test method



There are three problem areas related to this test method. Firstly, the “best viewing conditions” of the television in the test environment are achieved through adjusting brightness and contrast in a dark room. A dark room does not reflect a typical real-life viewing environment, where most people would watch the television with a certain amount of background light[92]. Consequently, the levels of brightness and contrast required in the test are likely to be insufficient to enable satisfactory viewing in a normal environment.

Secondly, for LCDs, the test method dictates that the eight-level grey pattern may be achieved through adjusting either the TV's “screen brightness” (by changing the angle of crystals of the panel)” or the “backlight brightness (by changing the light output of backlighting sources).” However, the two methods will typically result in considerably different values for power consumption, and thus efficiency.

Finally, test personnel are requested to accurately differentiate between neighboring grey levels in the pattern. Such requirements may lead to considerable variation or even errors to the testing results, due to the potentially differing interpretations or perceptions of different test personnel.

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[91] There are two EEIref values for PDPs in the EES depending on the screen resolution. For resolutions of 1920 x 1080 and higher, an EEIref of 0.32 is to be used. An EEIref of 0.45 is applied to PDP televisions of lower resolutions. In this report, the PDP EEIref of 0.32 is used as the proportion of LED and CCFL products with a resolution of 1920 x 1080 are similar to that of PDPs, and overall the market trend is increasingly towards high-resolution televisions.

[92] A similar issue was identified in a recent CLASP study on background illuminance for TVs in the USA (for details refer to http://www.clasponline.org/Resources/Resources/StandardsLabelingResourceLibrary/2011/Background-Illuminance-Levels)

Thus, Chinese policymakers may wish to consider harmonizing the Chinese test standard with IEC 62087. This would not only resolve the issues noted above, but could also contribute to improved international trade. Should this prove impractical, then at the very least, policymakers should consider revising the current test method to:

- Reflect more realistic viewing situations, by requiring the adjustment of brightness and contrast in the presence of a defined "typical" level of background light[93];
- Differentiate the adjustment of an LCD television's screen brightness from backlight brightness to make sure that products are tested fairly and no manufacturers are taking advantage of the inappropriate interchangeability of these values; and
- Avoid, or at least minimize, subjective measures in the test procedure. This might be achieved by developing some equipment to replace test personnel to read the eight-level grey pattern.

6.3 Subsidy Information

Televisions have been the beneficiary of all of the Chinese Government's appliance subsidy programs to date. In May of 2012, the government announced that televisions would also be included in the most recent subsidy program for energy efficient products. These subsidy programs have caused a major transformation in the energy efficiency of televisions and have also played a key role in the revision of the television EES.

The levels of support under the 2012 subsidy program for televisions of varying efficiency and screen size are shown in Table 25. These levels were differentiated by EEIs calculated using the 2010 EES methodology.

Table 25: Levels of TV support under the 2012 subsidy program

Screen Size (inches)	LCD (RMB/unit)		PDP (RMB/unit)	
	EEI>=1.7	EEI>=1.9	EEI>=1.4	EEI>=1.7
19-<32	100	150	-	-
32-<42	250	300	250	300
42 and above	350	400	350	400

As Table 25 shows, the 2012 subsidy program only provides support for televisions with EEIs higher than the current (2010) Tier 1 requirement (refer to Table 22). This suggests that policymakers are aware that the current Tier 1 requirements for LCD and PDP televisions are not sufficiently high to reflect the current levels of higher efficiency televisions. Further, the subsidy thresholds seem to suggest that EEIs of 1.7 for LCDs and 1.4 for PDPs represent energy efficient products, and EEIs of 1.9 for LCD and 1.7 for PDP represent highly energy efficient products.

[93] The definition of this degree of background light may require additional research.

However, in the 2012 revised draft of the TV EES, the proposed MEPR for LCDs and PDPs are 1.7 and 1.4, respectively. In other words, these values are the lowest, entry-level requirements for televisions. This implies the requirements for the subsidy policy are insufficiently stringent to define efficient products, and most of the televisions on the Chinese market are eligible for the program[94]. Alternatively, it is more likely that the MEPR set in the 2012 draft is very high, and as a result products are all high efficiency rather than a broad market spread.

Regardless, policymakers may wish to consider the withdrawal of subsidies for televisions of relatively lower efficiency and reallocate these resources to increase the subsidy for highly efficient products. In other words, stop subsidizing LCDs with EEIs lower than 1.9, as well as all PDPs, and increase subsidies for LCDs with EEI higher than 1.9. In order to recognize super-efficient products, policymakers may also consider setting a "super" subsidy for top level products, e.g. LCDs of EEI 3.0. In this way, the subsidy could be used more efficiently and effectively because consumers would more likely to buy these highly efficient products, as they could get a considerable percentage of rebate off the original price in addition to saving the associated energy in the home.

Further, there is a strong relationship between the screen size of televisions and their power consumption (see section 6.4.2.2). Televisions with larger screen sizes consume more energy. As policymakers' primary interest is not actually improvements in energy efficiency, but rather reductions in energy consumption, the government should be aiming to stimulate demand for appropriate smaller screen sizes, rather than larger. Very large screens are also regarded as luxury products, and their buyers are typically not sensitive to price. Therefore, the marginal subsidy available for these large screen size products is wasted. Consequently, policymakers may wish to limit the size of products receiving subsidy.

6.4 Data analysis

Our data analysis of flat panel televisions examines the performance, energy, and market related properties outlined in Table 26. The table also details the number of models for which data was available for each property.

Table 26: Overview of data for TV analysis

Data type	Note
Number of models	LCDs: 2189 (of which CCFL: 651 and LED: 1538); PDP: 148.
Types	LCD, CFL and PDP. When applicable and available, CCFLs and LEDs are analyzed separately. However, for some analysis and discussion, LED and CCFL are integrally regarded as LCD.
EEI	Range 0.6 - 3.5
Standby Power (W)	Range 0.1 – 1
Size /(inches)	Range 19" – 72" (Models above 72 inches are excluded from the study as they are considered too large for domestic/commercial use and with few models in the market).

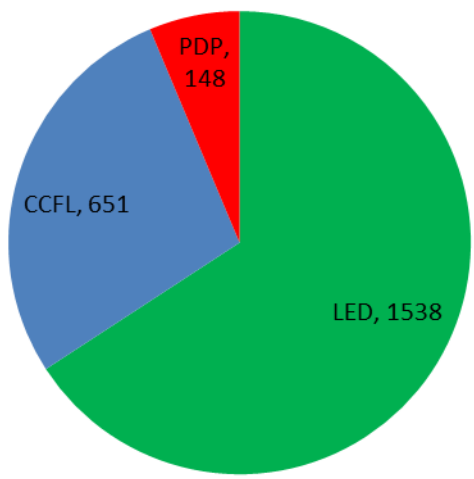
[94] Although the EEI requirements set in the 2013 draft are not directly comparable with the 2010 requirements due to the change of calculation method, the two values are related. See Table 24.

Price (RMB)	Range 799RMB – 69999RMB

6.4.1 Market distribution product type and screen size

As noted in section 6.1, there are currently two basic types of flat panel technologies, PDPs and LCDs. LCD units can be further subdivided into those with CCFL backlighting, and those back lit by LEDs. Figure 66 shows the distribution of televisions available in the Chinese market as of July 2012, classified by these screen technologies and method of backlighting.

Figure 66: Distribution of TVs available in the Chinese market (July 2012)



This figure illustrates the market dominance of LCD televisions, with PDP televisions representing just 6% of the models available.

The most popular screen sizes for televisions available in the market are 32" and 42" for LCD televisions and 42" and 50" for PDP televisions, as shown in Figure 67. By grouping the screen sizes into bins, the broader picture of the overall television market distribution by screen size becomes clearer, as shown in Figure 68. Again this Figure shows that models in the 30-34", 40-44", and 45-51" screen size ranges dominate the market. From 40-44" on, PDP products begin to enter the market gain increasing proportion of the market as screen sizes increase.

6.4.2 Market distribution by EEI and across energy efficiency Tiers

Figure 69 shows the distribution of televisions available on the market in July 2012 by the EEI declared by manufacturers[95]. From this Figure it is clear that the products with the highest efficiency levels are LED-backlit LCD products. Additionally, despite the majority of EEI declarations being below 2.0, there are televisions in the market with declared EEI values as high as 3.5. This may imply there is significant scope for policymakers to increase performance requirements in the future to push all products towards the higher efficiency of LED-backlit televisions, while maintaining a technologically neutral approach to allow for innovation in other product types.

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[95] Again, note that the EEI values for LCD and PCP televisions are not comparable in the current (2010) EES. (See Table 24)

Figure 67: Distribution of TVs in the Chinese market by screen size (July 2012)

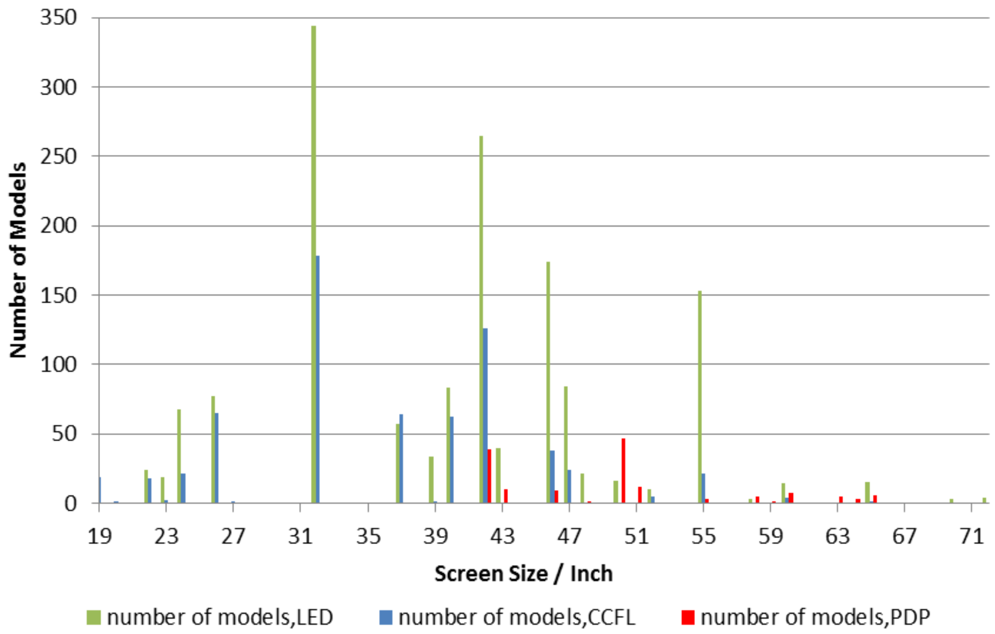
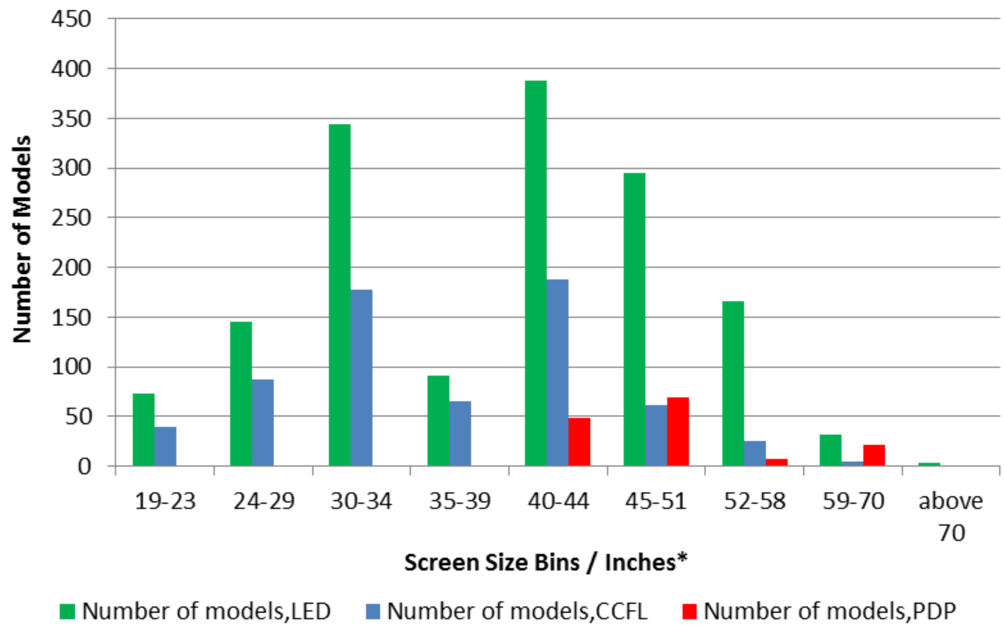
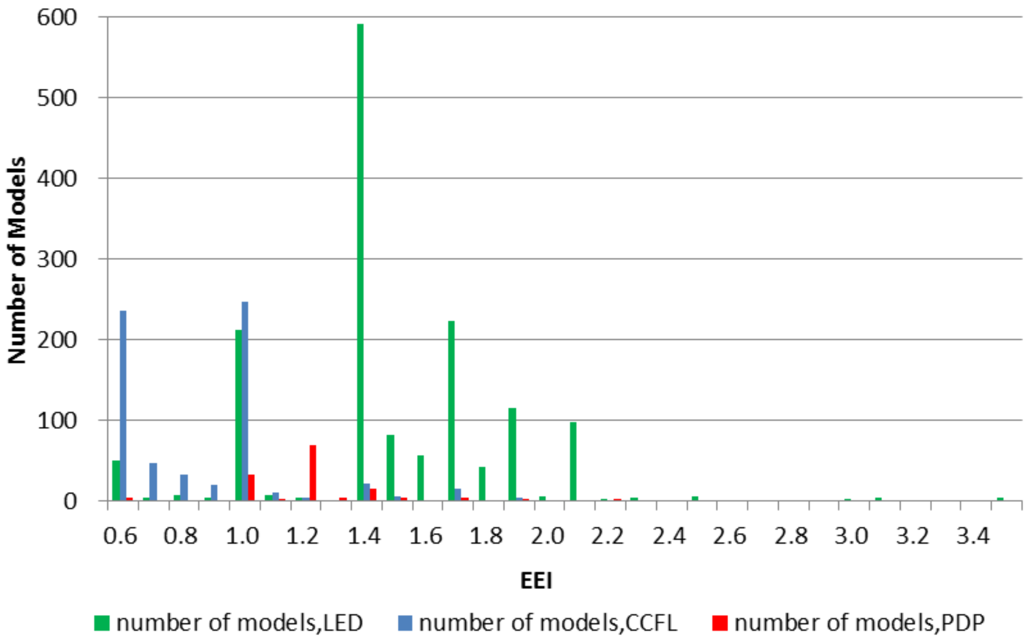


Figure 68: Distribution of TVs in the Chinese market by screen size range (July 2012)



**Note: screen size bin sizes are not of equal range*

Figure 69: Market distribution of declared EEI values for TVs on Chinese market (July 2012)



Comparing the declared product EEIs with the EET threshold requirements in the 2010 EES, as well as requirements to qualify for subsidy support, it is clear that many models are only just achieving EEI values above the threshold requirements. This implies one or more of the following:

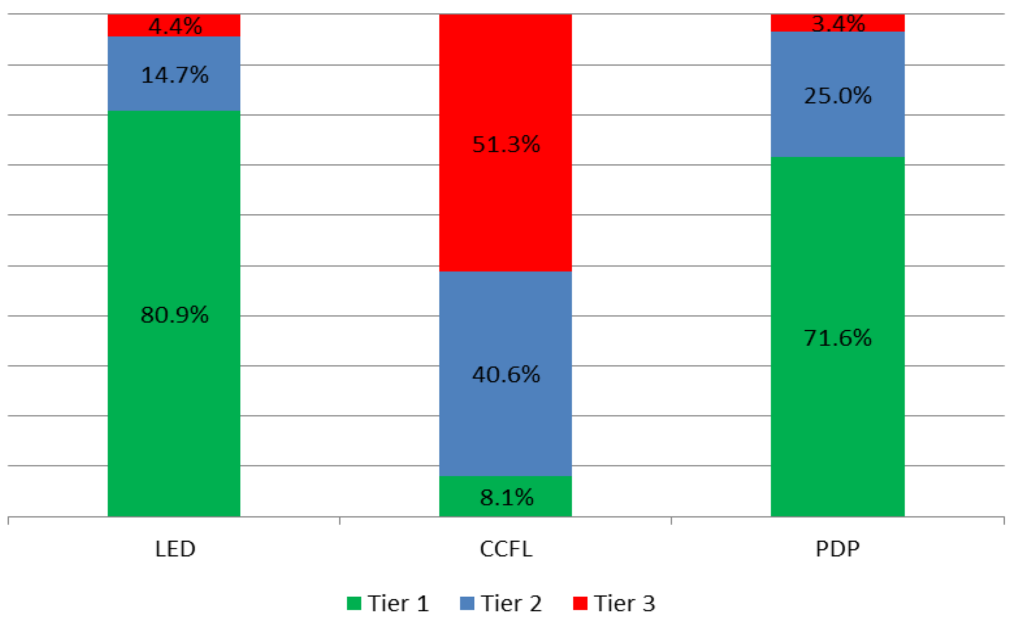
- Manufacturers may have very accurate control over the design and production of televisions and can deliver products that are just at the boundary conditions. If this is the case, any tolerances allowed for MEPR and labeling compliance are not required and can be removed, though test laboratory tolerances will still be required.
- Manufacturers may be exaggerating the performance of their products. For example, they may be declaring the lowest value of the EET above the one for which their products actually qualify, either to appear more efficient on the label and/or to qualify for subsidy support. This may be a perfectly legitimate action if the tolerances of the declarations are sufficiently high, but again, this implies that the tolerances for labeling declarations should be removed. However, it also may denote an abuse of the system by manufacturers, which would clearly require robust compliance actions.
- Manufacturers may be understating the performance of products; for example, by declaring the lowest value within the Tier for which their products qualify to ensure that their products pass any verification testing undertaken by the regulator. On one level, there is no problem with this situation as manufacturers are acting cautiously and protecting their reputations, while delivering products to the consumer that perform *better* than stated. However, from the policy maker point of view, this situation is problematic as knowledge of the true performance of products is important

when developing future EES and subsidy requirements and analyzing the potential impact of differing threshold levels.

At present there is no evidence to suggest which of the above reasons may be causing the performance declarations to be just above EET and subsidy threshold levels, and there is certainly no evidence of manufacturer malpractice. However, there is sufficient evidence to recommend that policymakers insist that claims made on product registration and labels must align with actual testing reports submitted to support the applications.

Figure 70 depicts an estimation of the distribution of televisions across the 2010 EES energy efficiency Tiers, making the breakdown easier to see.

Figure 70: Distribution of televisions on China's market across the 2010 EES Tiers



Note derivation of EEI's not comparable between LED/CCFL televisions and PDP televisions

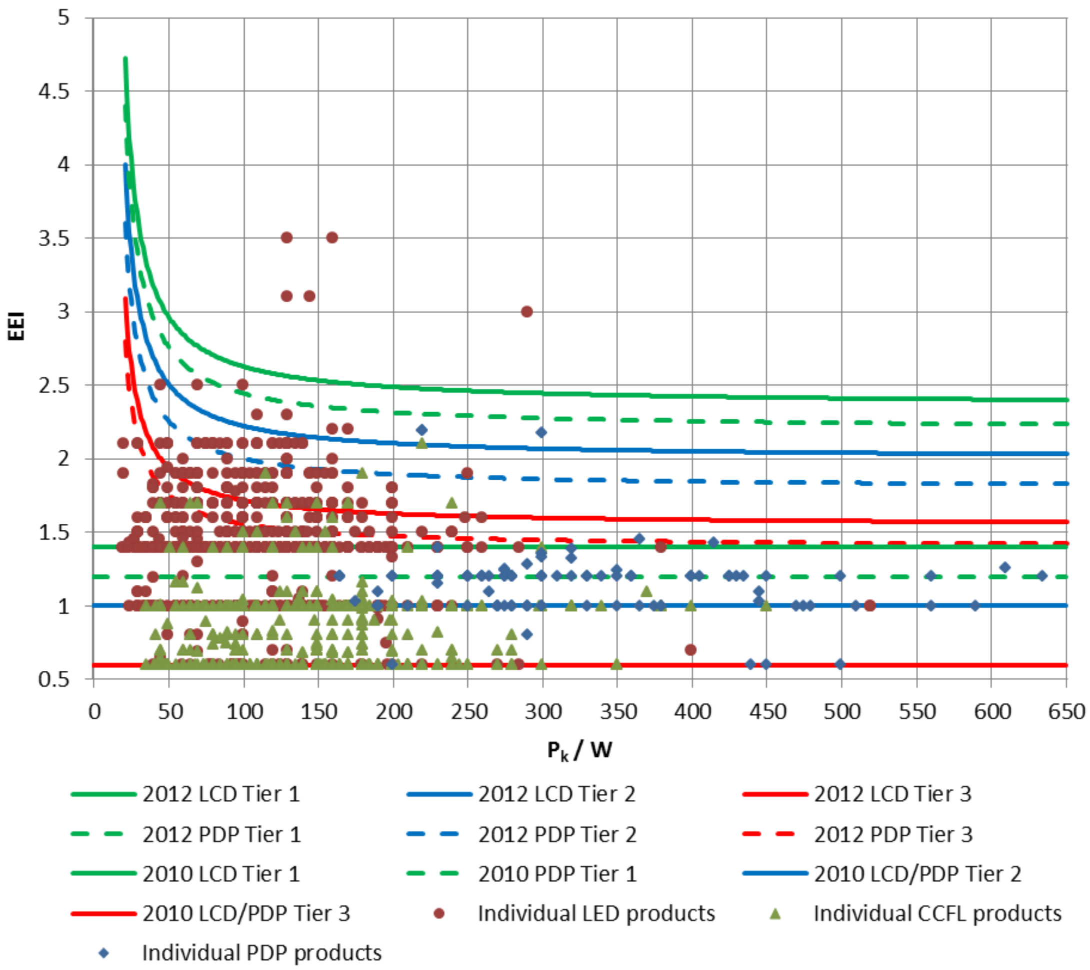
This clearly reiterates the observation above that LEDs are the most efficient television types, with over 80% of products achieving Tier 1, and only 4.4% at Tier 3. This distribution is reversed for CCFLs, with only 8.1% of CCFLs achieving Tier 1 and over 50% in Tier 3.

Superficially, the Tier distribution of PDPs is similar to LEDs. However, as noted in Table 24, the derivation of the EEI values on which the Tiers are based is very different between these two product types. Thus, although PDPs appear to the policy maker and consumer to be of similar efficiencies as LCD televisions, the PDP units have efficiencies significantly below both LCD and CCFL units. As noted previously, this is misleading, and it is strongly recommended that a technology-neutral derivation of EEI is developed to allow complete transparency to the policy maker and improved consumer understanding, allowing for more informed decision-making by both groups.

6.4.2.1 Impact of proposed August 2012 draft requirements on the market for televisions available in July 2012

To provide an idea of the potential impact on the availability and EET distribution of televisions if the draft 2012 EES is introduced, Figure 71 plots the EEI values of products available in the market in July 2012 against the requirement of the proposed 2012 EES[96].

Figure 71: EEI values of available products (July 2012) overlaid on 2012 draft*



**Energy efficiency Tiers of the 2012 proposals have been adjusted to equivalent EEI derivation in the 2010 energy efficiency standard to ensure comparability with declared product energy efficiency indices*

Assuming that manufacturer's current EEI declarations for their products are accurate, the proposed EET and associated MEPR thresholds in the 2012 EES draft

[96] In Figure 71, the requirement (curves) of EEI_{new} is based on power values of P_k, while the scattered EEIs of models on the market are based on the declared powers by manufacturers. These two powers are different because when testing P_k, some of the functions, i.e. Automatic Brightness Control, internet connection, etc, are turned off and some settings are adjusted to the test mode. But they are very much linked and should be close in value. Thus, as the test power of P_k is not obtainable, the declared power is used as the substitute of P_k and it would provide with very close, if not the same, results for this and similar analysis.

pose some significant problems. In particular, there are very few televisions with a power demand below 100W that can meet the new EET Tier 3/MEPR requirements[97]. This implies that many of these low energy-consuming products will be eliminated from the market. In other words, low power, and consequently low energy-consuming, products are being removed from the market, forcing consumers to buy higher power-consuming units. This appears to be a perverse outcome from a policy-making perspective.

Additionally, well over half of the LED models, more than 80% of CCFL models, and more than 95% of PDP models will be eliminated from the market. Excluding the issue of low energy using models potentially being completely removed from the market, this is a good outcome in terms of energy saving. However, this level of influence on the market may result in unexpected challenges to the industry. For example, manufacturers will potentially need to invest considerable capital in new production capacity in the very short term, which may not be a good pathway for the industry development.

Therefore, from the available evidence, it is recommended policymakers reconsider the MEPR value set in the draft EES. Alternatively, if the MEPR value is based on policymakers' knowledge that manufacturers are definitely under-declaring product performance, and the actual performance of most products could meet the new MEPR, then this new requirement should not cause the market restriction concerns and therefore no reconsideration is needed.

6.4.2.2 Relationship between television energy efficiency index, power and screen size

Figure 72 shows the relationship between the energy efficiency index, power, and screen size of televisions. As would be expected, the power demand of the television is strongly related to the screen size, with LED units consuming the lowest power over all screen sizes, and PDP units consuming the most from the point (40-44") where they enter the market.[98] There appears to be relatively little relationship between EEI and screen size, although perhaps there is a slight tendency for EEI to increase with increasing screen size up to 52-58", after which there is a slight drop for all but CCFL units.

Figure 72 clearly illustrates the *proportionately increasing* energy consumption of televisions as screen size increases. Policy makers may therefore want to consider introducing an absolute cap on the energy consumption of televisions, or adjusting the derivation of EEIs to have the same effect, to discourage the development of larger televisions that have equivalent or better levels of efficiency, but which actually consume much more energy.

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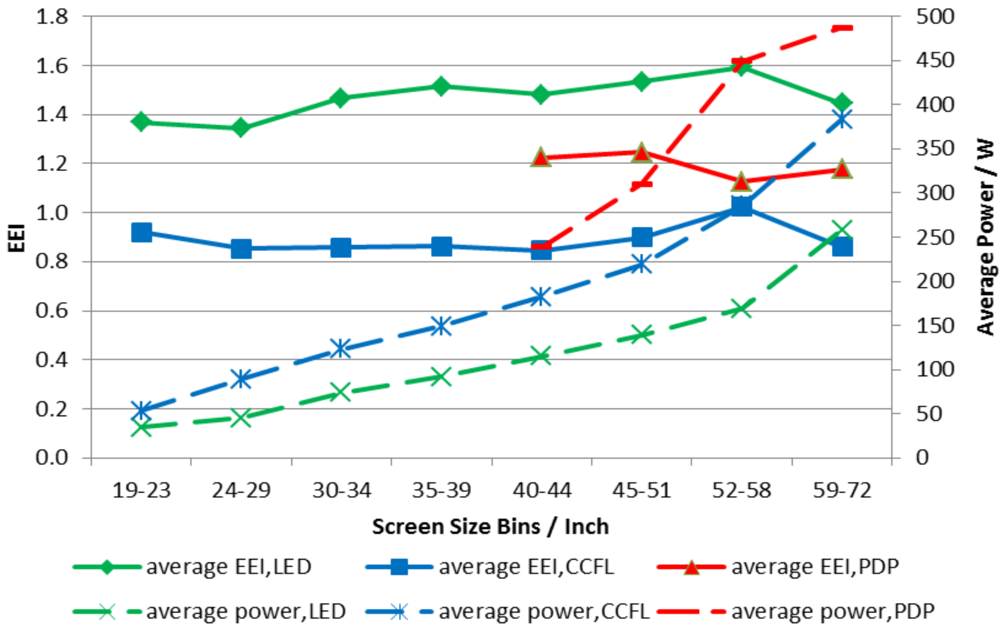
[97] Televisions with power demand lower than 100W are normally CCFLs below 30" and LEDs below 38", refer to section 0).

[98] The power data used here are declared values. Tested value may differ, especially for PDPs, as PDPs do not consume full power under normal viewing conditions.

Figure 72 Relationship between TV EEI, power, and screen size



**EEI calculated using the 2010 EES methodology.*
*** Due to limited data availability, the power data is not complete for all models. Power data was available for 1,547 models, broken down by 925 LEDs models, 520 CCFLs models, and 102 PDPs models. It is unclear how much this issue skews the dataset.*

However, note that as PDPs normally do not operate at full power, and LCDs may also consume less than declared values in certain conditions, i.e. lowered backlight level, the comparison presented may not be entirely appropriate.

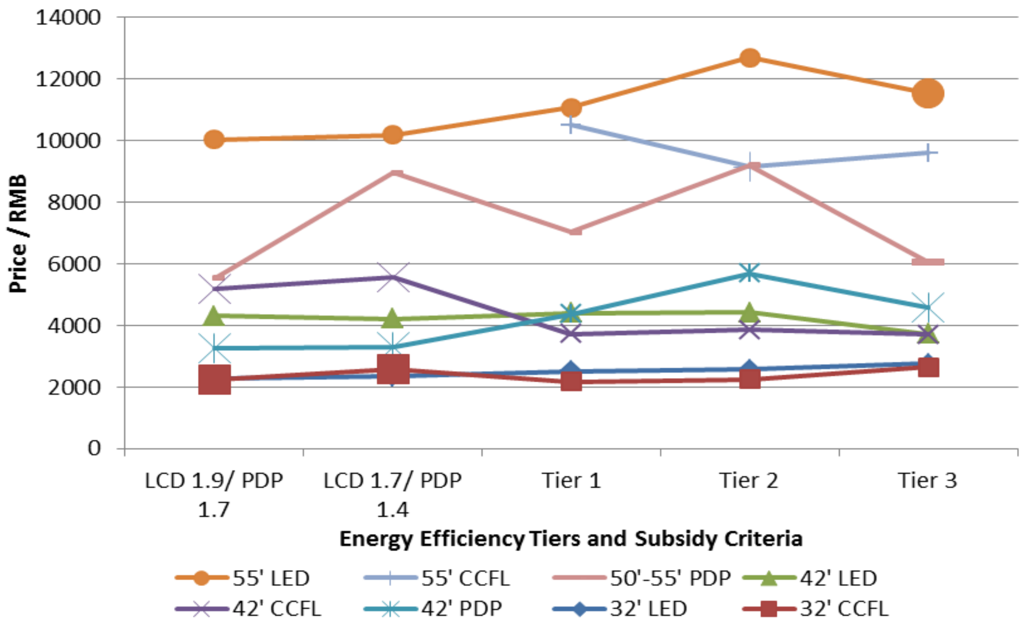
6.4.2.3 Relationship between television energy efficiency Tier and price

The relationship between TV screen size and price is strong. Therefore, to understand the relationship of price to EET, it is necessary to remove the influence of screen size. To this end, we have analyzed televisions of the same screen size. Three representative screen sizes were chosen, 32”, 42”, and 55”[99]. To provide additional comparative information, thresholds for subsidy qualification (seeTable 25) are also included[100]. It should be noted that for the models covered by the subsidy, the price used is before the rebate.

[99] Note that there are no PDP televisions with 32” screen sizes. Also, as the number of 55” models is very small, therefore the average of 50”-55” is used. Additionally, a small number of models have been eliminated from this analysis due to their apparently extreme low or high prices, which are believed to simply be errors in the reporting of data. Specifically, for LEDs and CCFLs, the deducted numbers are (5, 7, 9) and (3, 8, 1) for sizes of (32’, 42’, 55’), while for PDPs the numbers are (3, 6) for sizes of (42’, 50-55’).

[100] Televisions shown as qualifying for subsidy have been excluded from Tier 1 to avoid double counting.

Figure 73: Relationship of TV price to EET for 32", 42" and 55" televisions* (July 2012)



** There are no PDP televisions with 32" screen sizes. Also, as the number of 55" models is very small, therefore the average of 50"-55" is used. To give an indication of the reliability of each data point, points where less than five models form the average value shown are enlarged.*

As can be seen from Figure 73, there is actually very little relationship between price and EET. This is contrary to the common perception that more efficient products are more expensive. The reason for this is most likely that energy efficiency is not the primary focus for consumers. Hence, manufacturers price products based on other criteria such as brand, picture quality, 3D capability, interactive control, and network connectivity. These functions or attributes tend to be more expensive to incorporate in the product than efficiency, and this impact outweighs the costs of any energy efficiency attributes affecting the product price.

6.4.3 Market distribution of televisions by standby power

As shown in Table 23, the mandatory MEPR for standby power was 1.0W at the introduction of the 2010 EES, moving to 0.5W from January 1 2012, and remaining at this level under the draft August 2012 EES proposed requirements. Figure 74 illustrates how the market has reacted to this standby power requirement as of July 2012. As shown, the standby power of the majority of the models is declared to be 0.5W, followed by 1.0W.

Figure 74 Distribution of declared TV standby power (July 2012)

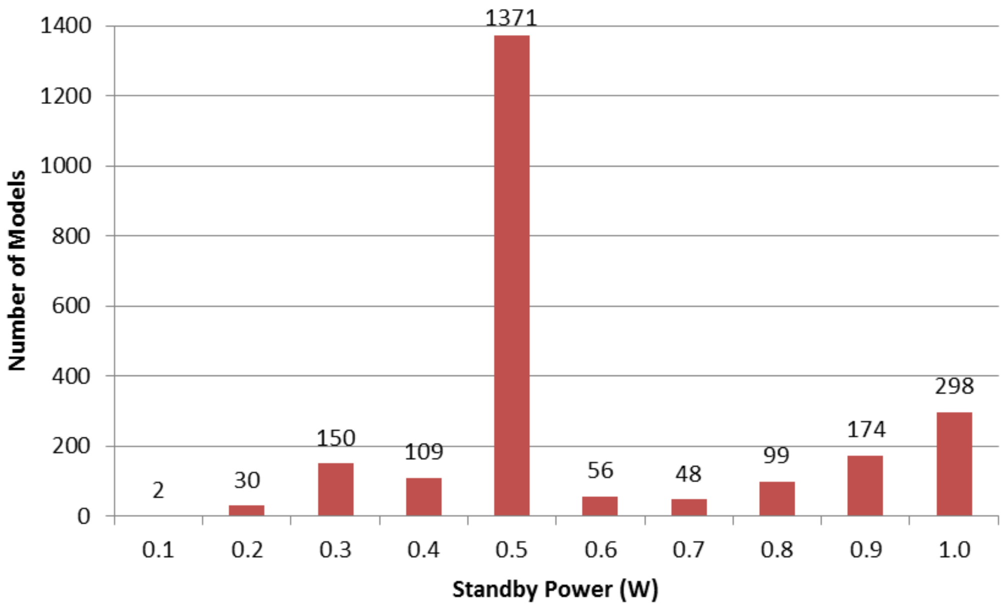


Figure 74 highlights two issues. Firstly, six months after the January 1, 2012, deadline for the implementation of the 0.5W MEPR value specified in the 2010 EES, there are still over 650 television models available in the market with standby power in excess of 0.5W. It is not clear if these products are being sold legally or not because there is a lack of clarity on whether products registered prior to the 2012 change in EES requirements are allowed to be sold even if they do not qualify for the revised requirements. This reiterates the need for policymakers to review the overall energy label management rules to clarify the lifetime of registrations and the actions to be taken at the time of EES revisions.

Secondly, as can be seen from the energy saving projections[101] the standby power consumption of televisions has a substantial impact on their overall annual energy consumption. As Figure 74 clearly demonstrates, there are a significant number of products (almost 300) with standby power below 0.5W. This demonstrates that there is little technological challenge in meeting lower standby power requirements.

Thus, it is recommended that the draft August 2012 EES proposals are revised to require a lower standby power requirement of 0.3W. Furthermore, including overall daily, monthly, or annual unit energy consumption on the energy label, as proposed in section 6.2.2 would highlight the impact of standby power in the overall energy consumption of televisions and encourage consumers to select (and hence manufacturers to produce) televisions with lower standby power requirements. Consideration should also be given to the inclusion of “other energy states” in the energy consumption calculation as increasingly TVs have functionality such as “instant-on” standby.

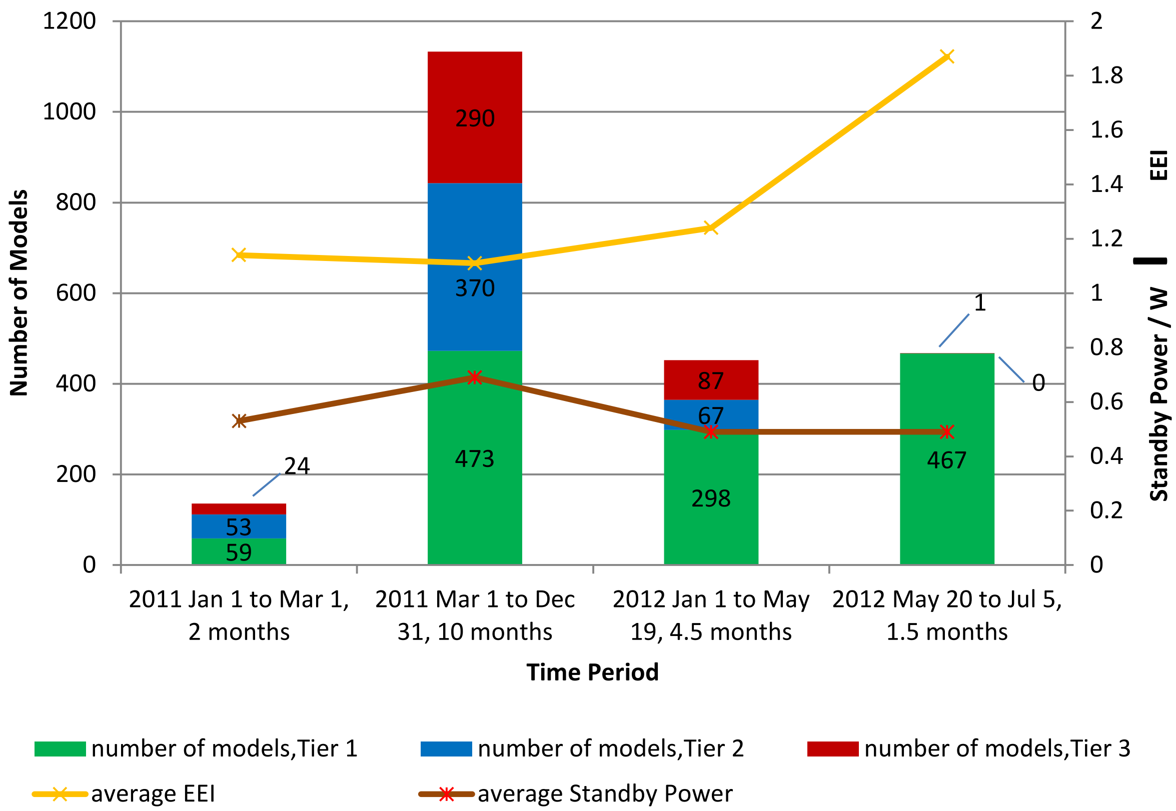
[101] Energy Saving Potential (ESP) Study for Nine Appliances in China, CLASP 2013

6.4.4 Overall transformation of the television market to date

While the above analysis provides substantial information on current issues that are of interest, market data from July 2012 gives no indication of how the television market has evolved over time and how policy interventions to date have impacted product efficiency. Figure 75 provides this information by showing the energy efficiency Tier, the average EEI, and the average standby power declared for televisions in registrations for the Chinese Energy Label over various timeframes. While not of equal lengths, the time periods shown in Figure 75 correspond to:

- The two months prior to the compulsory labeling of televisions on March 1, 2011 (refer to section 6.2.2)
- The ten months following the introduction of the energy label through to the end of 2011.
- The first period of 2012, prior to the public announcement of subsidy threshold levels on May 20, 2012
- The period after announcement of subsidy levels up to the point at which data collection for this study occurred on July 5, 2012.

Figure 75: Trends in the TV EETs, average EEI*, and average standby power declared at registration over various time periods



** All EEI values calculated based on 2010 EES derivation*
***Note that analysis is limited to the market-entry date of those products still in the market in July 2012. This may skew outcomes as some products may have entered/left the market over the period between*

market-entry and July 2012, while others remained in the market. However, as the total period is only one and a half years, we believe that the influence from the phase-out products is very limited.

As shown above, prior to the introduction of the subsidy in 2012, the proportion of products registered in energy efficiency Tiers 1, 2 and 3 remained broadly stable over time, albeit with a slight migration to higher-Tier levels resulting in the minor improvement in average EEI values and reduction in average standby power. The latter was also due to the revised standby power EES requirement introduced in January 2012.

However, the pattern and proportionate number of registrations changed sharply after the announcement of the subsidy criteria in May 2012. Over the one and a half months following the announcement of the subsidy criteria, the same number of products was registered as over the preceding 4.5 months, and all of these were Tier 1 products. Furthermore, all of the products registered in this 1.5 month period had declared EEI values equal to or in excess of the 1.7 threshold required to receive subsidies. The average EEI of models registered in this period rose by 50% over the preceding period, from 1.24 to 1.87. This indicates that the subsidy program has had a substantial impact on the market.

However, the nature of this impact is unclear. The above data highlights two key issues. Firstly, the speed with which products were registered after the announcement of subsidy levels is surprising; 467 products within just 1.5 months of the announcement. It is unlikely that so many new products could be developed and manufacturing processes changed to deliver products to the market in this limited timeframe. This suggests one or more of the following possibilities:

- Manufacturers already had products of this specification but had no incentive to bring them into the market. If this is the case, the draft 2012 revision to the EES will not severely impact the availability of products in the market, but will simply bring already-designed products into the market more quickly. This is a highly desirable outcome.
  Manufacturers were already producing products of this specification and were previously understating product performance. When the new subsidy requirements were announced, these products were simply re-registered with more accurate performance data. If this was the case, policy maker adoption of the requirement to register products with actual test results verifying their declarations (as recommended in section 6.4.2) will help prevent such a situation from occurring in the future.
- Manufacturers were over-declaring the performance of products registered after the subsidy announcement simply to qualify for the subsidy. It is impossible to know if this is the case. However, policymakers are encouraged to conduct check-testing on those models qualifying for subsidies to ensure that all manufacturers are in fact complying, and a small number of manufacturers are not unfairly claiming the subsidy when their products fail to meet performance claims, thus creating unfair competition for those manufacturers that wholly comply with the rules.

Secondly, the average declared standby power of televisions registered before and after the introduction of the subsidy program remained unchanged at 0.49W. This is not surprising, as the standby power requirement to gain access to the subsidy was that of the 2010 EES MEPR, i.e. 0.5W. Given the potential improvement that is possible for standby power (demonstrated in section 6.4.3), this appears to be a missed opportunity to improve the standby performance of products. Should policymakers wish to undertake further subsidy interventions for televisions, they may wish to set more challenging standby power targets to encourage market introduction of televisions with better standby performance, and potentially also include requirements for "other energy states" as outlined in section 6.4.3.

6.5 Conclusions and recommendations

Based on the analysis above, the authors recommend the following actions for policymakers on televisions in China.

Revise the Current Test Methodology and Conduct Consumer Usage Research

The television test methodology is critical to establishing a true baseline against which to measure the comparative energy consumption of televisions. Further, having the test methodology (and derivative calculations) represent actual consumer usage patterns as closely as possible is important to enabling appropriate comparisons of television energy performance and developing accurate projections of energy consumption and savings potential, which are necessary during the development of the Chinese energy efficiency standards.

At present, however, there appears to be little publically available information on consumer usage. Moreover, an analysis of the test method has highlighted a number of areas that may result in misleading comparative performance information. Therefore, policy maker may wish to consider:

1. Initiating research to establish true consumer usage patterns to enable more informed EES development in the future.
2. Revising the test method to reflect more realistic viewing conditions by requiring the adjustment of brightness and contrast against a defined "typical" level of background light. Identifying and defining this "typical" level may be included in the consumer research recommended above. Further, it is necessary to differentiate the adjustment of television brightness from the adjustment of backlighting to ensure the most efficient outcome is achieved. These issues would potentially be resolved through harmonization of the Chinese test standard with the international IEC 62087 standard;
3. Revising the current derivation of EEI for PDP televisions to be directly comparable with that for LCD televisions. As presently formulated, the differing methods of calculating EEI values between the two TV types are not comparable, resulting in PDP televisions appearing to be substantially more efficient than is actually the case in comparison with LCD televisions. Making $EEI_{lcd\ ref} = EEI_{pdp\ ref}$ will make EET, MEPR, and subsidy thresholds comparable for all product types. Such an action would create a technologically neutral energy performance

benchmark, allowing policymakers and consumers to make more informed policy and purchase decisions.[102]

Revise Energy Efficiency Tiers Proposed in August 2012 Draft

The proposed revisions to the energy efficiency standard in the August 2012 draft are both challenging and robust. However, policymakers should be aware that the proposed EET thresholds are significantly more stringent for smaller televisions when compared with larger televisions. This is potentially controversial because it is counter to the typical policymakers desire to minimize energy consumption.

Additionally, at the proposed MEPR levels, there are currently very few televisions with a power demand below 100W that could remain in the market. This would have a potentially perverse outcome from the policy maker perspective, as low energy-consuming products are being removed from the market, forcing consumers to buy higher power-consuming units.

4. Thus, policy makers may wish to reconsider the MEPR value set in the 2012 draft EES to accommodate smaller televisions.

However, if manufacturers are definitely understating product performance and the actual performance of most products could meet the new MEPR, then this new requirement should not cause the market restriction concerns and therefore no re-consideration is needed.

Require Declared Performance Values to be Substantiated by Test Results

As discussed in Section 6.4.2, a very high proportion of television models in the Chinese market have declared performance values that only just exceed the minimum EET or subsidy threshold limits. This indicates one of the following possibilities:

- Manufacturers have very accurate control of the design and production and allowances (or “tolerances”) for variance in performance results are not required;
- Manufacturers are over-reporting the performance of their products, which implies that the tolerances for labeling declarations should be removed; or,
- Manufacturers are understating the performance of their products, which is problematic when policymakers are developing future EES and subsidy requirements.

At present there is no evidence to suggest which of the above reasons may be causing the performance declarations just above EET and subsidy threshold levels, and there is certainly no evidence of manufacturer malpractice. However, there is sufficient evidence to recommend that policymakers:

[102] Note that this may require the Tier 3 threshold (and MEPR) for PDP televisions to be temporarily lowered to the equivalent current EEI value to allow manufacturers time to adjust to the new regulations, and ensure PDP televisions are not immediately removed from the market.

5. Insist that claims made on product registration and labels must align with actual testing reports submitted with the applications, and that these test reports are in line with typical product performance.

Manufacturers understating product performance is also potentially responsible for a large number of televisions with EEI values above Tier 1 entering the market within 1.5 months of the announcement of the 2012 subsidy threshold (see Section 6.4.4). Requiring manufacturers to register products as tested will also help to prevent future instances of this phenomenon.

Conduct Check-Testing on Models Qualifying for the Subsidy Program

As discussed in Section 6.4.4, a surprisingly high number of products with EEI levels significantly higher than the previous Tier 1 performance thresholds immediately entered the market within 1.5 months of the announcement of the 2012 subsidy threshold. One possible explanation for this is that manufacturers were over-declaring the performance of products registered after the subsidy announcement, simply to qualify for the subsidy.

While it impossible to know if this was the case, policymakers may wish to:

6. Conduct check testing on those models qualifying for subsidies to ensure that all manufacturers are in fact complying, and a small number of manufacturers are not unfairly claiming the subsidy when their products fail to meet performance claims, creating unfair competition for those manufacturers wholly complying with the rules.

Revise Standby Power Requirement Proposed in August 2012 Draft

Standby power consumption of televisions has a substantial impact on the overall annual energy consumption of televisions. As discussed in Section 6.4.3, there are already a significant number of products (almost 200) with standby power below 0.5W, which demonstrates that there is little technological challenge in meeting lower standby power levels. Given this fact, policymakers may wish to consider:

7. Revising the draft August 2012 energy efficiency standard proposals to require a lower standby power requirement of 0.3W.

Replace EEI with Power Consumption Value on TV Energy Label

To improve transparency to consumers and enhance their ability to preferentially select lower energy consuming-products at the time of purchase, policymakers may wish to

8. Replace the declaration of the television's EEI value with the more understandable and useful (to consumers) value of how much power the product consumes. While this will still not give consumers full information on the energy consumption of the television, it will at least enable them to compare the power (and hence probable energy) consumption between different TV models. Additionally, should the research on consumer usage patterns be undertaken (as recommended above), this labeled power measurement could eventually be replaced with a typical daily, weekly, or annual energy consumption based on

real viewing hours of the television, which is likely to be of significant value to the consumer.

Revise Future Subsidy Thresholds for Televisions

Policymakers may wish to consider:

9. Withdrawing subsidies for relatively lower-efficiency televisions and reallocating those resources to increase subsidies for highly efficient products. Specifically, policy makers may consider withdrawing subsidies for all PDP TVs and LCDs with EEIs lower than 1.9, and increasing subsidies for LCDs with EEIs higher than 1.9.

In order to recognize super-efficient products, policymakers may also want to consider:

10. Setting a "super" subsidy for top level products, such as LCDs of EEI 3.0. In this way, the subsidies would be more effective because consumers would be more likely to buy these highly efficient products, as they could get a considerable percentage of rebates off the original price in addition to saving the associated energy in the home.

Furthermore, very large screens are regarded as luxury products, and buyers of these products are typically not sensitive to price. Therefore, the marginal subsidy available for these large screen size products is wasted, particularly as these large screen units consume significantly more energy than smaller screen alternatives. Consequently, policymakers may wish to:

11. Limit the size of products receiving subsidy.

6.6 Addendum: Comparison and Analysis of March 2013 Draft EES

Before this report was completed, a revised "for approval" draft EES for televisions was published in March 2013. This revised document contains substantial changes to the previous version, and typically the "for approval" version (hereafter referred to as "2013 draft") is adopted as the final version for publication. We have attempted to conduct further analysis to review the impact of this new draft.

As shown in Table 27, comparing with the 2012 draft and the current EES, the 2013 draft contains major changes; specifically:

- Changing $EEI_{lcd\ ref}$ back to 1.1, as in the current EES;
- Again applying P_s in the EEI derivation, although with a value of 4W rather than the 10W used in the current EES; and
- A minor change to the definition of P_k.

Table 28 compares EET requirements for the current EES and draft 2012 and 2013 versions. Again, note that the EEI values are not directly comparable due to the difference in derivation methods in the three versions of EES. However, Figure 76 illustrates a direct comparison.

As illustrated, between the 2012 and 2013 drafts, the energy efficiency requirements for PDPs have been lowered across all energy efficiency Tiers; for LCDs, the MEPR value has been lowered, but the Tier 1 requirement has been raised.

As discussed in section 6.4.2, the MEPR requirement for both LCD and PDP televisions set in the 2012 draft was very stringent and may have eliminated an unexpectedly high percentage of products from the market. It seems that policymakers have realized this situation and have amended the MEPR requirement accordingly. Unfortunately, the issue highlighted in the 2012 draft that the stringent of requirements for smaller sized televisions is higher than for larger screen units still exists in the 2013 draft.

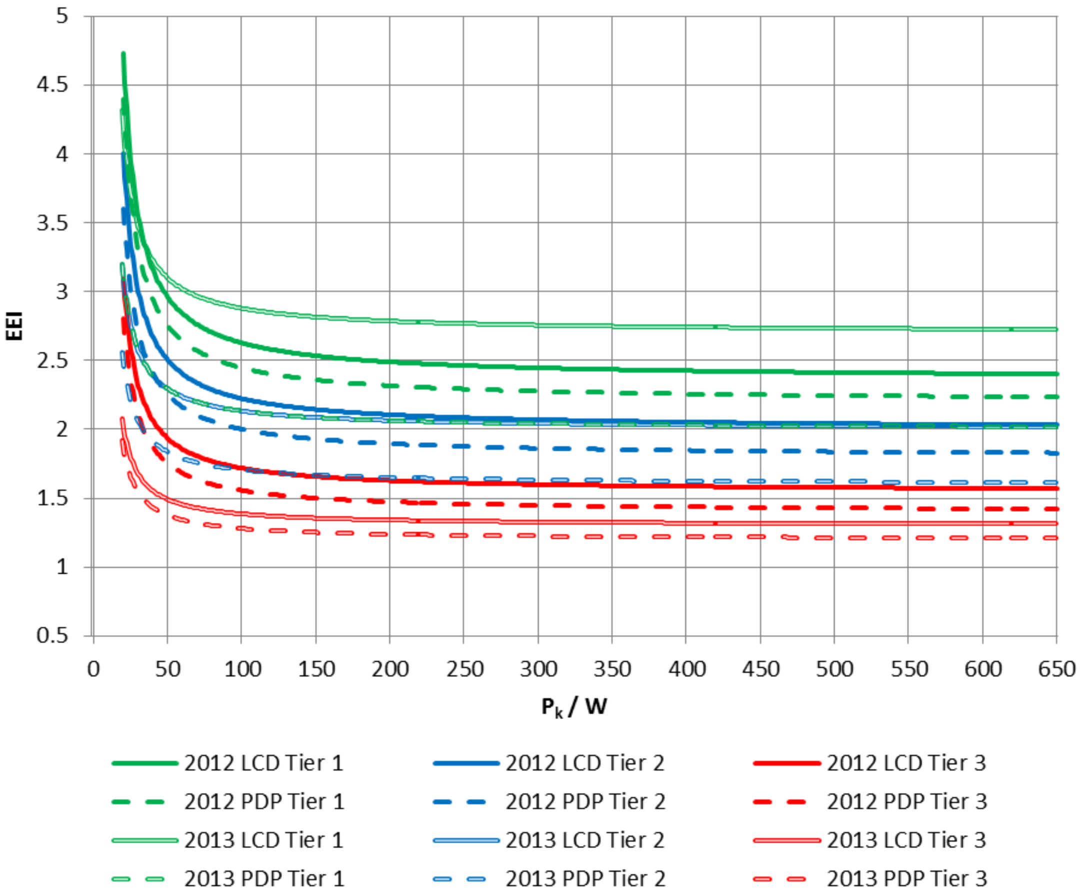
Table 27: Derivation of EEI values in the current (2010) Energy Efficiency Standard and in 2012 and 2013 revisions

	EEI Derivation (2010 EES)		EEI Derivation (2012 draft EES)		EEI Derivation (2013 draft EES)	
TV Type	**LCD**	**PDP**	**LCD**	**PDP**	**LCD**	**PDP**
EEI calculation	$EEI_{lcd\ now}=[L*S/(P_k-P_s)]/1.1$	$EEI_{pdp\ now}=[L*S/(P_k-P_s)]/0.32$	$EEI_{lcd\ new}=(L*S/P_k)/1$	$EEI_{pdp\ new}=(L*S/P_k)/0.32$	$EEI_{lcd\ new}=[L*S/(P_k-P_s)]/1.1$	$EEI_{pdp\ new}=[L*S/(P_k-P_s)]/0.32$
	Notes: *L: average screen luminance;* *S: area of the screen;* *P_k: power when TV is on and dynamic image is displayed* *P_s: power to process signal:* *P_s=6W, when YP_bP_r interface is used;* *P_s=10W, when Analog Radio Frequency interface is used;***Error! Bookmark not defined.** *P_s=17W, when Digital Radio Frequency interface is applied.* *$EEI_{lcd\ ref}$ = 1.1* *$EEI_{pdp\ ref}$ = 0.32* **Error! Bookmark not efined.**		*Notes:* *All symbols mean the same as 2010 EES, except Pk.* *$P_k=P_i$ if P_i varies more than 15% from P_d and P_i is higher than P_d otherwise $P_k=P_d$*[84]*.* *where:* *P_i: power when TV is on and static image is displayed;* *P_d: power when TV is on and dynamic image is displayed* *$EEI_{lcd\ ref}$ = 1* *$EEI_{pdp\ ref}$ = 0.32***Error! Bookmark not efined.**		*Notes:* *All symbols mean the same as 2010 EES, except P_k and P_s.* *$P_k=P_i$ if P_i varies more than 30% from P_d and P_i is higher than P_d otherwise $P_k=P_d$*[84]*.* *where:* *P_i: power when TV is on and static image is displayed;* *P_d: power when TV is on and dynamic image is displayed* *P_s=4W, when Analog Radio Frequency interface is used***Error! Bookmark not defined.***;* *P_s=8W, when Digital Radio Frequency interface is applied;* *P_s=0W, when other type of interface is applied;* *$EEI_{lcd\ ref}$ = 1.1* *$EEI_{pdp\ ref}$ = 0.32***Error! Bookmark not defined.**	
Conversion of EEI_{now} and EEI_{new}			*LCD: $EEI_{lcd\ new}=[EEI_{lcd\ now}*1.1*(P_k-10W)]/P_k$;* *PDP: $EEI_{pdp\ new}= EEI_{pdp\ now}*(P_k-10W)/P_k$;*		*LCD: $EEI_{lcd\ new}=EEI_{lcd\ now}*(P_k-10W)/(P_k-4W)$;* *PDP: $EEI_{pdp\ new}= EEI_{pdp\ now}*(P_k-10W)/(P_k-4W)$;*	
Observation	/		*Comparing with current 2010 EES:* *1. The new $EEI_{lcd\ ref}$ in 2012 draft has changed from 1.1 to 1;* *2. The 2012 draft has excluded P_s as a variable in the calculation of EEI.*		*Comparing with current 2010 EES:* *1. The 2013 draft has changed P_s from 10W to 4W.*	

Table 28: TV energy efficiency requirements in the current (2010) and revised August 2012 and March 2013 draft Energy Efficiency Standards

TV type	Energy Efficiency Index (EEI) Tier Thresholds Requirements								
	Current (2010) EES			Revised draft EES (August 2012)			2013 draft EES		
	Tier 1	Tier 2	Tier 3	Tier 1	Tier 2	Tier 3	Tier 1	Tier 2	Tier 3
LCD	1.4	1.0	0.6	2.6	2.2	1.7	2.7	2.0	1.3
PDP	1.2	1.0	0.6	2.2	1.8	1.4	2.0	1.6	1.2
PDP (*normalized to LCD equivalent*)	0.35	0.29	0.17	0.70	0.58	0.45	0.58	0.47	0.35

Figure 76: Comparison of 2012 and 2013 draft EES Tier threshold values*



** Comparison based on the 2010 EES methodology for derivation of EEI.EEI values are comparable for LCD and PDP threshold between years, the LCD and PDP EEI thresholds are not comparable between screen technology types as detailed in section 6.2.1 with the revisions highlighted in this Addendum.*

*** To make the graph easier to read, we have only plotted the EET requirements for the 2012 and 2013 draft standards.*

Section 7: Analysis of Washing Machine Market and Product Performance

Washing machines are increasingly considered to be a necessity in households. Consequently, as income levels rise, particularly in rural areas, the total stock of installed washing machines continues to rise. Based on the projections prepared as part of this analysis[103], approximately 366 million washing machines were installed across China by the end of 2012. This stock is expected to rise to 484 million in 2030. Under a business-as-usual scenario, washing machines are expected to consume approximately 17 TWh per year of energy in 2030[104]. Such projections clearly demonstrate the need to address the energy efficiency and overall consumption of washing machines.

7.1 Product Background

There are three main types of washing machine on the Chinese market:

- Drum (front load) units;
- Impeller (top load) units; and
- Twin tubs (top loading units with two tubs, one for washing and one for spin drying).

However, the sales of twin tub washing machines have been falling. Although they still account for a significant share of the market (refer to section 7.4.1), it is anticipated the proportion of sales of twin tub units will continue to fall. Therefore, this analysis primarily focuses on drum and impeller units.

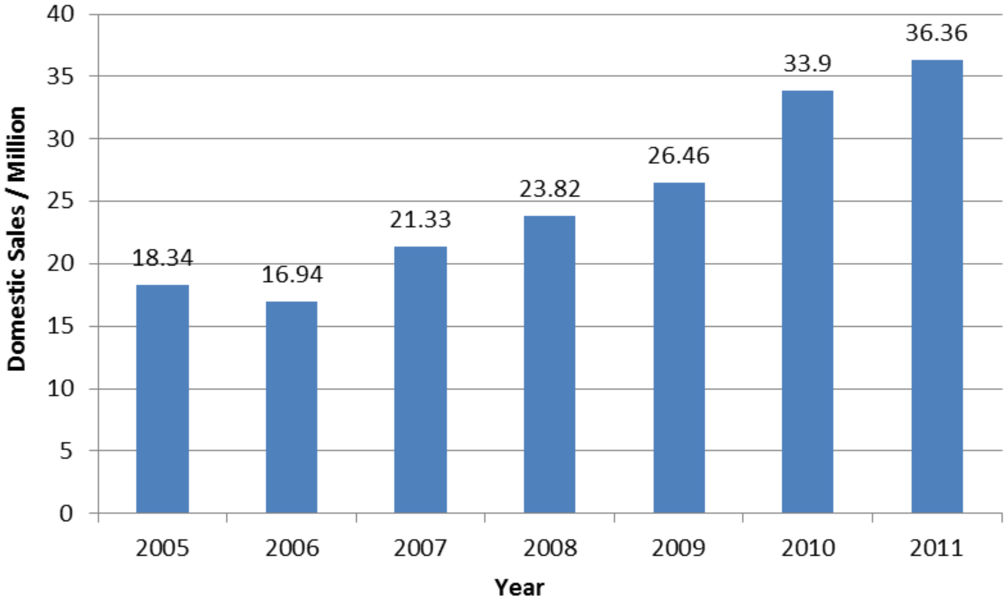
7.1.1 Production, sales, and stock level

As shown in Figure 77, annual sales of washing machines within China in 2011 reached an historic peak of 36.4 million units, up from 18.3 million units sold in 2005. The high levels of sales in recent years are at least partially due to the stimulus subsidy (refer to section 7.3). Over the same period, the estimated number of washing machines installed Chinese households rose from approximately 247 million to 353 million, and is projected to continue to grow to 443 million by 2020.

[103] Energy Saving Potential (ESP) Study for Nine Appliances in China, CLASP 2013

[104] It should be noted these projections are based on energy consumption for washing machines under test conditions. There is some doubt over how representative the test method is of actual consumer use. This coupled with a poor understanding of how consumers actually use their washing machines, means there is a potentially large differential between estimated energy consumption, and what is consumed in reality.

Figure 77: Annual sales of washing machines in China (2005-2011)

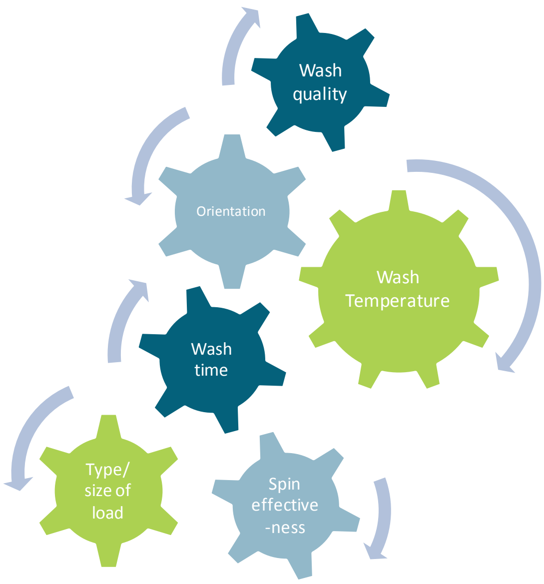


** Data source : China Industry On-line (www.chinaiol.com)*

7.1.2 Usage patterns

As shown in Figure 78, the orientation of the washing machine, the length of cycle, wash temperature, the type and size of the load, and the desired wash quality and dryness of the laundry at the end of the cycle are all interlinked. Hence, changing any one of these variables has a significant impact on each of the others, and ultimately on the machine's energy consumption.

Figure 78: Inter-relationship of variables on the performance of washing machines



While there is anecdotal evidence to suggest that consumers tend to wash clothes in cool or cold water, it is not clear exactly what the average temperature of this water is, nor what amount of water heating has occurred. Further, there is little public information that can be found on the sizes of loads actually washed compared with the rated capacity of the washing machine; nor is there information on the cycle time, wash quality, and post-wash dryness that Chinese consumers expect from their washing machines.

As a result, this analysis and the supporting projections[105] rely entirely on declared data under test conditions which, as noted in section 7.2.3, may not provide true estimates of actual unit energy consumption, nor of comparability between product types.

7.2 Regulation, Labeling, and MEPS

7.2.1 Energy Efficiency Tiers and MEPRs

The most recent energy efficiency standard (EES) for washing machines is GB 12021.4-2004[106]. This EES was issued in 2004 and became mandatory in 2005. The EES defines three performance indicators for measurement and declaration during the washing machine test: energy efficiency, water efficiency, and washing ability:

- *Energy efficiency* is defined as the energy consumption per washing cycle per kilogram of rated capacity.
- *Water efficiency* is defined as the water consumption per washing cycle per kilogram of rated capacity.
- *Washing ability* is the measure of the capability of the machine to remove stains from the load (based on the relative performance of the machine under test in comparison with the cleansing ability of a reference unit).

As shown in Table 29, the EES sets five energy efficiency Tiers (EET), with Tier 1 being the most efficient. To qualify for a particular Tier, the washing machine must satisfy all three energy, water, and wash ability requirements. The EES also specified a minimum energy performance requirement (MEPR) that all washing machines must satisfy, which aligns with the lower boundary value of Tier 5.

Table 29: Energy efficiency Tier requirements for drum and impeller washing machines

	Impeller			**Drum**		
EET	Energy efficiency (kWh/kg)	Water efficiency (kWh/kg)	Washing ability	Energy efficiency (kWh/kg)	Water efficiency (kWh/kg)	Washing ability
1	≤0.012	≤20	≥0.90	≤0.19	≤12	≥1.03
2	≤0.017	≤24	≥0.80	≤0.23	≤14	≥0.94
3	≤0.022	≤28		≤0.27	≤16	
4	≤0.027	≤32	≥0.70	≤0.31	≤18	≥0.70
5	≤0.032	≤36		≤0.35	≤20	

As explained in section 7.2.3 below, the performance of the two washing machine types is not comparable due to the differences in wash temperature. As such, the EES is subdivided

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[105] Energy Saving Potential (ESP) Study for Nine Appliances in China, CLASP 2013.

[106] During the final stages of this study, a revised version of the EES for washing machines was issued, which contains a new test method for the measurement of energy efficiency and cleansing ability. There has been insufficient time to fully integrate these new proposals into the current version of the report.

into the separate performance requirements for impeller and drum washing machines. Policymakers may wish to consider undertaking consumer research to identify actual consumer wash patterns and develop a test method that is technology-neutral. This would allow for a direct comparison of product performance, irrespective of type, to enhance consumer choice and enable improved EES development.

Policymakers may also wish to note that the current energy and water efficiency metrics are both based on rated capacity. At the time when the EES was developed in 2004, this was very sensible as most washing machines were likely to have been of a very similar capacity, typically 3-5 Kg. More recently, however, washing machine capacities have risen significantly. The analysis shows that current average washing machine capacities are in the range of 5-8Kg (see section 7.4.2). Energy and water consumption typically rise with increased unit capacity, but larger washing machines should theoretically use proportionately less energy and water per kilogram of load than smaller machines, though more energy overall for a single cycle.

This has two major implications. First, as washing machines are now, on average, significantly larger than when the EES thresholds were developed, the energy and water efficiency thresholds are effectively less challenging than at the time of introduction. The thresholds should therefore be revised.

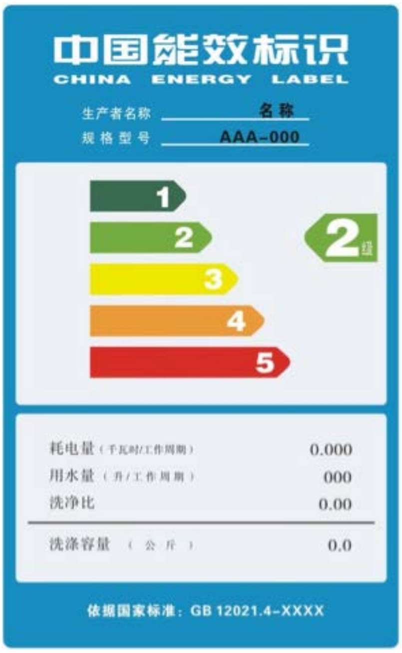
Secondly, as the EES thresholds are based on rated capacity rather than actual consumer wash sizes, there is an incentive for manufacturers to build and promote larger washing machines that will appear more efficient on the label declarations. This situation could be very positive assuming that consumers actually fill the larger washing machines to rated capacity since, overall, less energy will be used per kilogram of laundry cleaned. However, if consumers are only washing partial loads, then the total energy consumption of washing machines may be rising, even if the apparent efficiency of units based on full rated capacity appears to be improving. Therefore, policymakers may wish to conduct consumer research to establish if consumers are indeed washing on full loads and, if not, revise the test methodology as proposed in section 7.2.3.

Finally, policymakers may want to examine the issue of standby power. As more drum machines are entering the market, it is possible that these machines will be installed in more recessed areas than traditional impeller units, with the associated probability that they will remain connected to the electricity supply for longer periods due to the potential inaccessibility of the power supply. This may result in significant off-mode standby energy consumption. Therefore, policymakers may want to consider including off-mode standby, and potentially active standby mode for microprocessor controlled units, as one of the energy performance requirements in future revisions to the EES.

7.2.2 Energy labeling of washing machines

The use of the China Energy Label became mandatory for washing machines in March 2007. The label, shown in Figure 79, has five Tiers aligning with the EETs defined in the EES. In addition to the colored bars indicating the specific energy efficiency Tier of the washing machine, the label also includes basic identification information of the model, energy consumption per washing cycle, water consumption per washing cycle, washing ability, and the (rated) capacity.

Figure 79: China energy label for washing machines



While the information on the label is comparable for machines of the same type, it is *not* comparable for units of different types – e.g. impeller units versus drum units. This fact, however, is not clear to the consumer at the point of purchase, and consumers are thus likely to consider the declarations comparable. For example, it is highly unlikely that consumers will realize that they will also have to pay for the water heating energy for impeller washing machines (if water is locally heated or central supply hot water is metered), but that this energy consumption is included in the drum washing machine declarations. Similarly, consumers are unlikely to understand that the declared wash performances are based on very different washing conditions.

Therefore, again, policymakers may wish to consider the introduction of technology neutral performance tests to ensure that labeling declarations to the consumer are understandable, and that performance indications on the label are directly comparable between all types of washing machine.

7.2.3 Test Method

The Chinese test method for both impeller and drum washing machines is GB/T 4288-2008. This test method measures the same performance variables for both types of machine including energy consumption, water consumption, and wash quality. However, the testing conditions for the two types of machine are very different:

- Impeller washing machines are tested using relatively cool water at 30 ± 2°C. Water is heated from ambient temperatures to the test temperature externally, and the energy used to heat the water is not included in the declared unit energy consumption.
- Drum washing machines are tested using hot water. For units with an integrated water heater, the washing machine is fed by cold water at 15 ± 2°C and run at the default standard hot washing setting. For units without an integrated water heater, the washing machine is fed the hot water at 50 ± 2°C. Again, this water is heated from ambient to the test temperature externally, and the energy used to

heat the water is not included in the declared unit energy consumption. However, most drum washing machines are fitted with integrated heating equipment[107].

Clearly the difference in test methods creates substantially differing results. The tested energy consumption of the impeller units comprises only the mechanical energy needed to agitate and spin the laundry, plus the energy used for water pumping. In contrast, the energy consumption of the drum machines includes the mechanical energy in addition to the energy to heat the water, which is high relative to the mechanical energy element. While the energy efficiency standard specifies differing unit energy performance due to the differing test requirements, the very different test methods still present policymakers with problems.

For example, excluding a measure of water heating energy for units without integrated water heating capability is misleading. While the consumer may not have to pay for the electrical energy to heat the water within the washing machine, that energy is still being consumed somewhere, either by a household water heater of some kind, or by the central hot water supplier. As a result, the washing process is actually consuming more overall energy than is indicated on the label, which can skew calculations of product energy consumption in future revisions to the label or EES.

Additionally, as there is very little publically available information on actual consumer usage patterns, it is not clear that the current test method represents true consumer use. For example, consumers may typically use cold water (i.e. ambient supply temperature) for wash loads, which is substantially cooler than the 30^{o}C specified in the impeller test. Similarly, it is possible that drum machine consumers may also choose to wash in cold water.

In sum, the declared energy consumptions potentially bear little resemblance to the actual energy used by consumers and central hot water suppliers; the measurement of efficiency based on full load may not reflect actual consumer usage (as noted in 7.2.1); and due to the interrelationship of variables indicated in section 7.1.2, the wash quality is likely to be very different from the test declaration.

Thus, at present, it is almost impossible for policymakers to promote the most efficient products, as the definition of “most efficient” is not clear. For example, it is possible that one type of washing machine (e.g. a drum type) is inherently more efficient than the other in the Chinese context. Consequently, policymakers setting the current energy efficiency standard may be defining units of one type of machine as highly efficient, when these “high efficiency” units may in fact be less efficient than the worst available models of the other type.

Even if the current test methods represented common usage patterns by the majority of consumers, the test results do not produce useful information for the energy label to assist consumers in comparing different washing machines at the point of purchase. It will not be

[107] Given the very high proportion of drum machines that contain integrated heating elements, for the remainder of the report references to “drum machines” should be assumed to be “drum machines with integral water heating” unless otherwise stated. However, readers should be aware that there is a possibility of some small incomparability of results were the very small number of drum machines without heaters are included in analysis.

clear to consumers that the energy consumption values are not comparable because the different washing machine types have undergone very different tests.

Therefore, policymakers may wish to consider the following actions:

- Conduct research into actual consumer use of washing machines to establish current typical wash temperatures, methods of water heating, size of loads, etc. This will provide the basic information to enhance the test methods to better reflect consumer use, and assist policymakers in developing appropriate energy efficiency standards.
- Introduce technology-neutral tests[108]. For example, the wash water temperatures should be comparable, and the energy to heat the water should be included in both test results. This would have the duel benefit of making energy consumption declarations of different washing machine types comparable, and would allow consumers to truly compare the energy consumption, water consumption, and wash quality under the same conditions. Such a directly comparable test would also allow policymakers more accurately develop energy efficiency standards and projections of national energy consumption, and to identify the "most efficient" products for labeling and for other policy purposes, such as subsidy support.
- Depending on the outcome of the consumer research, it may be appropriate to have a hybrid test that combines differing washing temperatures and load sizes and uses an average for the declaration, as is the case in Europe[109], or to have two separate tests and labels for cold wash and warm wash, as is done in Australia.

7.3 Subsidy information

Washing machines were included in the national Subsidy Program for Energy Efficient Products for the first time in July 2013. Table 30 details the levels of support for washing machines of varying capacity and type.

Table 30: 2012 subsidies for washing machines

Product type	EET and Energy efficiency requirements	Subsidy amount (RMB/Unit)
Full-automatic impeller	Washing capacity≤3.5 kg, Tier 2 and Tier 1 Washing capacity＞3.5 kg， Tier 1	100 200
Drum	Tier 1， Washing ability≥1.03， Water consumption≤10 L/kg，Energy consumption≤0.17 kWh/kg	260

It is interesting to note that for impeller machines, all products in Tier 1 are eligible, as well as Tiers 1 and 2 for products above 3.5kg capacity (provided they are fully automatic units). However, for drum machines, eligible products are required to be Tier 1 performance and also have energy and water efficiency levels significantly above the current Tier 1

[108] Note that there will obviously need to be some differences in the details of the tests, for example it will be necessary to define the water "fill" level for some impeller machines, while drum units typically self-control this function.
[109] This would require the specification of a minimum wash performance.

requirements. This clearly suggests that the recommendation in section 7.2.1 to increase the stringency of performance Tiers is appropriate, at least for Tier 1 and 2 products.

7.4 Data analysis

In addition to the generic cautions provided in Approach and Methodology section of the Introduction, readers should note that not all performance and other parameters were available for all washing machine models identified. The specific number of models where each product property was known, and hence included in the analysis, is indicated in Table 31. However, it has not been possible to estimate the bias this has introduced into the analysis for any given parameter.

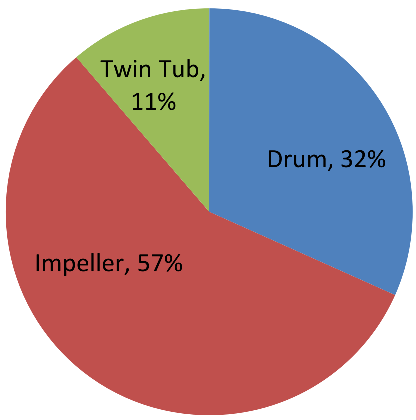
Table 31: Overview of the data used for the analysis of washing machines

Data type	Note
Number of models	1406
Rated load/capacity (Kg)	Range: 2 - 13
Energy efficiency Tier	Range: 1 - 5
Energy efficiency (kWh/Kg)	Range: 0.011 - 0.19
Water efficiency (liters/Kg)	Range: 6 -37.3
Price (RMB)	Range: 287 - 16899

7.4.1 Market distribution by washing machine type

As noted above, impeller washing machines have traditionally dominated the Chinese washing machine market. Figure 80 shows that they still account for 57% of market share as of 2012. However, in recent years, manufacturers and retailers have invested significant resources to promote drum washing machines, resulting in a market share of over 30% by July 2012. Twin tub washing machines still account for 11% of models, but this percentage is falling. Therefore twin tubs are excluded from this analysis[110].

Figure 80: Market share of washing machine market by product type (July 2012)

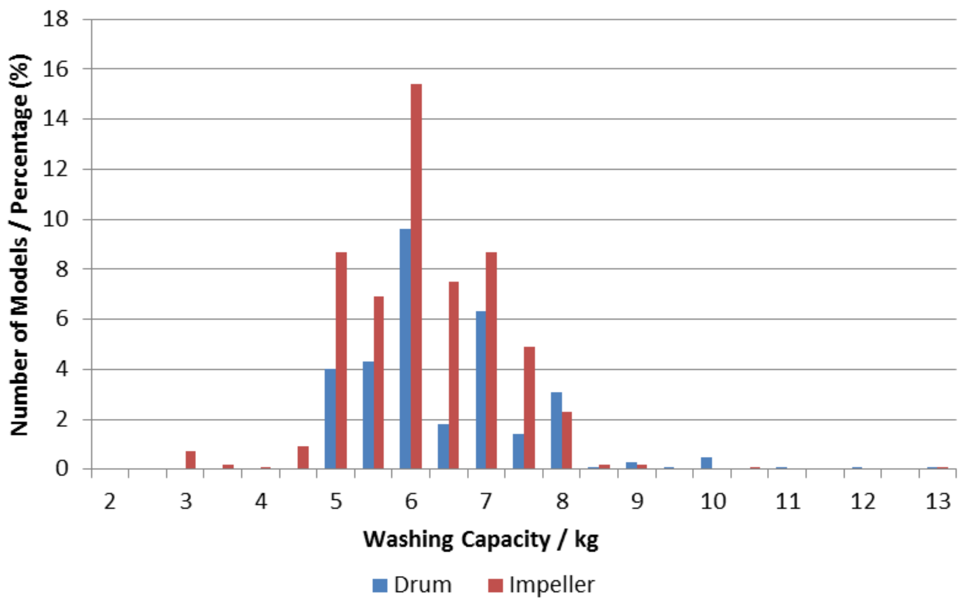


[110] Twin tub washing machines use impeller technologies, but most twin tubs don't have automatic washing capacity, and hence do not qualify for subsidies.

7.4.2 Market distribution by washing machine rated capacity

Drum and impeller washing machines have similar rated capacity distributions, as shown in Figure 81. The vast majority of products are in the 5 to 8 kilogram range, with 6 kilograms being the most popular. No drum machines below 5Kg appear in the market.

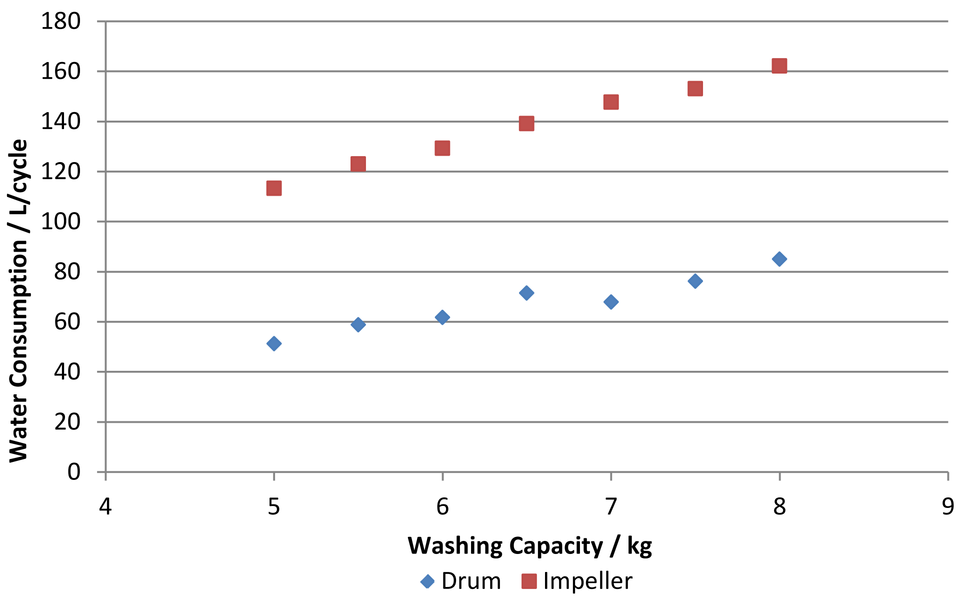
Figure 81: Washing machine rated capacity distribution (July 2012)



7.4.3 Relationship of washing machine rated capacity to energy and water consumption

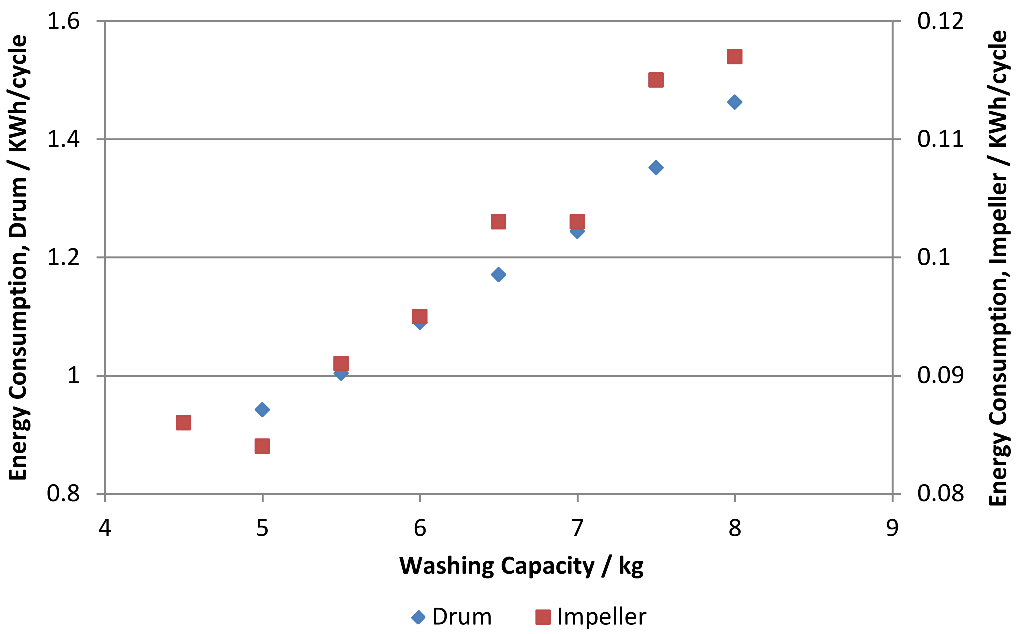
Figure 82 illustrates that water consumption increases in a broadly linear fashion in relation to increasing rated capacities for both drum and impeller washing machines. Further, on average the water consumption of impeller units is over twice that of drum units at all rated capacities.

Figure 82: Relationship of washing machine rated capacity and water consumption (July 2012)



When examining the energy consumption per cycle in relation to the rated capacity, as shown in Figure 83, it is clear that the declared energy consumption of drum and impeller units rises as a function of increasing capacity, in line with the increasing water consumption, although it is very important to note the differing scales for the energy consumption of drum and impeller units.

Figure 83: Relationship of washing machine rated capacity and energy consumption (July 2012)



On average, the energy consumption of drum units under test conditions is over 11 times that of impeller units at all rated capacities, because of the different testing conditions of the drum and impeller washing machines. This clearly highlights the inconsistency of the current approach to energy consumption (and efficiency) declarations for drum and impeller units, as well as the misleading information being given to consumers and policymakers. It emphasizes the need to create a technology-neutral test standard and EES and label requirements.

7.4.4 Relationship of rated capacity to washing machine energy and water efficiencies

The energy and water efficiency of drum washing machines is broadly stable across the range of washing capacities, as shown in Figure 84 and Figure 85. However, the average energy and water consumption of impeller washing machines increases as washing capacity increases.

Figure 84: Washing machine energy efficiency across rated capacities (July 2012)

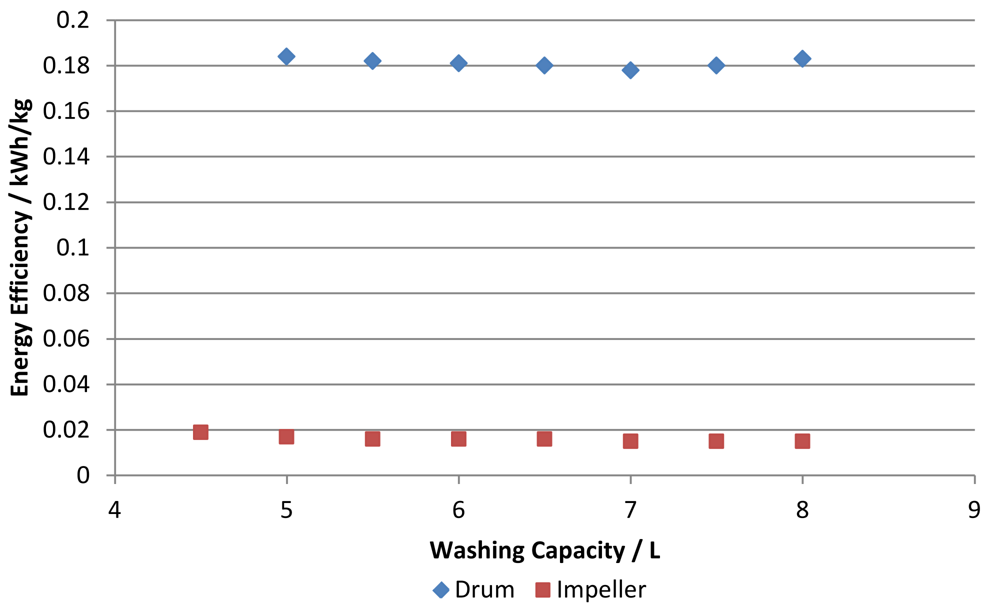
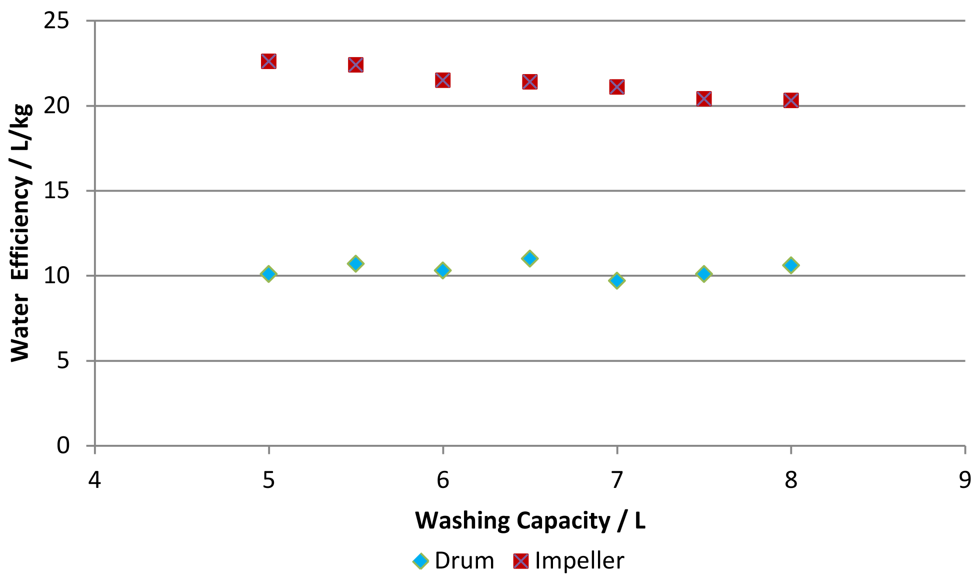


Figure 85: Washing machine water efficiency across rated capacities (July 2012)

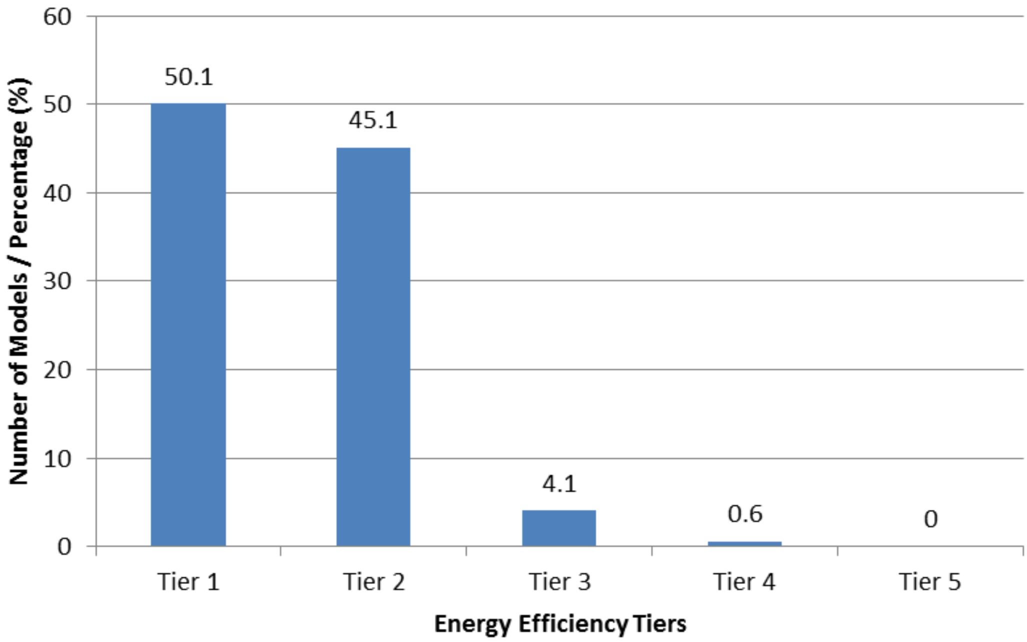


However, as noted in section 7.2.1, this assumes that consumers use larger machines at full capacity, which may not be the case. If consumers do actually use machines at less than full capacity, the apparently equal or improving efficiencies of larger machines may be misleading, and total energy and water consumption for both types of washing machines may in fact be rising as units become larger. This reinforces the need for research on consumer usage patterns proposed in section 7.2.3.

7.4.5 Washing machine energy and water efficiency across energy efficiency Tiers

As noted above, the washing machine EES contains five energy efficiency Tiers. If both impeller and drum washing machines are grouped together, Tier 1 and Tier 2 products account for more than 85% market share in 2012, while there are almost no Tier 4 and 5 products available as shown in Figure 86.

Figure 86: Distribution of washing machines of all product types by energy efficiency Tier (July 2012)

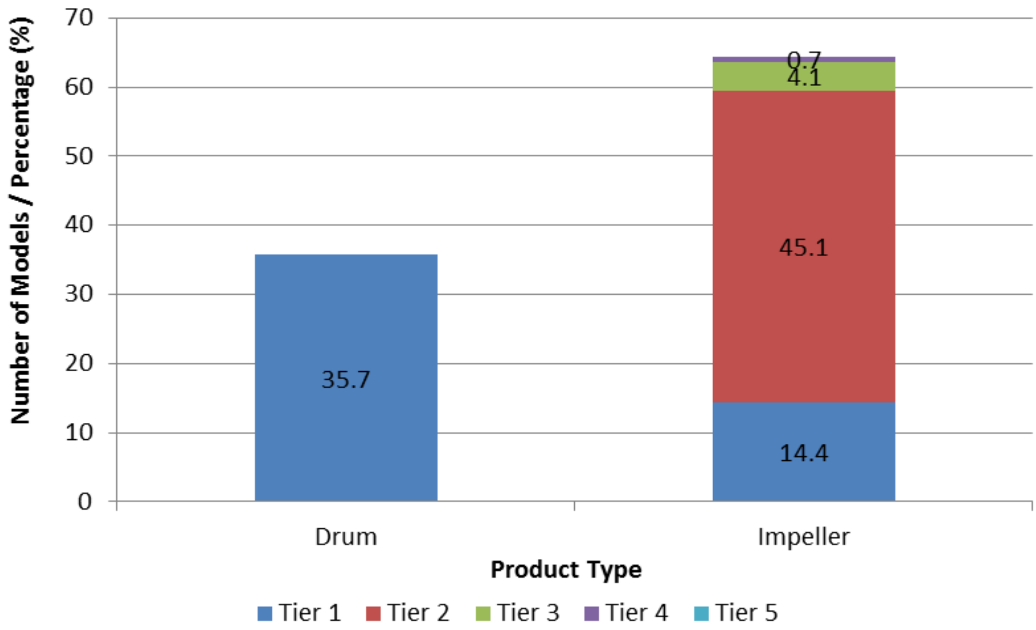


However, when breaking the market down by product type, as shown in Figure 87, it is clear that *all* drum machines are currently Tier 1 products, with almost 80% of impeller units ranking at Tier 2, and over 10% at Tier 1.

This situation presents policymakers with a problem because the current energy efficiency Tier definitions are:

- Limiting choice for consumers by not accurately reflecting the spread of product efficiencies in the market place;
- Failing to achieve the goal of only allowing the most efficient products to be ranked in Tiers 1 and 2 (and hence considered “energy efficient products”);
- Failing to motivate manufacturers to increase the efficiency of their products to differentiate from their competitors; and
- Not creating a wide distribution in efficiency of products, thus limiting the opportunities for future revisions of the EES and in particular, the MEPR.

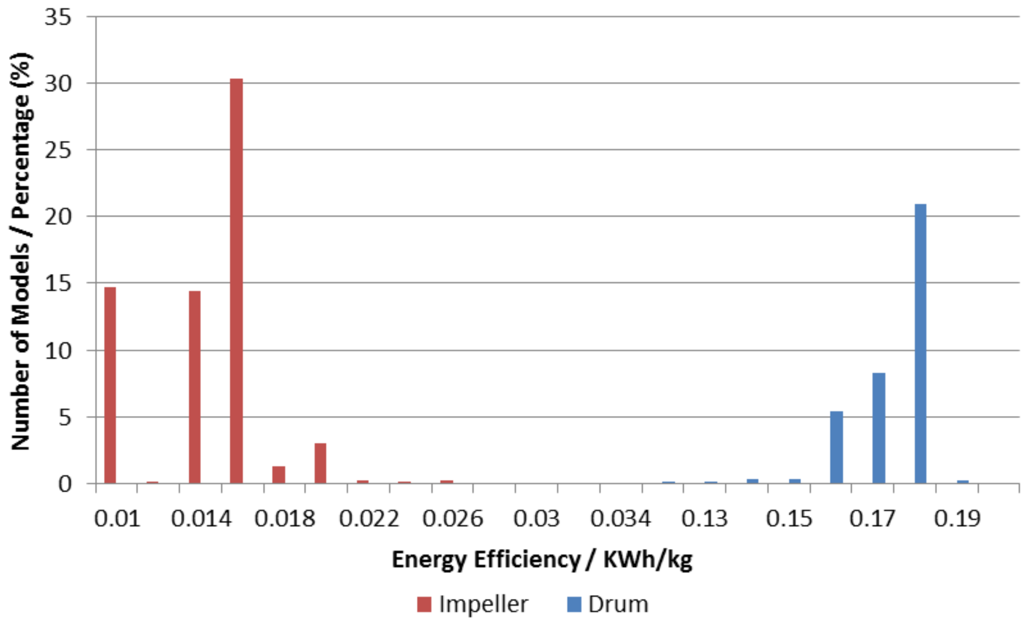
Figure 87: Distribution of washing machines of by product type across energy efficiency Tiers (July 2012)



However, if we examine the actual distribution of declared energy and water efficiencies, we find that there is a wider range of efficiencies of products in the market than currently indicated by the EETs.

Figure 88 shows that although almost all products rank at Tiers 1 or 2, there is still a reasonable distribution of declared energy efficiency values for drum and impeller washing machines.

Figure 88: Distribution of declared energy efficiency of each product type (July 2012)



Note that for impeller units the bars include products in 0.002kWh/Kg increments. For example, the 0.01kWh/Kg bar includes products from 0.010 to 0.012 kWh/Kg.

This demonstrates that even if policymakers believe it is not practical to create a technology-neutral test method and comparable efficiency requirements in the short term, or possible to amend the test method to more accurately reflect actual size of loads washed by consumers, it is still possible to make revisions to the EES based on the current test methodology[111].

Such revisions would:

- Remove the very worst performing products of each type from the market;
- Provide consumers with more product differentiation based on comparative efficiency, allowing them to preferentially choose the more efficient units (of a particular type) at the time of purchase.
- Incentivize manufacturers whose products are currently categorized as Tier 4 or 5 to improve their product performance so as not to appear "inferior" in comparison with competitive models.
- Allow policymakers to more appropriately focus other policy support measures on only the most efficient products. For example, approximately 90% of impeller and around 50% of drum machines washing machines currently qualify for subsidy support. The proposed EES revisions would allow policymakers to grant future subsidies or similar policy support to only the most efficient products in the market.

Figure 89 combines the average declared product energy efficiency values in Figure 88 with the current EET threshold values in Table 29. It shows that although almost all products rank at Tiers 1 or 2, there is still a reasonable distribution of declared energy efficiency values for drum and impeller washing machines. This demonstrates that even if policymakers believe it is not practical to create a technology-neutral test method and comparable efficiency requirements in the short term, or possible to amend the test method to more accurately reflect actual size of loads washed by consumers, it is still possible to make revisions to the EES based on the current test methodology.

It is clear from Figure 89 that the declared energy efficiency values are only just achieving the minimum threshold requirements.

A similar story emerges when we examine the distribution of water efficiencies across the current energy efficiency Tiers, as shown in Figure 90. Once again, most products qualify for Tiers 1 or 2, but there is a reasonable distribution of efficiency values.

[111] During the preparation of this study, proposed revised EES requirements for both water and energy efficiency have been issued. These are available at: http://www.sac.gov.cn/gybzyb/zxtz_843/201209/W020120912612574632217.doc

Figure 89: Average washing machine energy efficiency declarations in each Tier compared with the threshold value for that Tier (July 2012)

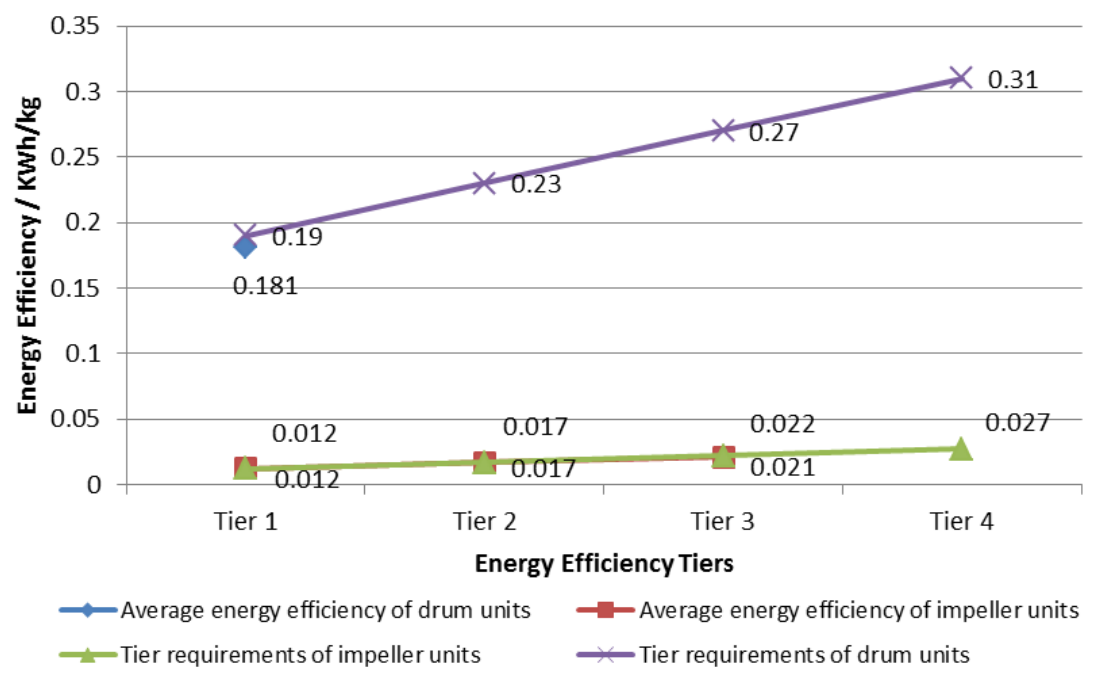


Figure 90: Distribution of declared water efficiency of each product type (July 2012)

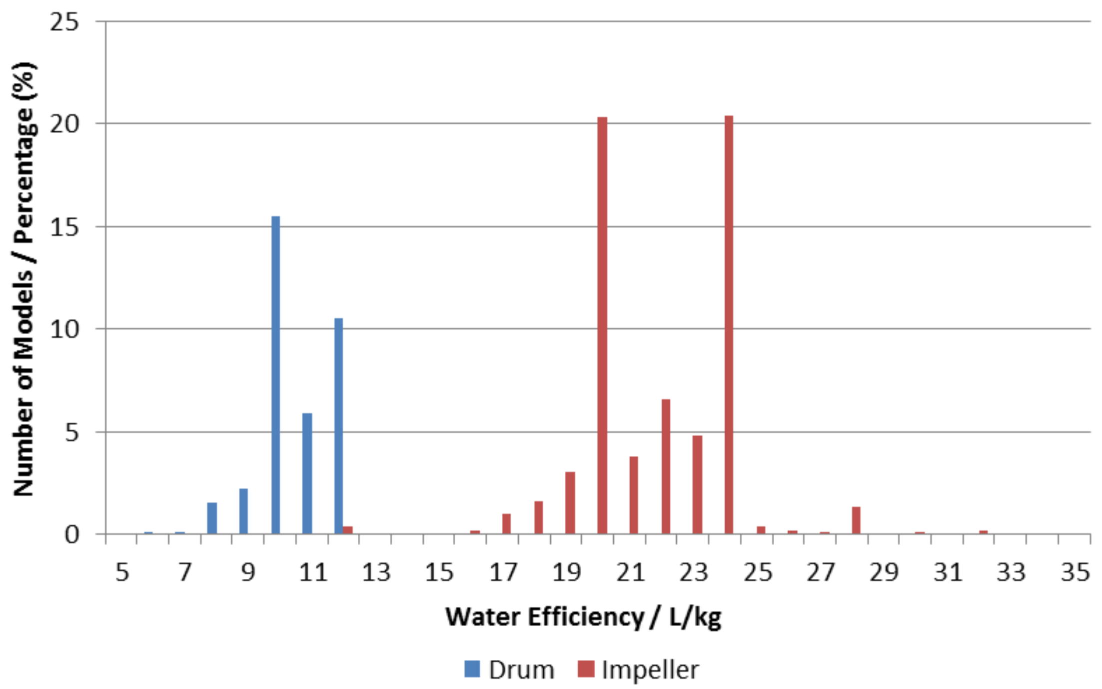
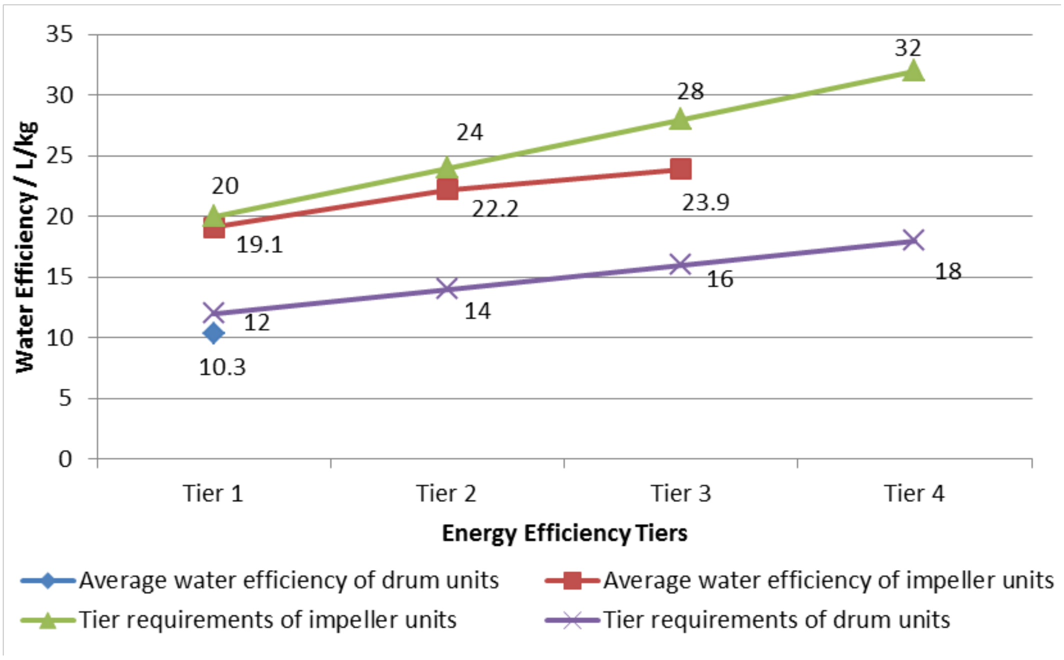


Figure 91 combines the average declared water efficiency values Figure 90 with the current EET threshold values in Table 29. Again, it is clear that the vast majority of declared water efficiency values are only just achieving the minimum Tiers 1 and 2 threshold requirements.

Figure 91: Average washing machine water efficiency declarations in each energy efficiency standard Tier, compared with the threshold value for that Tier (July 2012)



** Note the declared averages for Tier 4 products are based on a relatively small number of impeller washing machines found to be in the markets and thus may not be comparable to the averages for Tiers 1 to 3.*

The fact that the majority of both energy and water efficiency declarations are only just achieving the minimum Tiers 1 and 2 threshold requirements implies one or more of the following possibilities:

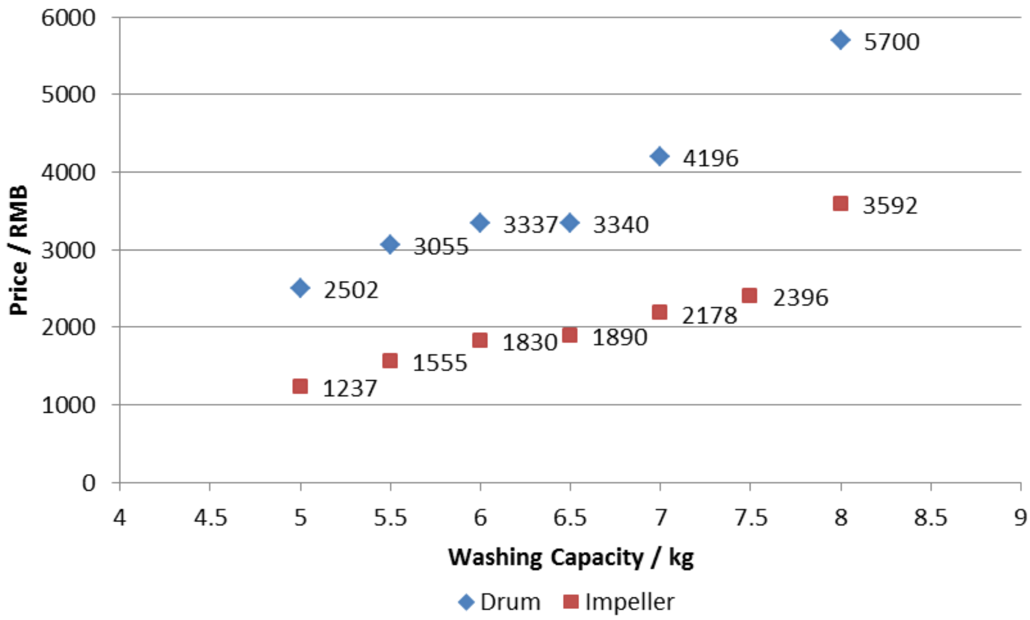
- Manufacturers have very accurate control of the design and production of washing machines and can deliver products that are just at the boundary conditions. If this is the case, any tolerances allowed for MEPR and labeling compliance are not required and can be eliminated, although test laboratory tolerances will still be required.
- Manufacturers are over-reporting the performance of products; for example, declaring the lowest value of the EET Tier above that for which their products qualify, either to appear more efficient on the label and/or to qualify for subsidy support. This may be a perfectly legitimate action if the tolerances of the declarations are sufficiently high, but again this implies that the tolerances for labeling declarations should be removed.
- Manufacturers are understating the performance of products; for example, declaring the lowest value within the EET Tier for which their products qualify to ensure their products pass any verification testing undertaken by the regulator. On one level, there is no problem with this situation as manufacturers are acting cautiously and protecting their reputations, while delivering products to the consumer that perform better than stated. However this scenario is problematic from the policymaker point of view, as knowledge of the true performance of products is important when developing future EES and subsidy requirements and analyzing the potential impact of differing threshold levels.

At present there is no evidence to suggest which of the above scenarios may be causing the performance declarations just above EET and subsidy threshold levels, and there is certainly no evidence of manufacturer malpractice. However, there is sufficient evidence to recommend that policymakers insist that claims made on product registration and labeling must align with actual testing reports submitted to support the applications, and these test reports must be from a unit with performance that is representative of typical production units. Once declarations are accurate, further research can then be undertaken to establish whether tolerances (other than those required by test laboratories) may be tightened.

7.4.6 Relationships of washing machine price to technology, rated capacity and efficiency across EETs

Product technology has a significant impact on price. As Figure 92 illustrates, drum washing machines are approximately twice as expensive as impeller machines of equivalent rated capacity.

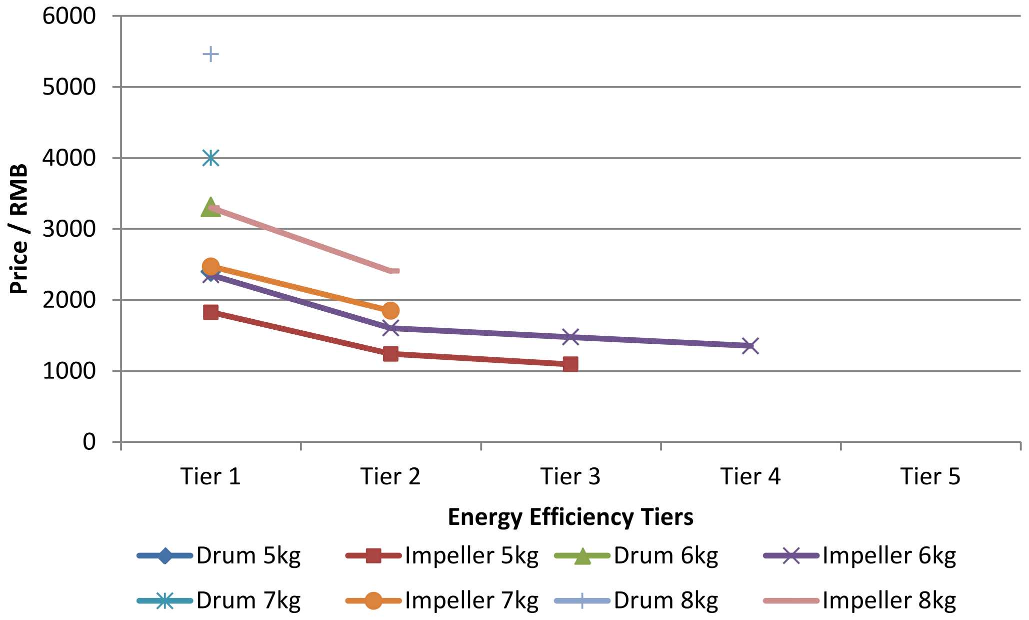
Figure 92: Average washing machine price across capacities (July 2012)



Within a given technology, there is a close correlation between price and rated capacity. However, it is not clear if this is related to additional manufacturing costs, or simple pricing strategy by manufacturers.

For impeller washing machines the price increases with higher efficiency Tiers, as shown in Figure 93. However, when looking in more detail at the average prices at each specific energy efficiency level (Figure 94), it is clear that for a given rated capacity of impeller washing machine, the general trend is for the price to rise with increasing levels of efficiency, but the relationship is not strong.

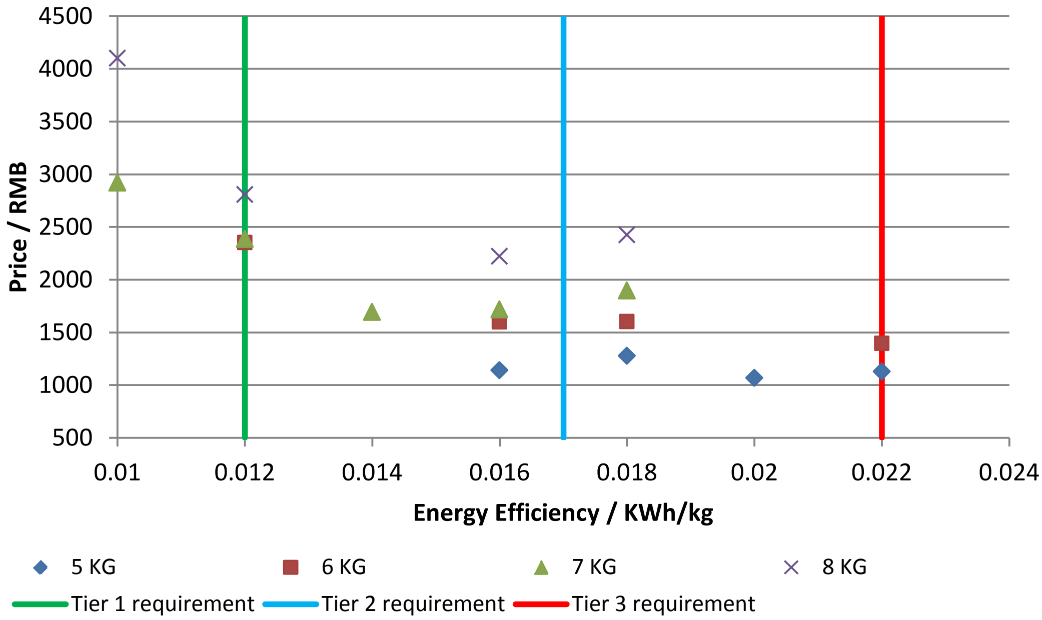
Figure 93: Average washing machine price in across energy efficiency Tiers



** Note the declared averages for Tier 4 products are based on a relatively small number of impeller washing machines found to be in the markets and thus may not be comparable to the averages for Tiers 1 to 3.*

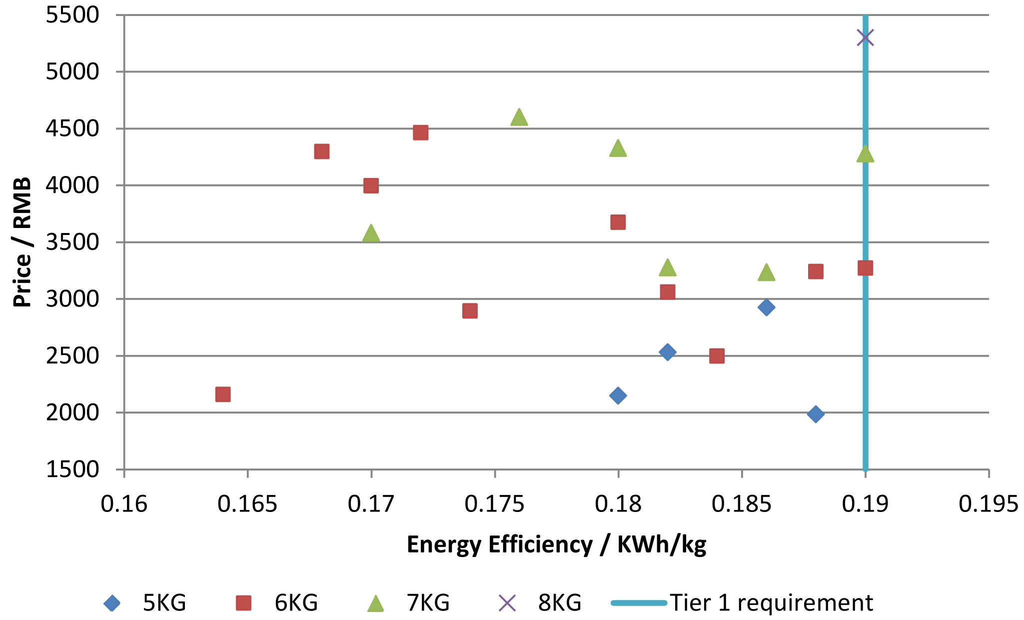
*** Note that capacities have been separated to discount the relationship to rated capacity shown in the Figure 91.*

Figure 94: Average impeller washing machine price per energy efficiency level



As all drum washing machines are Tier 1, it is impossible to establish a relationship between price and EET. However, again looking in more detail at the average prices at each specific energy efficiency level (Figure 95), it appears that there is no relationship between drum efficiency and price.

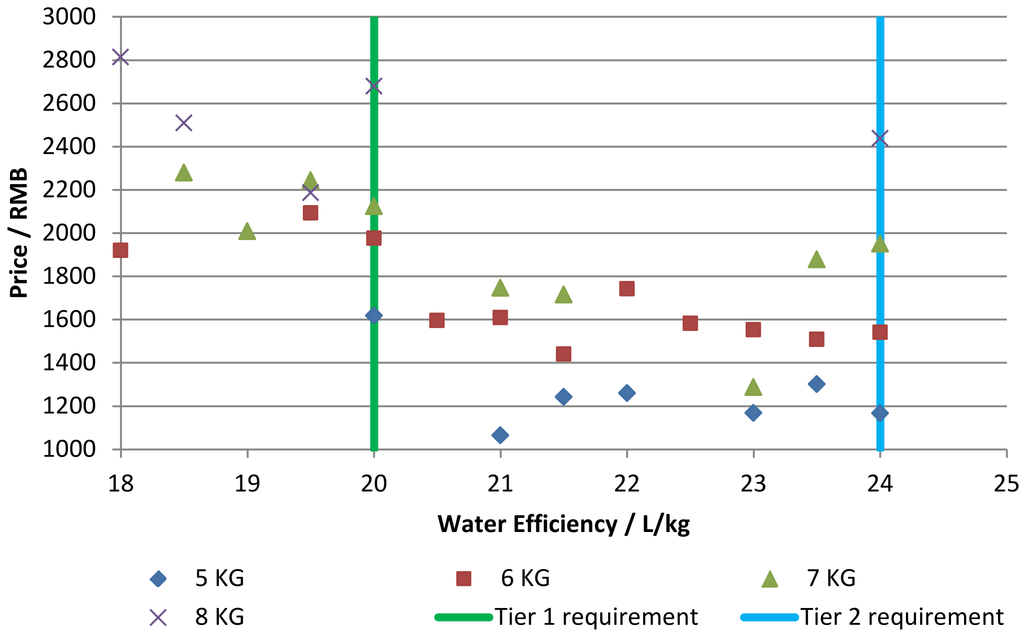
Figure 95: Average drum washing machine price per energy efficiency level



The lack of any close correlation between increasing energy efficiency and price gives policymakers some degree of assurance that increases in efficiency Tier thresholds proposed in section 7.4.4 should have little negative impact on washing machine price paid by the consumer.

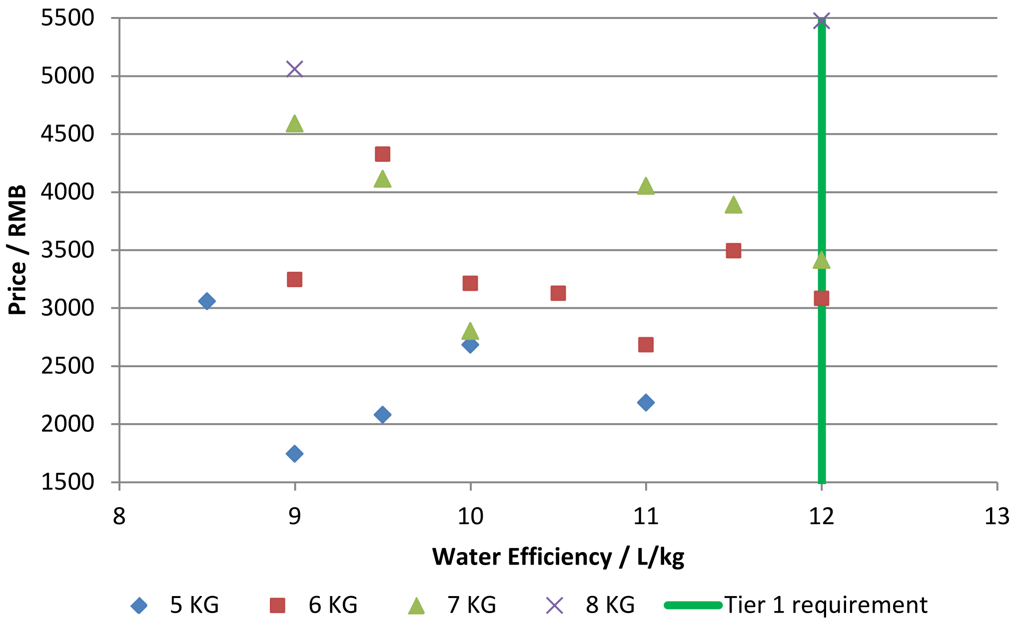
Looking at changes in price related to water efficiency in the same level of detail, there appears to be no relationship between water efficiency and price for impeller washing machines as efficiency increases within an EET (Figure 96), but in general there is a significant step upwards in price as products move over the Tier 1 threshold.

Figure 96: Average impeller washing machine price at each water efficiency level



This implies there is limited manufacturing cost increase for impeller washing machines as efficiency rises, but manufactures are using the Tier thresholds as a product pricing mechanism. This view is supported when looking at drum washing machines (Figure 97), which have no efficiency Tier differentiation and show no relationship of price to water efficiency levels.

Figure 97: Average drum washing machine price at each water efficiency level



Therefore, again, there is a degree of assurance to policymakers that the proposals for increases in the water efficiency Tier thresholds proposed in section 7.4.5 should have little negative impact on washing machine price paid by the consumer.

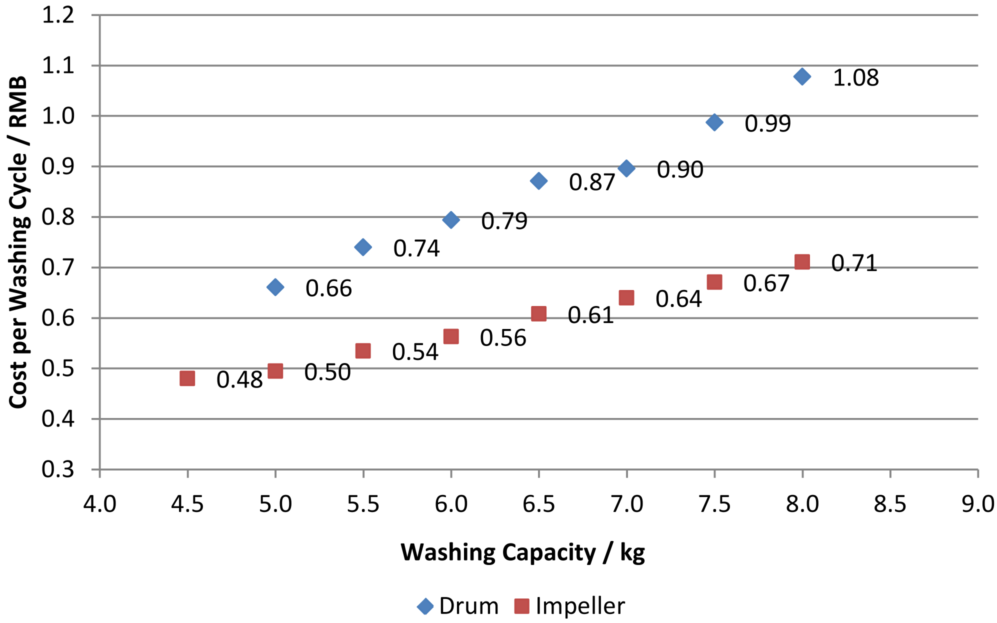
7.4.7 Operational and lifetime costs of washing machines

The operational and lifetime cost of impeller and drum washing machines can be partially compared if the costs of water and electricity are known. While these costs vary across China, typical costs to households are approximately 0.5 RMB per kWh of electricity and 4 RMB per cubic meter of water. Using these costs estimates as the basis of calculations, Figure 98 compares the cost of a single wash cycle for impeller and drum machines.

Obviously costs rise with the increases in energy and water consumption associated with increasing unit rated capacity. However, the additional costs associated with the higher water consumption of impeller washing machines is more than offset by the water heating energy used by drum units, resulting in drum washing machines typically costing 50% more per cycle than impeller machines of the same capacity.

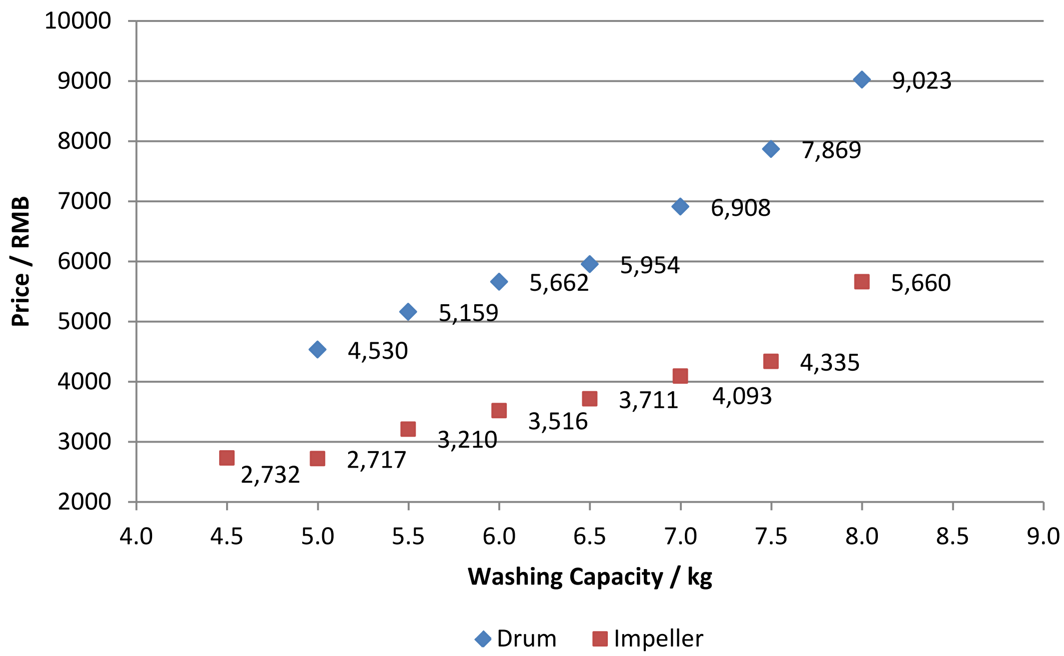
Assuming the lifetime of a washing machine is approximately 3,000 cycles, Figure 99 provides an estimate of overall lifecycle costs of impeller and drum washing machines to consumers, including average initial unit purchase price.

Figure 98: Estimated total cost per washing cycle by rated capacity



** Note that water heating energy is included in drum washing machines calculations but not impeller calculations, so the results are not directly comparable across technologies.*

Figure 99: Estimated total cost of lifetime ownership of washing machines to consumers



Doing a similar calculation using the average energy and water consumptions for washing machines based on their EET, again drum machines are over 50% more expensive per cycle (Figure 100).

Figure 100: Estimated total cost per washing cycle by energy efficiency Tier

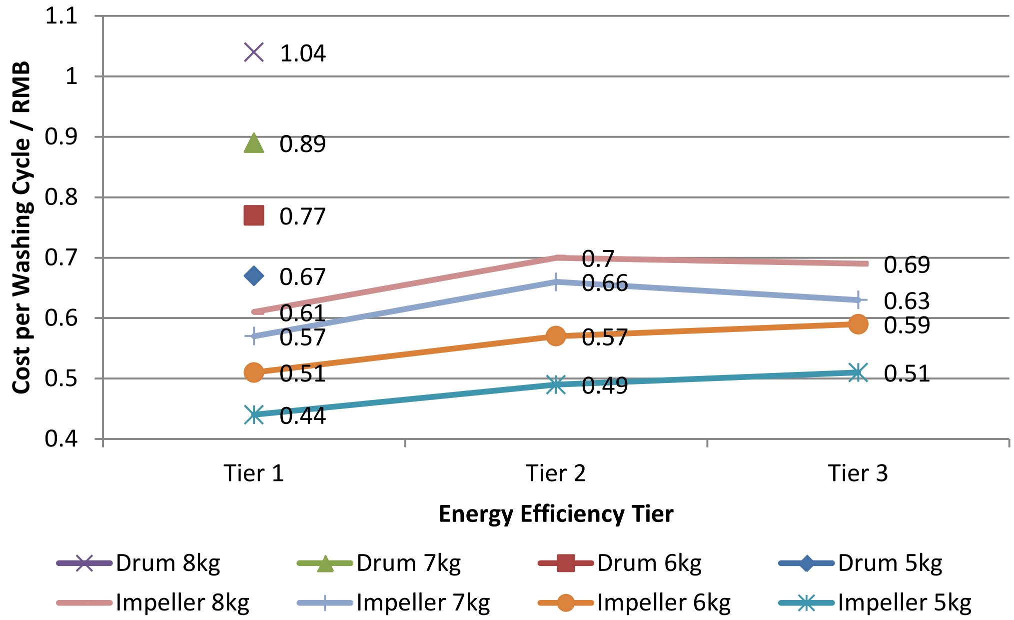
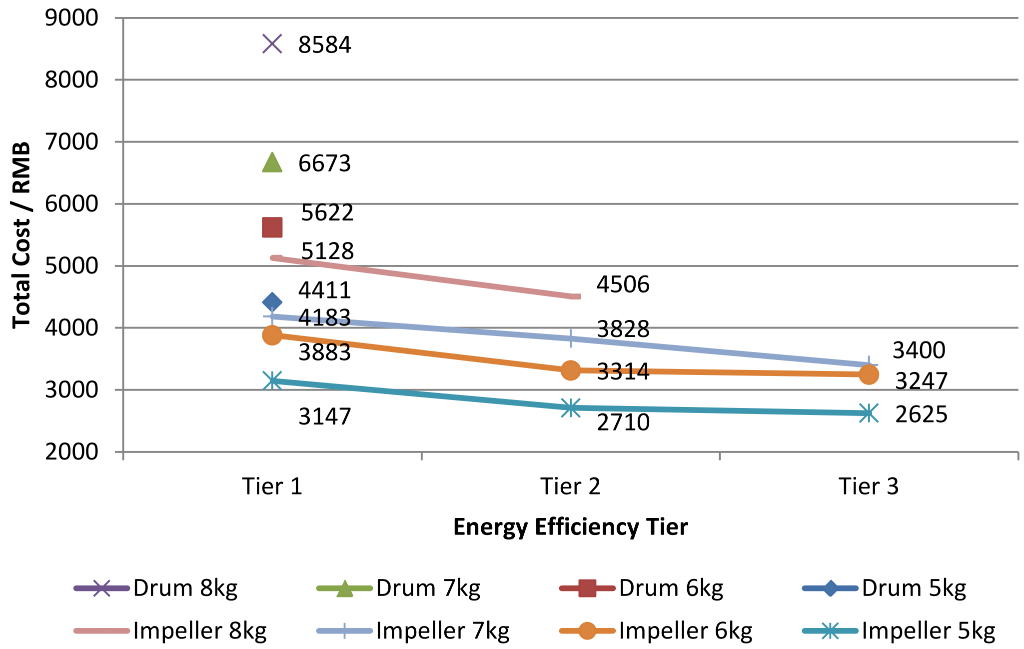


Figure 101 converts the cost per cycle values based on EET to total lifecycle cost. However, the same lifecycle cost of the washing machines after the subsidy (refer to section 7.3) is subtracted from the total lifetime cost of ownership. Clearly the subsidy is relatively marginal (around 5% of lifecycle cost) so it may be having little influence on the consumer purchase decision.

Figure 101 Life-time total cost and EET (after subsidy)



7.5 Conclusions and recommendations

Based on the analysis above, the authors recommend the following actions for policymakers on washing machines in China.

Revise the energy efficiency Tier thresholds[112]

Currently, all drum washing machines qualify for energy efficiency Tier 1, and the vast majority of impeller units are either Tier 1 or Tier 2 products, which is likely limiting ongoing improvements in washing machine performance. However, even before the consumer research or revisions to the test procedure proposed below are undertaken, there is currently a sufficient spread of water and energy efficiencies among products on the market to enable policymakers to:

1. Revise the current energy efficiency standard to increase the energy and water efficiency Tier requirements.

Such an action would:

- Provide consumers with more product differentiation based on the comparative efficiency of the products, allowing them to preferentially choose the more efficient units (of a particular type) at the time of purchase.
- Provide manufacturers whose products have now been categorized as Tier 4 and 5 with incentives to improve their product performance so as not to appear "inferior" compared with competitive models.
- Allow policymakers to more appropriately focus other policy support measures on only the most efficient products. For example, currently approximately 90% of impeller and around 50% of drum machines washing machines qualify for subsidy support (based on energy efficiency alone). The proposed energy efficiency standard revisions would allow policymakers to focus future subsidy or similar policy support at only the most efficient products in the market.

On the evidence available, there is no indication that such revisions to the performance thresholds would have any adverse impact on the purchase price of washing machines.

Conduct research into consumer usage patterns of washing machines

As there is very little publically available information on actual consumer usage patterns, it is not clear that the current washing machine test method represents true consumer use. For example, consumers *may* typically use cold water (i.e. ambient supply temperature) for cold washes, which is substantially below the 30^{o}C specified in the impeller test. Similarly, it is possible that drum machine consumers may also choose to wash in cold water. Hence, the declared energy consumption potentially bears little resemblance to the actual energy used by consumers and central hot water suppliers.

Therefore, policymakers may wish to:

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[112] During the preparation of this report, proposed revised EES requirements for both water and energy efficiency were issued. These are available at: http://www.sac.gov.cn/gybzyb/zxtz_843/201209/W020120912612574632217.doc

2. Undertake research into actual consumer use of washing machines to establish current typical wash temperatures, methods of water heating, size of loads, etc. This will provide the basic information to enhance the test methods to better reflect consumer use and assist policymakers in developing appropriate energy efficiency standards.

Revise the test methods for deriving washing machine energy consumption

Impeller and drum washing machines are tested at very different wash temperatures, and the water heating energy for drum machines is included in the total energy consumption calculation for the EES, but excluded for impeller washing machines. This very different derivation of energy consumption presents policymakers with a number of problems.

Firstly, the exclusion of water heating energy for units without integral water heating capability is misleading. While the consumer would not have to pay for the electrical energy to heat the water within the washing machine, the energy to heat the water is still being consumed somewhere, either by a household water heater of some kind, or by the central hot water supplier.

Secondly, even if the current tests are representative of washing machine use by the majority of consumers, the results of the test do not provide true comparisons of the efficiencies of washing machines of differing technologies to either consumers or policymakers. This prevents consumers from preferentially selecting the “most efficient” units at the point of purchase and policymakers from promoting them.

Therefore, policy makers may wish to consider:

3. Introducing technology-neutral tests. This would allow consumers to truly compare declarations of energy consumption, water consumption, and wash quality between machines types. Such a direct comparability of test results would also allow policymakers to more accurately develop energy efficiency standards and projections of national energy consumption, as well as identify the “most efficient” products for labeling and other policy purposes such as subsidy support.

   Depending on the outcome of the consumer research, it may be appropriate to develop a hybrid test that combines differing washing temperatures and load sizes and uses an average for the declaration, as is the case in Europe.[113] Alternatively, there could be two separate tests and labels for cold washes and warm washes, as used in Australia.

4. Examining the issue of standby power. As more drum machines are entering the market, it is possible that these machines will be installed in recessed areas with the associated probability that they will remain connected to the electricity supply for longer periods. This may result in significant off-mode (and potentially active) standby energy consumption which policymakers may want to include in future revision to the EES.

Require transparent reporting of washing machine performance

A very high proportion of product energy and water efficiency declarations are closely aligned with the energy efficiency standard Tier threshold requirements. This implies one of the following possibilities:

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[113] This would require the specification of a minimum wash performance

- Manufacturers have very accurate control of the design and production of washing machines and can deliver products that are just at the boundary conditions. If this is the case, any tolerances allowed for MEPR and labeling compliance are not required and can be removed, although test laboratory tolerances will still be required.
- Manufacturers are over-reporting the performance of their products; for example, declaring the lowest value of the EET Tier above that which their products qualify, either to appear more efficient on the label and/or to qualify for subsidy support. This may be a perfectly legitimate action if the tolerances of the declarations are sufficiently high, but again this implies that the tolerances for labeling declarations should be removed.
- Manufacturers are understating the performance of their products; for example, declaring the lowest value within the EET Tier for which their products qualify to ensure their products pass any verification testing undertaken by the regulator. From the policymaker point of view, this situation is problematic, as knowledge of the true performance of products is important when developing future EES and subsidy requirements and analyzing the potential impact of differing threshold levels.

At present there is no evidence to suggest which of the above scenarios may be causing the performance declarations to be just above EET and subsidy threshold levels, and there is certainly no evidence of manufacturer malpractice. However, there is sufficient evidence to recommend that policymakers should:

5. Insist that claims made on product registration and labeling must align with actual testing reports submitted to support the applications, and the test reports must be from a unit with typical performance for that model. Once declarations are accurate, further research can then be undertaken to establish whether tolerances (other than those required by test laboratories) may be tightened.

Section 8: Analysis of the Fixed Speed Air Conditioner Market and Product Performance

This section of the report examines the market, product performance and regulatory framework for fixed speed air conditioners. However, for obvious and practical reasons, some of the analysis in this section overlaps with that in the variable speed air conditioner section; therefore, readers are encouraged to consider both sections in parallel.

Fixed speed air conditioners, and air conditioners in general, are of importance as the installed number of units is rising. The energy saving projections developed as part of this analysis[114] indicate that the number of fixed speed air conditioners installed in China will rise from approximately 282 million in 2011 to 393 million in 2030. Under the business as usual scenario, the projected 2030 stock of fixed speed air conditioners would consume approximately 364 TWh per year of energy. This is particularly important as air conditioners tend to be used at hours of peak load and hence stress in the electricity generation and distribution system.

8.1 Product background

8.1.1 Production, sales and stock level

Rapid economic development and urbanization in China has led to sales of room air conditioner units (both fixed and variable speed) increasing significantly over the last ten years. However, as shown in Figure 102, this increase in sales has been somewhat sporadic. Sales of room air conditioners remained steady from 2007 to 2009, but rose rapidly in 2010 and 2011 as a result of the Household Appliances to Rural Areas, Old to New, and, especially, the Subsidy Program for Energy Efficient Products programs mentioned in the Policy Interventions section of the Introduction. However, in 2012, the annual sales fell back following the phase out of the incentive policies.

Fixed speed air conditioners dominated the market before 2009. However, variable speed air conditioners have been rapidly penetrating the market in recent years and the market shares of the two technologies were almost equal by 2012 (See Figure 103).

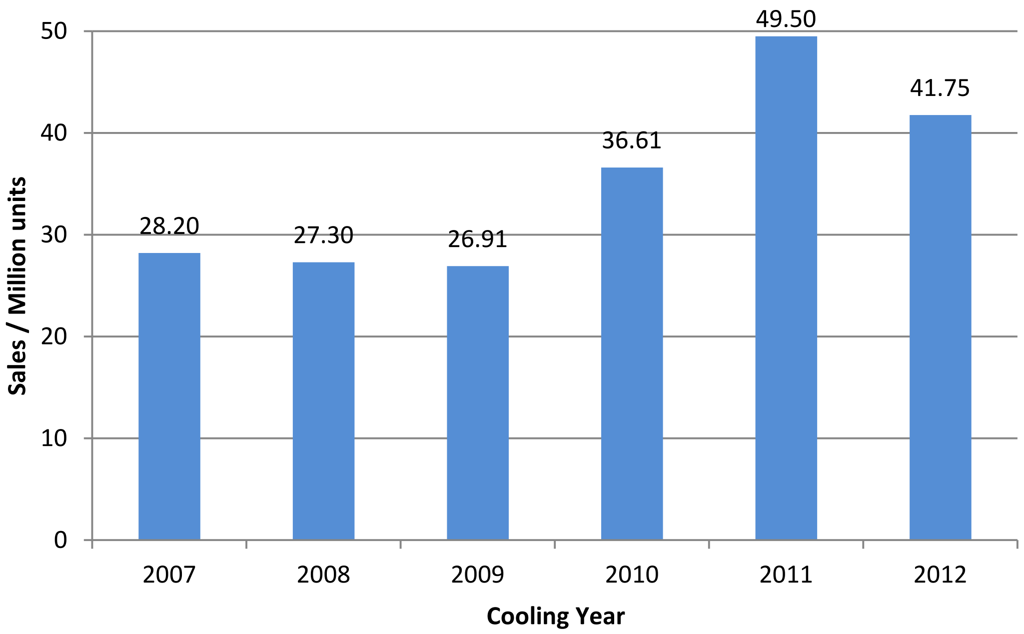
8.1.2 Usage patterns

Specific usage patterns for air conditioners vary significantly across China due to the large variations in climate. This study finds no public available information of such usage patterns. However, a performance metric of total use hours in both cooling and heating seasons is adopted by the Energy Efficiency Standard (EES) for variable speed drive air conditioners (GB 21455-2013). This analysis takes the same core assumptions as the basis of relevant analysis, i.e. the numbers of hours used for

[114] Energy Saving Potential (ESP) Study for Nine Appliances in China, CLASP 2013

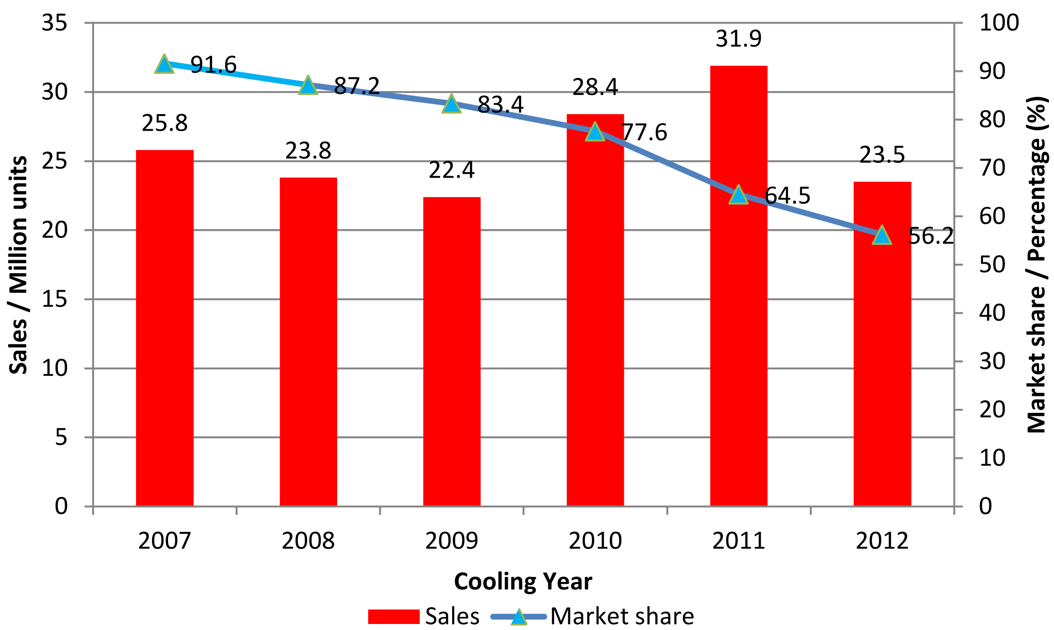
cooling and heating per year are 1136 hours and 433 hours respectively. Although these numbers are for variable speed drive air conditioners, it is believed that they could equally apply to fixed speed air conditioners.

Figure 102: Annual sales of room air conditioners in China



Data source: AVC Market Research, http://www.avc-mr.com/
Sales based on cooling year from September-August

Figure 103: Sales and market share of fixed speed air conditioners in China



Data source: AVC Market Research, http://www.avc-mr.com/

8.2 Regulation, Labeling and MEPS

8.2.1 Energy Efficiency Standard

The current energy efficiency standard (EES) for fixed speed air conditioners is GB12021.3-2010. When revised in 2010, the number of Energy Efficiency Tiers (EETs) in the standard was reduced from five to three. The energy efficiency ratio (EER) thresholds for each of the three cooling capacity ranges is detailed in Table 32. The lower threshold of Tier 3 defines the minimum energy performance requirement (MEPR) that all fixed speed air conditioners are required to meet to enter the market.

Table 32: Minimum efficiency requirements in fixed speed air conditioner standard (2010)

Cooling capacity range (W)	Tier 1 EER requirement	Tier 2 EER requirement	Tier 3 EER requirement
CC≤4500	3.6	3.4	3.2
4500<CC≤7100	3.5	3.3	3.1
7100<CC	3.4	3.2	3.0

8.2.2 Energy labeling of fixed speed air conditioners

Air conditioners were the first product to be labeled under the China Energy Label Program. The first labeling requirement came into force in 2005 and was revised in 2010 to align with the revisions to the EETs (i.e. reducing them from five to three).

The label, shown in Figure 104, displays basic product identification information, the three EETs as defined in the EES, and an indicator showing the efficiency level achieved by the product, plus the EER value and the rated cooling capacity and power input.

Figure 104: China Energy Label for fixed speed air conditioners

8.2.3 Test Method

GB/T 7725 - 2004 "Room air conditioners" is the testing method for air conditioners and defines the performance indicators. However, the metrics used for the regulation of the energy performance of fixed and variable speed air conditioners are different. The EER is used to measure the performance of fixed speed air conditioners, while a seasonal energy efficiency ratio (SEER) is used for the performance of variable speed units.

8.3 Subsidy Program

Fixed speed air conditioners were one of the first products to be subsidized under the Subsidy Program for Energy Efficient Products started in 2009. The levels of subsidy available in 2009/10 and 2010/11 are shown in Table 33. In the two years from 2009 to 2011 the subsidy stimulated significant efficiency developments in the fixed speed air conditioning market, allowing the MEPR value under the previous EES to move from Tier 5 to Tier 2 and facilitating a revision of the EES to the current 2010 standard.

Table 33: Fixed speed air conditioner subsidy standards

Cooling capacity (W)	June 2009 to May 2010[115] (RMB/Unit)		June 2010 to May2011[116] (RMB/Unit)	
	Tier 1	Tier 2	Tier 1	Tier 2
CC≤2800	500	300	200	150
2800<CC≤4500	550	350	200	150
4500<CC≤7100	650	450	250	200
CC>7100	850	650	/	/

Both fixed and variable speed air conditioners are included the latest subsidy program from July 2012 to May 2013. The levels of subsidy support in this round of the program are shown in Table 34.

Table 34: 2012 fixed and variable speed air conditioner subsidy levels

Cooling capacity (W)	Fixed speed air conditioner (RMB/Unit)		Variable speed air conditioner (RMB/Unit)	
	Tier 1	Tier 2	Tier 1	Tier 2
CC≤4500	240	180	300	240
4500<CC≤7100	280	200	350	280
CC>7100	330	250	400	330

[115] http://www.sdpc.gov.cn/zcfb/zcfbqt/2009qt/W020090525657958778890.pdf
[116] http://www.sdpc.gov.cn/zcfb/zcfbqt/2010qt/t20100511_346219.htm

8.4 Product analysis

The analysis examines the performance, energy and market related properties outlined in Table 35. In addition to the generic cautions provided in the Approach and Methodology section of the Introduction, readers should note that not all performance and other parameters were available for all models identified as available in the market. Where not all products are included in a particular analysis, this is noted in the associated text. However, it has not been possible to estimate the bias this has introduced into the analysis for any given parameter.

Table 35 Overview of data used for fixed speed air conditioner analysis

Data type	Notes	
Total Number of Models*	CC**≤2800	587
	2800<CC**≤4500	604
	4500<CC**≤7100	360
	7100<CC**	325
Cooling capacity	Range: 2200 - 12600	
Energy efficiency Tier	Range: 1 - 3	
Energy efficiency ratio (EER)	Range: 3 - 4.1	
Price/RMB	Range: 1399 - 15099	
Heating capacity	Range: 2500 - 14000	
Co-efficiency of the performance (COP)	Range: 2 - 4.89	

**Note the EES does not use the CC*≤2800 category. However, given the large number of models in this group, this extra categorization assists in product analysis.

***CC= cooling capacity*

8.4.1 Market distribution and types of fixed speed air conditioners

Fixed speed air conditioners can be segmented into two product types, wall mounted and stand-alone floor units, or "stand." Wall mounted air-conditioners are mainly used in smaller rooms, such as bedrooms, and the stand-alone units are used in bigger rooms, such as living rooms and some offices and restaurants. The market share of the two types of conditioners in July 2012 is shown in Figure 105.

The market for fixed speed air conditioners can also be segmented into units that provide cooling only and units that provide both heating and cooling. As Figure 106 shows, in July 2012, 75% of fixed speed air conditioners available on the market had both cooling and heating functions (this compares with 97% of variable speed units).

Figure 105: Share of fixed speed air conditioner types available in the market (July 2012)

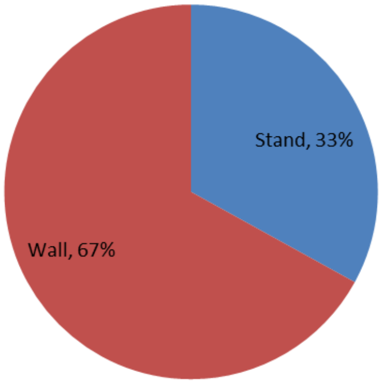
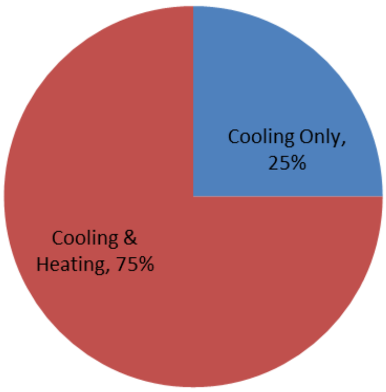
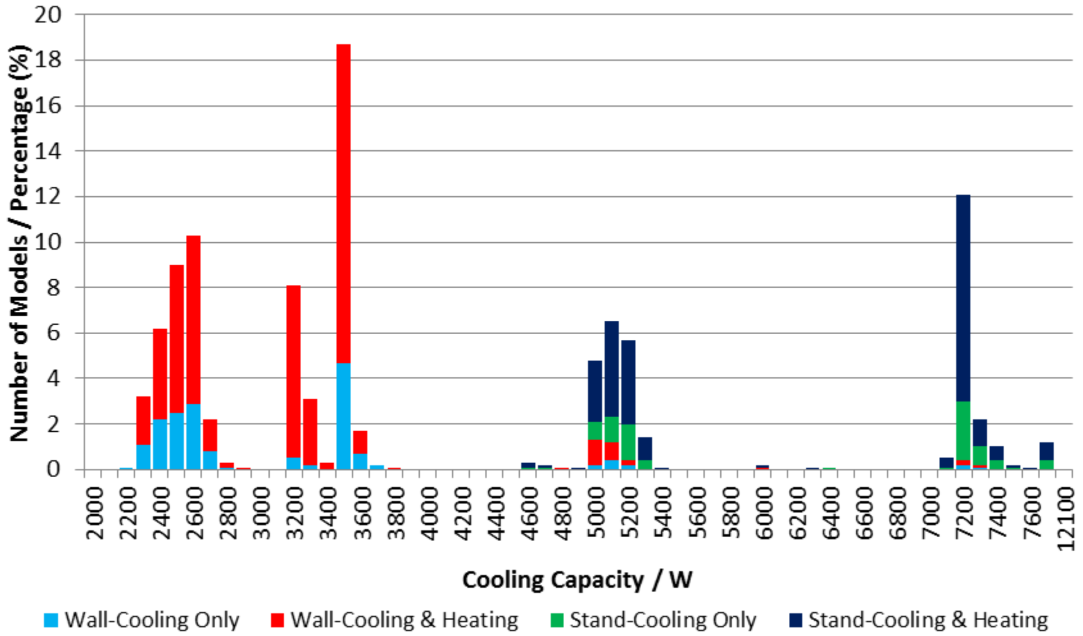


Figure 106: Share of cooling only, and heating and cooling fixed speed air conditioners available in the market (July 2012)



Cooling capacity is the main indicator of the ability of the air conditioner. The market distribution of products centers around four distinct cooling capacities: 2600W, 3500W, 5000W, and 7200W. As shown in Figure 107, the 2600W and 3500W segments are made up entirely of wall mounted units, with stand-alone units dominating the two larger capacities. There are almost no wall mounted units with capacity greater than 5000W.

Figure 107: Fixed speed air conditioner cooling capacity distribution (July 2012)



Although heating capacity requirements are not included in the EES, 75% of models have a heating function, as noted previously. However, as Figure 108 shows, there is a linear correlation between the heating and cooling function, with the heating capacity being slightly higher than the cooling capacity. Hence the distribution of available models by heating capacity group around slightly higher capacity levels (approximately 3000W, 4000W, 5800W and 8000W) as shown in Figure 109.

Figure 108: Correlation between the cooling and heating capacity of fixed speed air conditioners (July 2012)

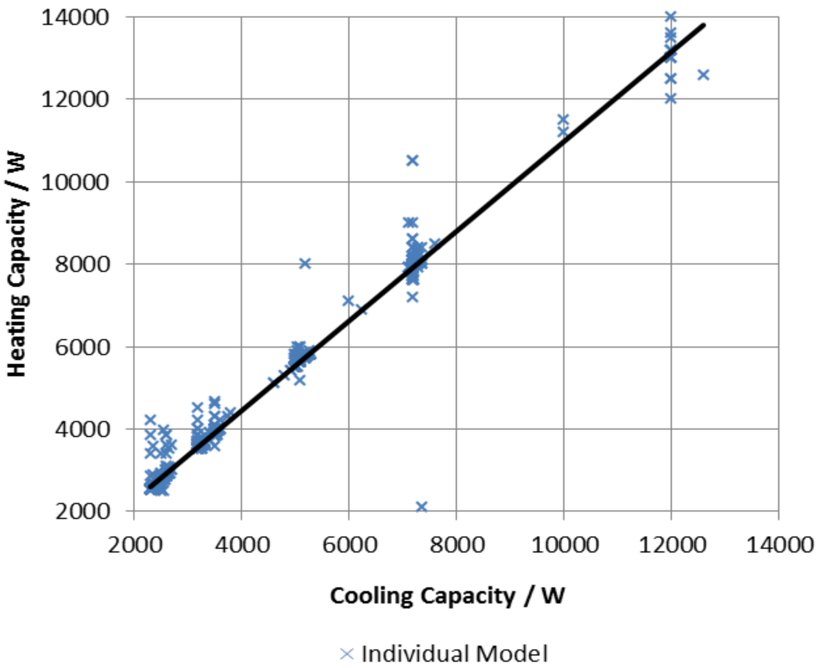
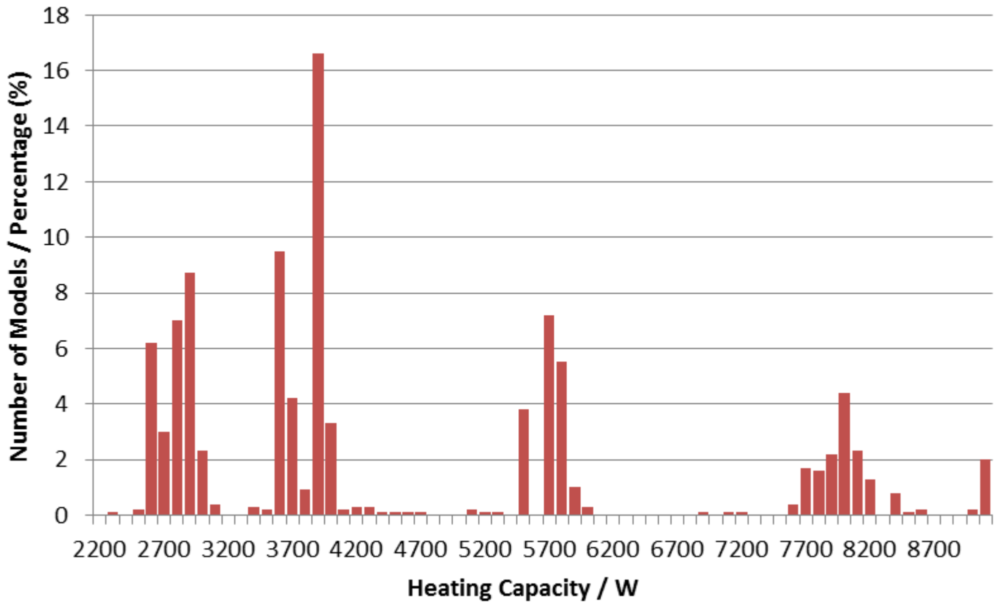


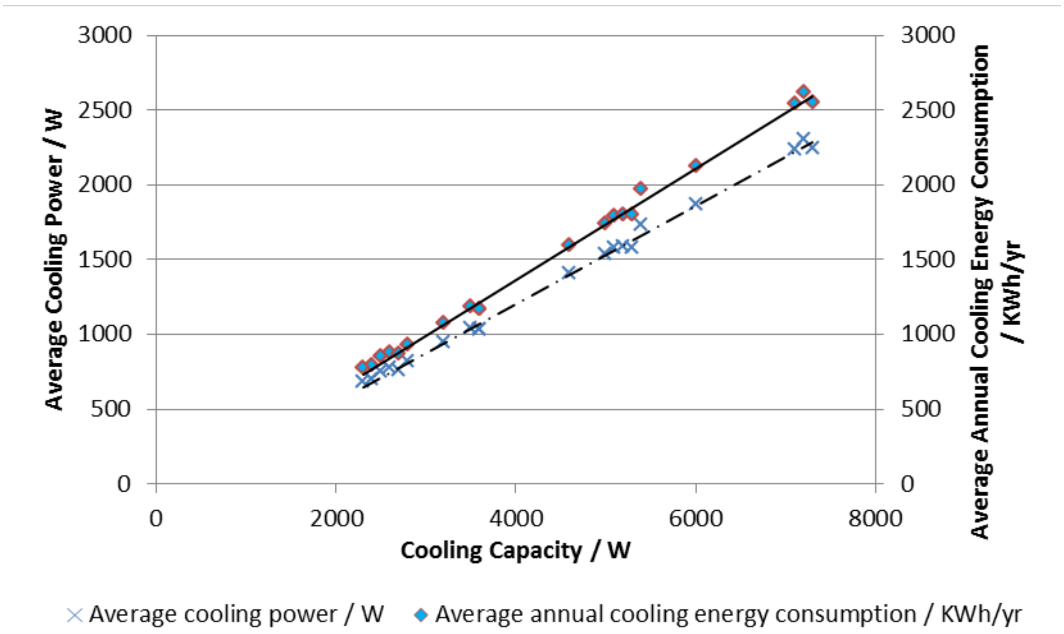
Figure 109: Fixed speed air conditioner heating capacity distribution (July 2012)



8.4.2 Relationship of power and energy consumption in fixed speed air conditioners

As would be expected, the power consumed by fixed speed air conditioners increases with the cooling capacity in a broadly linear fashion. Consequently, cooling energy consumption is also linear. Figure 110 illustrates the cooling power and energy consumption relationships to cooling capacity, using 1,136 hours for cooling (as defined in the EES).

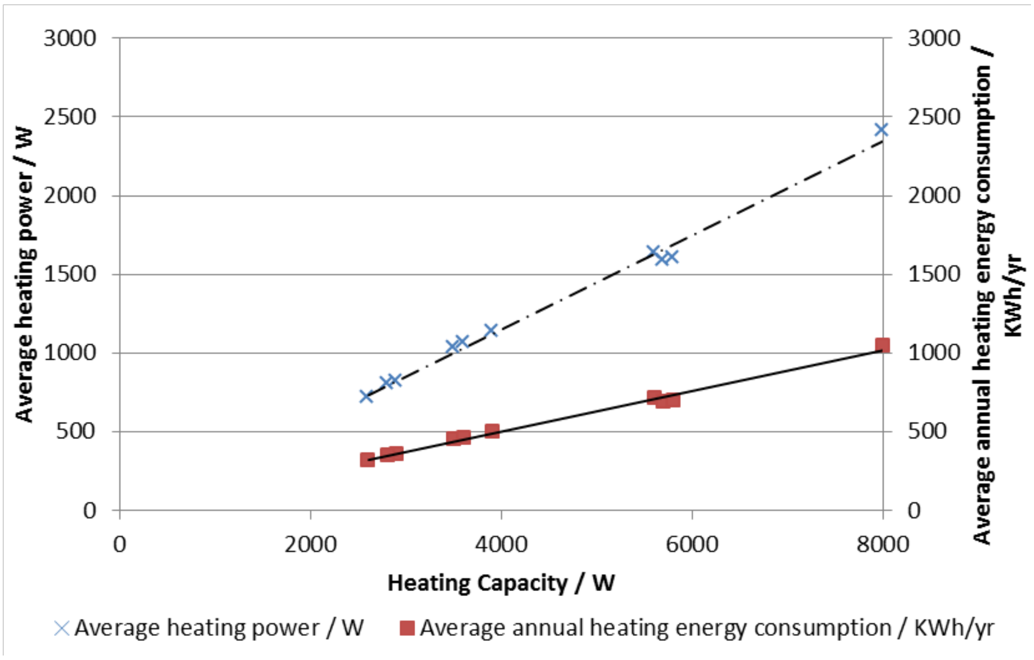
Figure 110: Relationship of cooling capacity to average cooling power and energy consumption (July 2012)



** Using cooling time of 1136 hour per years as set as the annual cooling season by GB 21455 – 2008.*

Figure 111 shows a similar relationships for heating power and energy consumption related to heating capacity. Heating energy consumption is based on 433 hours, as suggested in a new draft GB 21455 - 20XX standard for variable speed air conditioners[117].

Figure 111: Relationship of heating capacity to average heating power and energy consumption (July 2012)



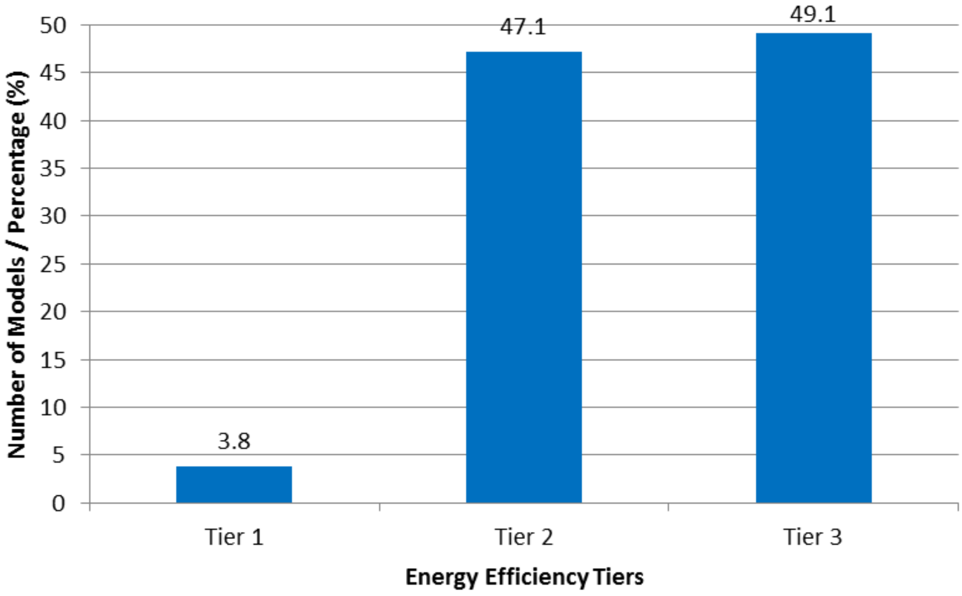
** Using 433 hours annual heating based on GB 21455 - 20XX, which introduces the heating season (currently a draft for revision).*

8.4.3 Market distribution of fixed speed air conditioners related to energy efficiency

At the time of data collection in July 2012, two years had passed since the implementation of GB12021.3 in 2010. However, the share of models available registered as Tier 1 remained very low (4.1%) with the remaining products evenly distributed between Tiers 2 and 3 as shown in Figure 112. As both Tier 1 and 2 products are eligible to receive subsidy support (refer to section 9.3), this means over 50% of products available in the market are eligible for subsidy support.

[117] Refer to section 9.3.1

Figure 112: Fixed speed air conditioner energy efficiency Tier distribution (July 2012)



Examining the breakdown further, as shown in Figure 113, most Tier 1 air conditioners are from the low cooling capacity groups. In the lower cooling capacity product groups, the share of Tier 2 air conditioners is higher than Tier 3, while in the high cooling capacity product groups, the share of Tier 3 air conditioners is higher than that of Tier 2.

Figure 113: Fixed speed air conditioner EET distribution by cooling capacity (July 2012)

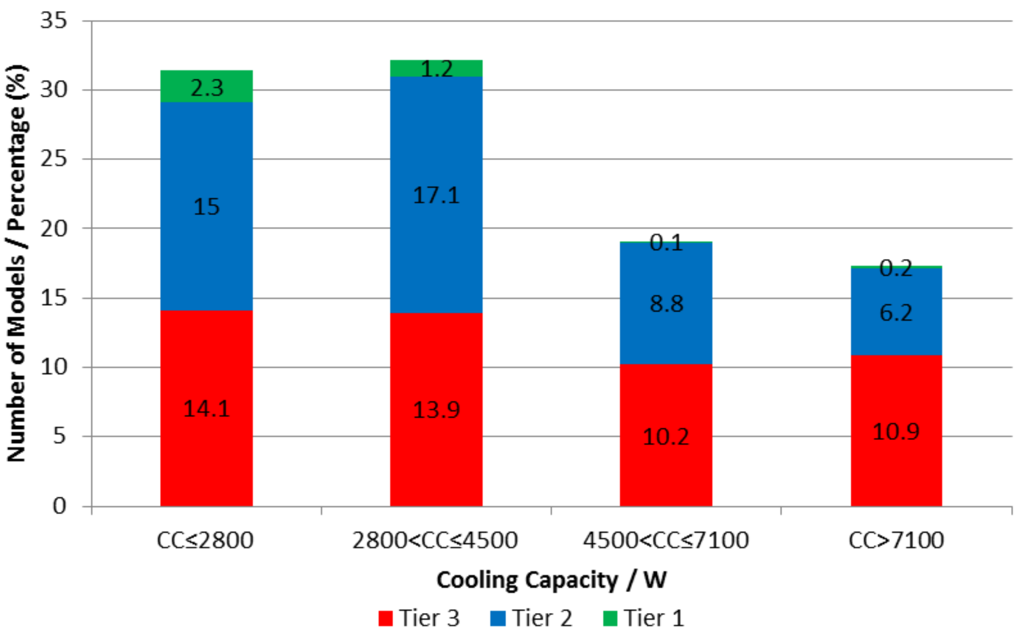


Figure 114 shows the distribution of fixed speed air conditioner by EER and cooling capacity.

Figure 114: Distribution of fixed speed air conditioner by energy efficiency ratio and cooling capacity (July 2012)

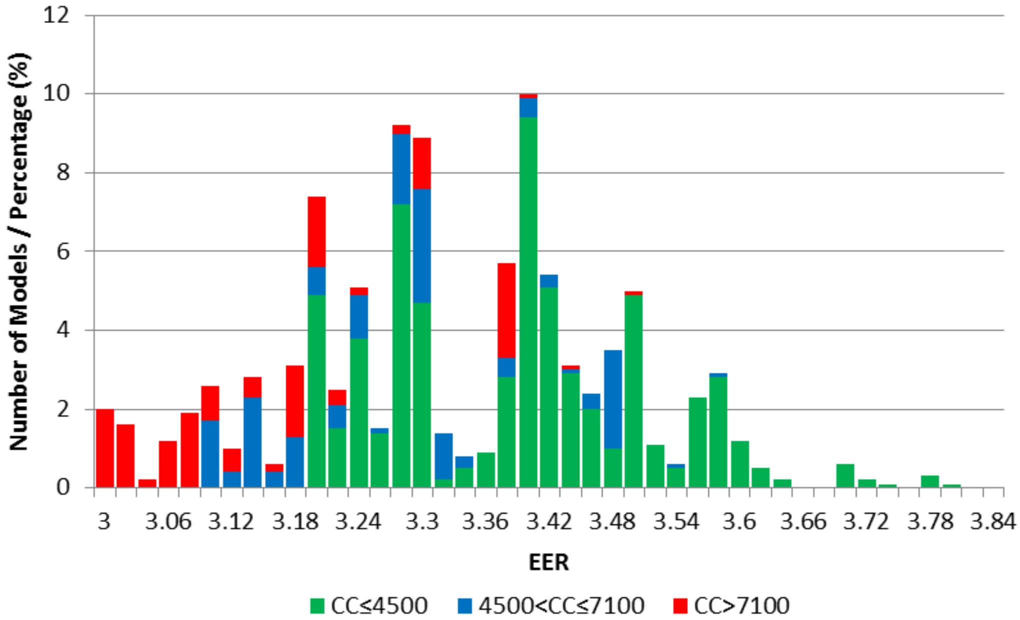


Figure 115 and Figure 116 respectively show a further breakdown of the distribution of products by energy efficiency Tier based on the average EER by capacity range and, for the Tier 1 and 2 products, the distribution of individual product EERs within the Tier bands.

Figure 115: Energy efficiency Tier and corresponding average EER for each capacity range for fixed speed air conditions (July 2012)

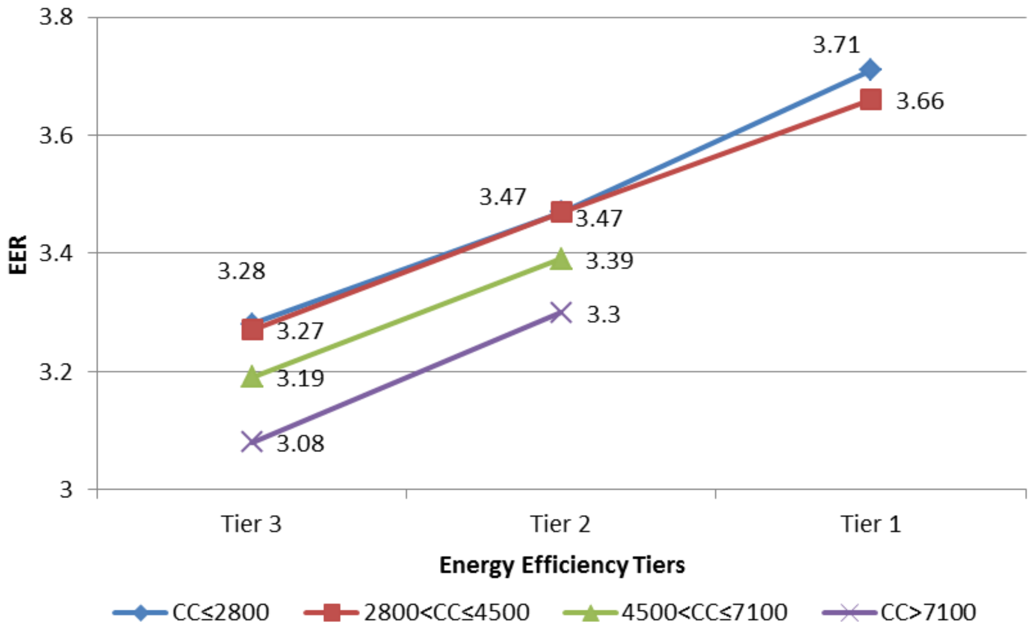
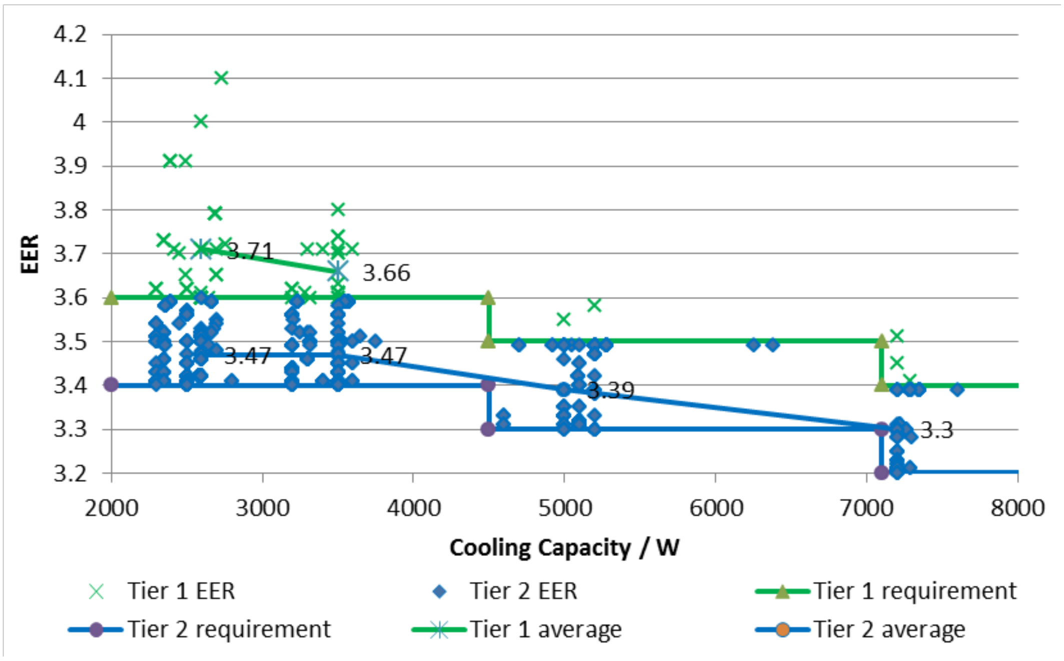


Figure 116: Energy efficiency Tier thresholds, individual model EER and average EER for energy efficiency standard Tier 1 and 2 fixed speed air conditions (July 2012)



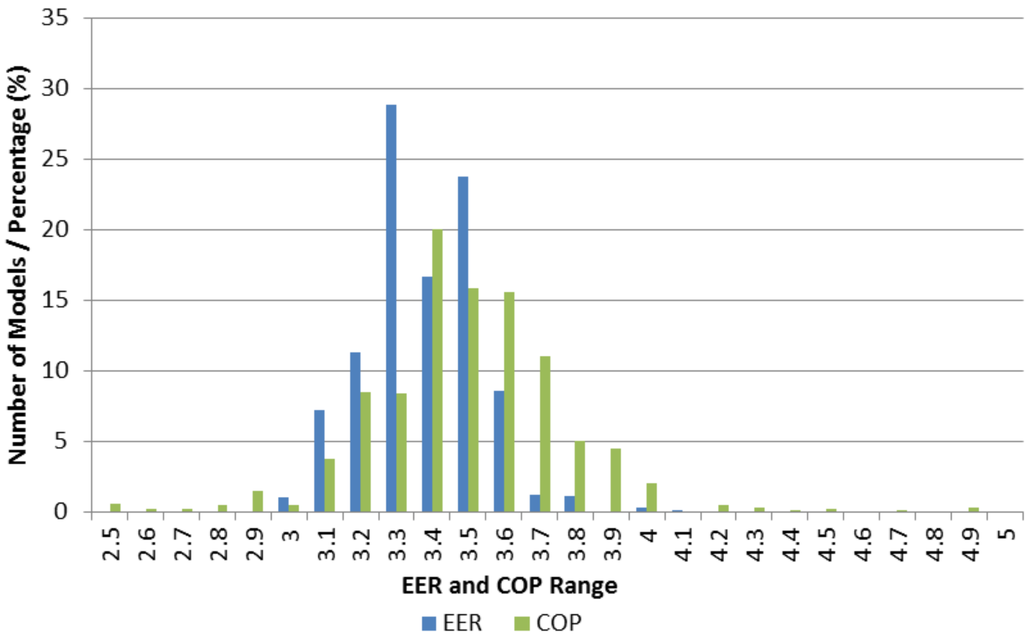
Given the broad distribution of products, it appears possible for policymakers to revise the current energy efficiency standard to remove some of the worst performing products within Tier 3 from the market, and move the worst-performing products within Tier 2 to Tier 3. This can be achieved by adopting the revised EET boundaries as proposed in Table 36. Such action would not affect the proportion of Tier 1 products. This revision would not only improve the overall average efficiency of new fixed speed air conditioners, but would also reduce the number of (currently) less efficient Tier 2 models that are receiving subsidy support. Should policymakers wish to be bolder still, they may consider only offering subsidy support to products in the revised Tier 1 category, thus encouraging movement of products to the higher efficiency categories.

Table 36: Potential revisions to the current minimum efficiency requirements for fixed speed air conditioners

Cooling capacity range (W)	**Tier 1 EER requirement**	**Tier 2 EER requirement**	**Tier 3 EER requirement**
CC≤4500	3.7	3.5	3.3
4500<CC≤7100	3.6	3.4	3.2
7100<CC	3.5	3.3	3.1

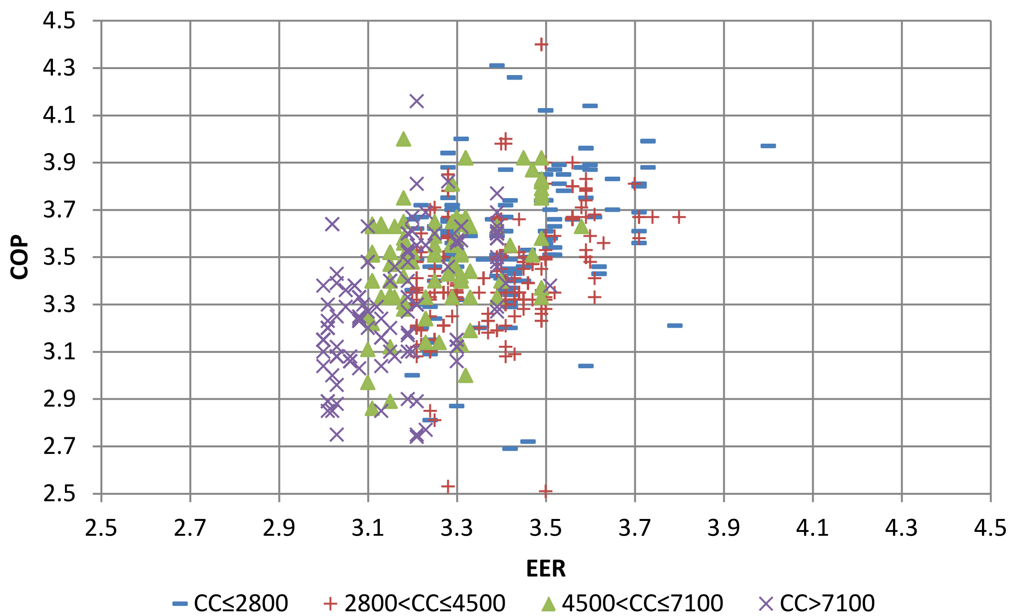
Although the heating efficiency of fixed speed air conditioners is not covered by the current EES, the co-efficiency of the performance (COP) can be calculated by the heating capacity and power. The COPs have a range between 2.5 and 5, with a normal distribution similar to that of the EERs.

Figure 117: Distribution of fixed speed air conditioners by co-efficient of performance and EER



The relationship between EER and COP is not completely regular, although generally the higher the EER of the air conditioners, the higher COP. Again, the higher the cooling capacity, the lower the COP – in line with the lower the EER.

Figure 118: Relationship between co-efficient of performance and EER for fixed speed air conditioners



8.4.4 Relationship of price to other fixed speed air conditioner parameters

As demonstrated in Figure 119 below, there is a close relationship between increasing cooling capacity and the price of fixed speed air conditions. Where units also have heating capacity, the price is slightly higher, but the relationship of price to cooling capacity remains very similar.

Figure 119: Relationship of average price to fixed speed air conditioner cooling capacity (July 2012)

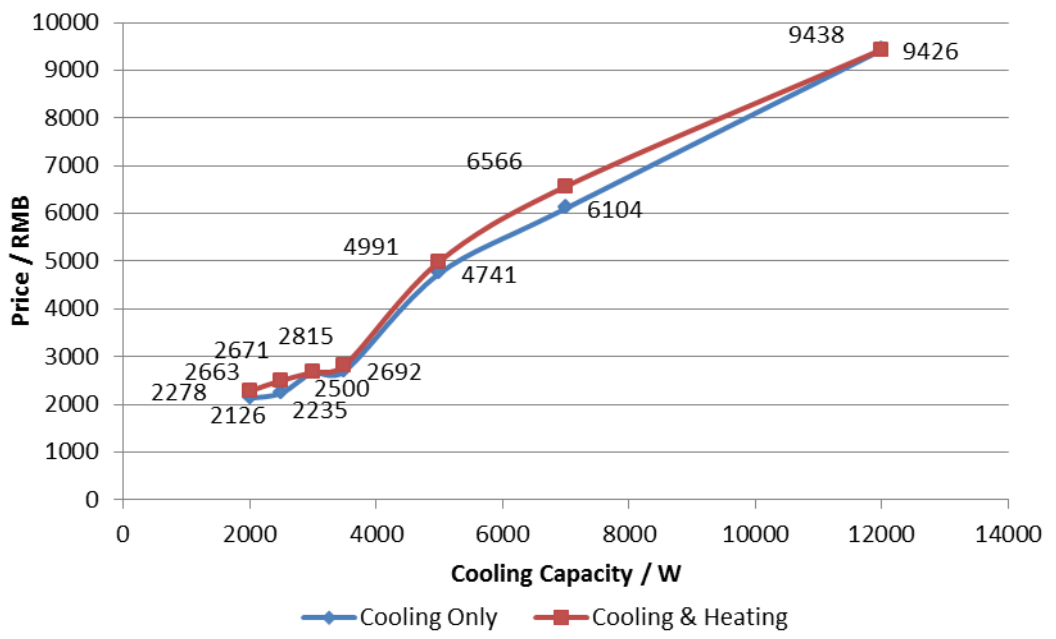
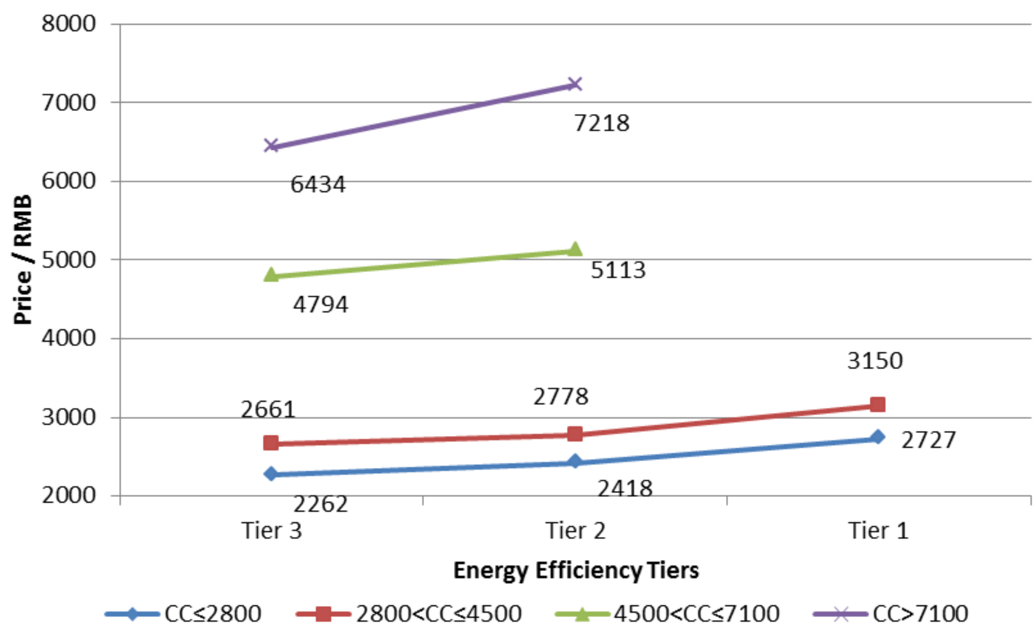


Figure 120 shows the relationship between energy efficiency Tier and average price for each of the cooling ranges defined in the EES. There is clearly a rise in average price between efficiency Tiers within each cooling range. The difference between Tiers 1 and 2 is slightly higher than the difference between Tiers 2 and 3 for smaller cooling ranges. The average price difference between Tier 3 and Tier 2 or 1 is 390 RMB, which means that inefficient products are generally 11% cheaper than the efficient ones.

One of the aims of the current subsidy is to bridge this price differential between the lower and higher efficiency products. As shown in Table 34, the current subsidy standard is based on the cooling capacity and EETs (from 180 RMB to 330 RMB), which appear slightly low to bridge the Tiers 3-2 price increase, and particularly the jump to Tier 1. Therefore, policymakers may wish to consider increasing the subsidy for Tier 1 products to increase the incentive for manufacturers to supply products in this group. This may have the additional benefit of increasing competition among products in this higher Tier and thus has the potential to bring down market prices.

Figure 120: Relationship of average price of fixed speed air conditioner to energy efficiency Tier (July 2012)

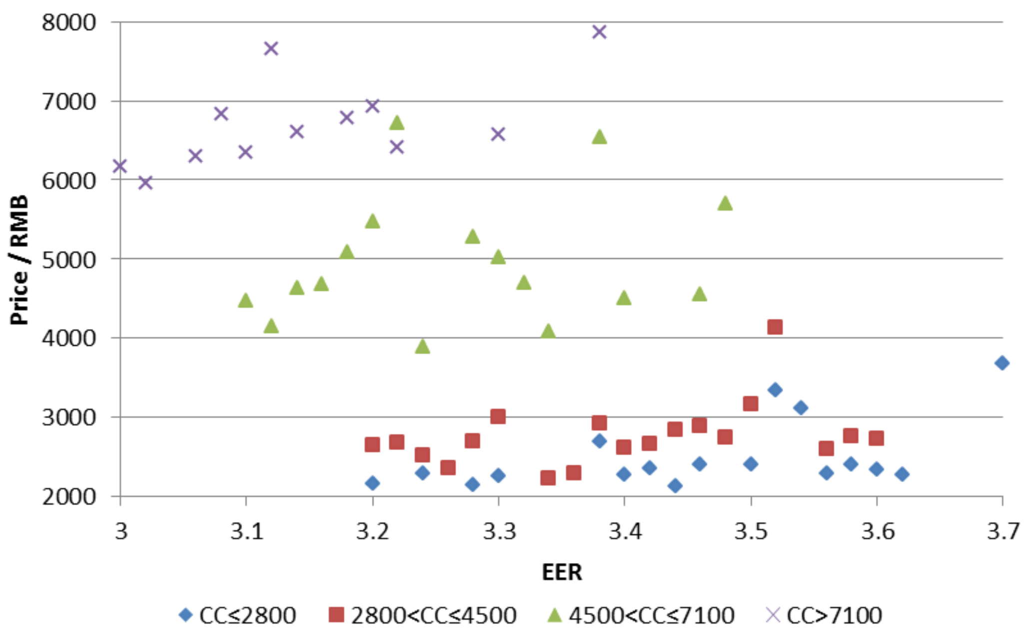


**Note that there is no price for Tier 1 products in the high cooling capacity range due to the small number of models available in the market*

8.4.5 Relationship of price to EER and cooling capacity of fixed speed air conditioners

As the energy efficiency Tiers are derived from the EER for each capacity range, then in line with Figure 120 **Error! Reference source not found.**, generally the price of fixed speed air conditioners increases with the higher EER, as shown in Figure 121.

Figure 121: Relationship of the price of fixed speed air conditioner to EER (July 2012)

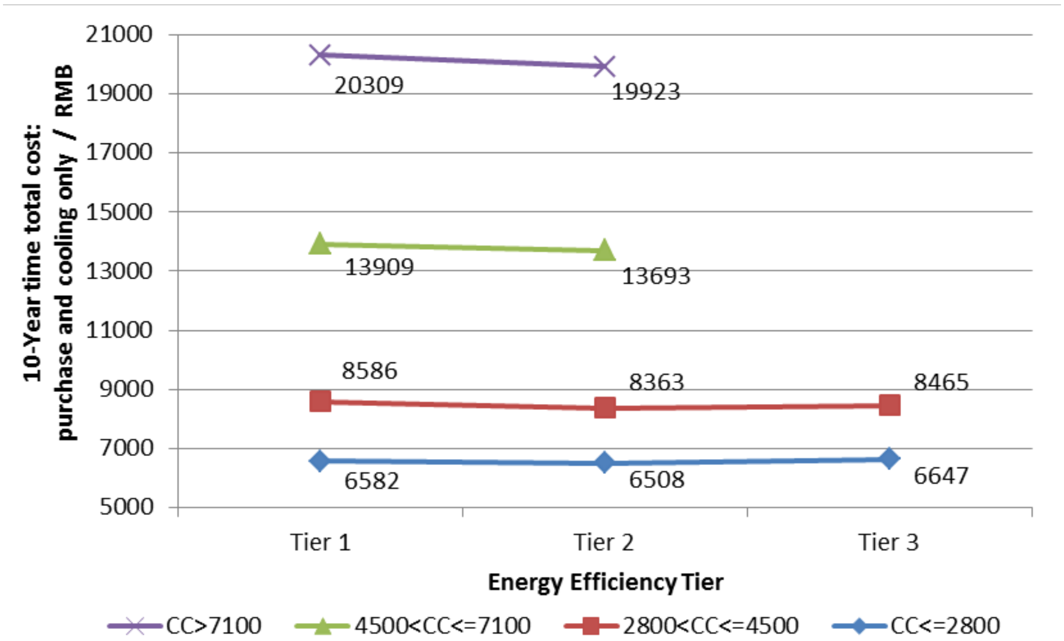


8.5 Cost and benefit analysis

Based on an expected lifetime of ten years, the lifetime ownership of an air conditioner can be calculated as the sum of the purchase cost plus ten years of operation cost based on the rated capacity for cooling and/or heating.

The lifetime cost of ownership (based on cooling only) for fixed speed air conditioners of differing capacity for each EET is shown in Figure 122.

Figure 122: Ten-year lifetime cost of fixed speed air conditioners based on cooling only for differing capacity and EETs only (July 2012)

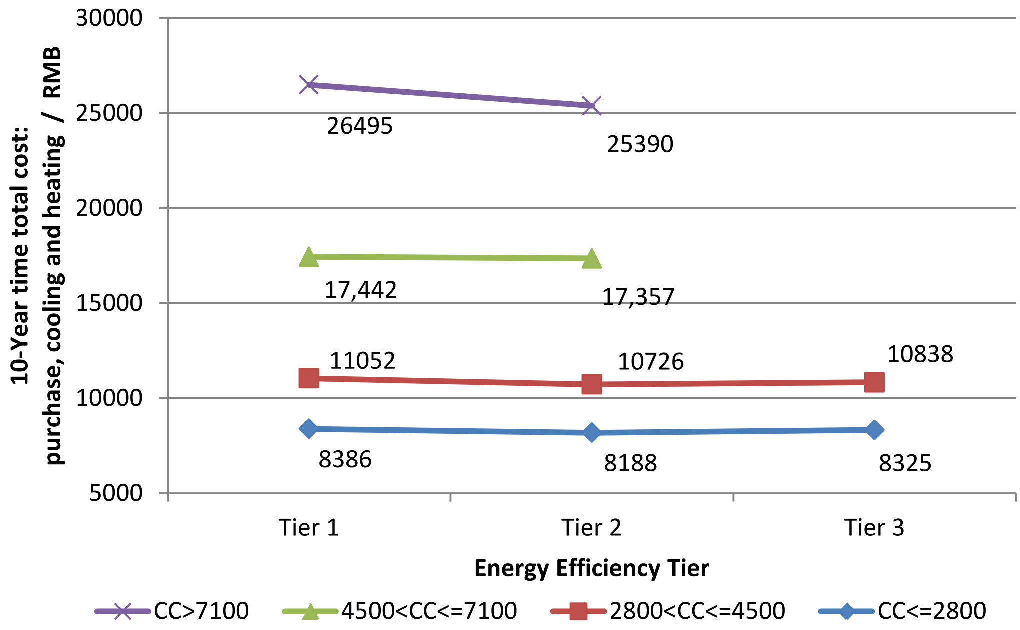


** Using cooling time of 1136 hour per years as set as the annual cooling season by GB 21455 – 2008.*
*** Assumed electricity price: 1kWh = 0.5 RMB.*

Based on cooling only, the variations in lifetime cost of ownership between EETs is quite small and within a few hundred RMB in all capacity ranges. The lifetime cost of ownership is generally lower for higher efficiency products (e.g. Tier 1 and Tier 2 products). However, for the smaller capacity ranges, Tier 2 products have lower lifetime costs than Tier 1 products. Adding the subsidy into calculation increases the lifetime cost advantage of the Tier 2 products.

When adding the heating functions into the cost calculation, as shown in Figure 123, the total lifetime cost of cooling and heating still renders Tier 3 products as the most expensive, but by only 330 RMB on average, approximately 2% of the total cost.

Figure 123: Ten year total lifetime cost of ownership for fixed speed air conditioners based on the combined cost of purchase, cooling, and heating (July 2012)



** Using cooling time of 1136 hour per years as set as the annual cooling season by GB 21455 – 2008, and 433 hours annual heating based on GB 21455 - 20XX, which introduces the heating season (currently a draft for revision).*
*** Assumed electricity price: 1kWh = 0.5 RMB.*

8.5.1 Lifetime cost and benefit comparison of fixed and variable speed air conditioners

To compare the lifetime cost of ownership of fixed and variable speed air conditioners, it is first necessary to understand the difference in initial purchase price. Figure 124 illustrates the differences in purchase price of the two products in July 2012, and shows that variable speed air conditioners are approximately 40% more expensive than fixed speed units of equivalent cooling capacity.

As noted previously, within China, the energy efficiency performance of fixed and variable speed air conditioners is measured by different indicators, EER and SEER respectively. However, using the 1136 hour annual cooling season defined in GB1455–2008, the cooling energy consumption of fixed speed air conditioners can be calculated based on rated power, and the energy consumption of variable speed air conditioners can be similarly calculated since the cooling season power consumption as declared on the label. Using these base annual energy consumptions, Figure 125 shows comparison of lifetime cooling costs between variable and fixed speed air conditioners over a ten year life.

Figure 124: Comparison of purchase price for fixed and variable speed air conditioners (July 2012)

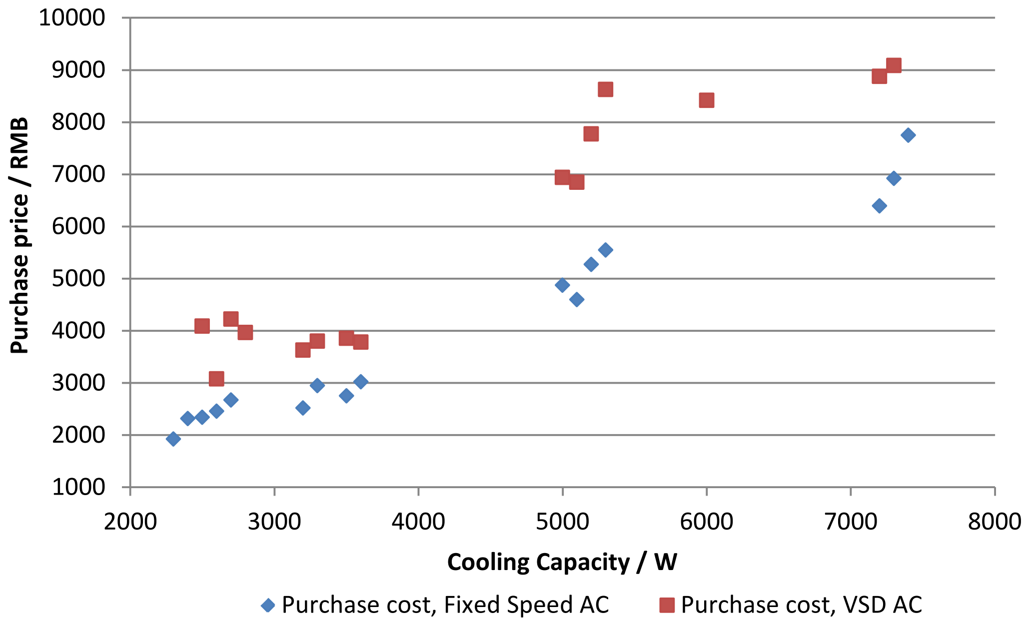
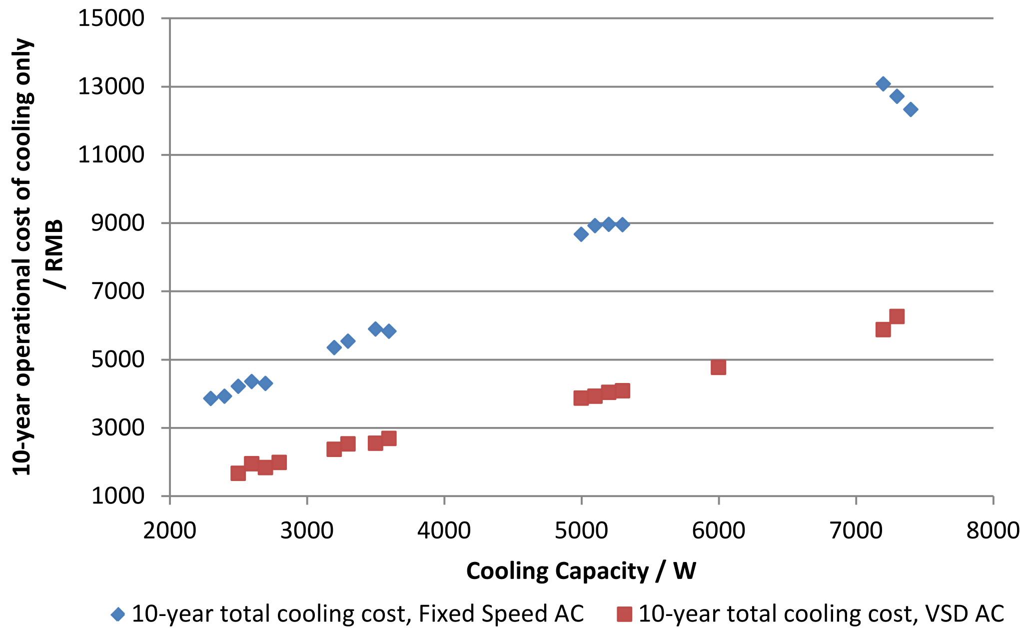


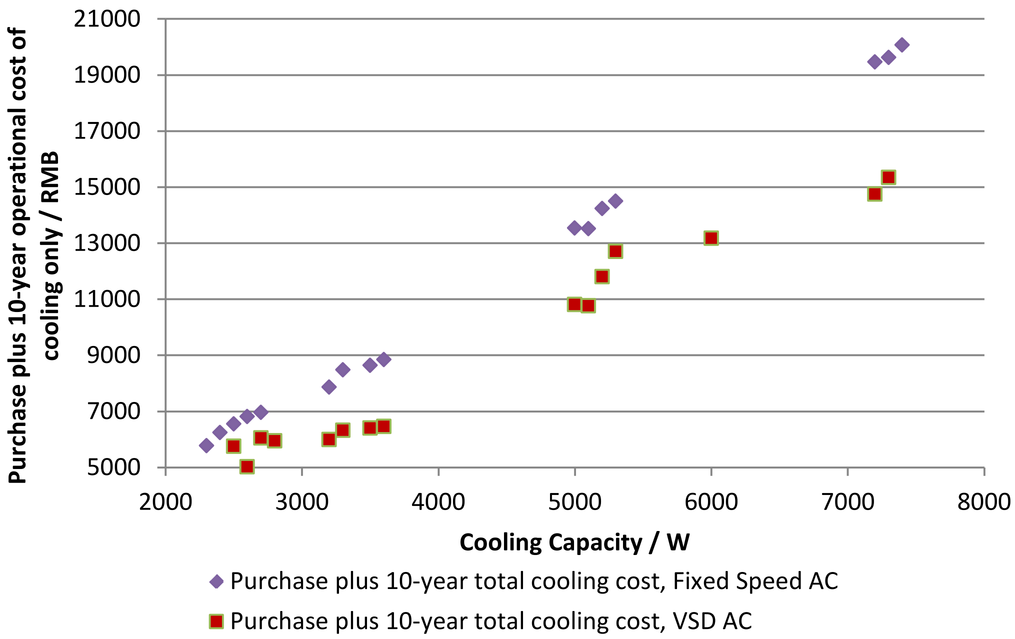
Figure 125: Ten year lifetime cost for fixed and variable speed air conditioners based on cooling only (July 2012)



** Using cooling time of 1136 hour per years as set as the annual cooling season by GB 21455 – 2008.*
*** Assumed electricity price: 1kWh = 0.5 RMB*

As can be seen, the average ten years cooling cost of the variable speed air conditioners is much lower, by approximately 2.3 times, than that of the fixed speed air conditioners of the same capacity. When the purchase cost of the two air conditioner types are added to the ten year cooling costs, it becomes clear that the lifetime cost (for cooling only) of variable speed air conditioners is significantly lower than that of fixed speed units, particularly at higher cooling capacities. This is depicted in Figure 126.

Figure 126: Comparison of ten year lifetime cost for fixed and variable speed air conditioners based on purchase and cooling costs only (July 2012)



** Using cooling time of 1136 hour per years as set as the annual cooling season by GB 21455 – 2008.*
*** Assumed electricity price: 1kWh = 0.5 RMB.*

8.6 Conclusions and recommendations

From the analysis above, policymakers may wish to consider the following measures.

Revise the energy efficiency standard and label to include heating functions

Currently the energy efficiency standard and associated label for fixed speed air conditioners are presenting a distorted picture to the market. In particular, while 75% of fixed speed air conditioners have a heating function, the energy consumption impact of the heating function is not included in information given to the consumer on the energy label.

Moreover, the exclusion of this information, combined with the difference in the measurement of product performance, makes it almost impossible for consumers and retailers to compare the performance of fixed and variable speed air conditioners. This *may* lead to consumers buying products that appear more efficient than competing products, but ultimately may not be so and potentially use more energy.

Therefore, policymakers may wish to consider:

1. Revising the metric by which fixed speed air conditioners are measured. The use of SEER would have the dual benefits of including the energy consumption of the heating element of the product and making the performance of fixed speed air

conditioners more directly comparable to the performance of variable speed units.

2. Should the standard be revised, the label should also be revised to reflect the new information. In particular, it is recommended that cooling capacity, heating capacity and annual energy consumption values are included on the label.

Increase the stringency of the energy efficiency Tiers

While the revision to the energy efficiency standard in 2010 reflected the leap in product energy efficiency brought about by the subsidy support over the preceding two years, there has been little further product development since this date. Consequently, the distribution of fixed speed air conditioners within the energy efficiency Tiers remains heavily skewed to Tier 2 and 3 products, with few products in Tier 1. As the revision of the performance metric will take some time for products to be tested and registered, policymakers may wish to:

3. Immediately increase the stringency of the current Tier thresholds as proposed in section 8.4.3 and Table 36.

Such a revision would remove the worst performing products within Tier 3 and move the poorer performing products within Tier 2 to Tier 3 without significantly affecting the proportion of Tier 1 products. Further, the revision would not only improve the overall average efficiency of new fixed speed air conditioners, but would also reduce the number of (currently) less efficient Tier 2 models receiving subsidy support.

Revise air conditioner subsidies

Currently, the energy efficiency subsidy is supporting a large number of high energy consuming-fixed speed air conditioners (relative to the variable speed products of equivalent capacity). Adopting the revision to the energy efficiency standard outlined in above would reduce the number of air conditioners qualifying for this subsidy. However, policymakers may also wish to consider:

4. Only subsidizing energy efficiency Tier 1 fixed speed air conditioners (with a larger subsidy of approximately 400RMB to bridge the current purchase price differential), thus encouraging manufacturers to improve product performance and increasing number of Tier 1 products available to consumers. This may have the added benefit of increasing competition and reducing the average Tier 1 product price.

5. Completely removing the subsidy for fixed speed air conditioners and instead targeting additional subsidies at the lower energy-consuming variable speed air conditioners.

Section 9: Analysis of the Variable Speed Air Conditioner Market and Product Performance

This section of the report examines the market, product performance and regulatory framework for variable speed air conditioners. However, for obvious and practical reasons, some of the analysis in this section overlaps with that in the fixed speed air conditioner analysis section; and therefore, readers are encouraged to consider both sections in parallel.

Variable speed air conditioners, and air conditioners in general, are of importance as the installed number of units is rising. Current projections[118] indicate that the number of variable speed air conditioners installed in China will rise from approximately 30 million in 2011 to 77 million in 2030. Under the business as usual scenario, the projected 2030 stock of variable speed air conditioners would consume approximately around 49 TWh per year of energy.

9.1 Product background

9.1.1 Production, sales and stock level

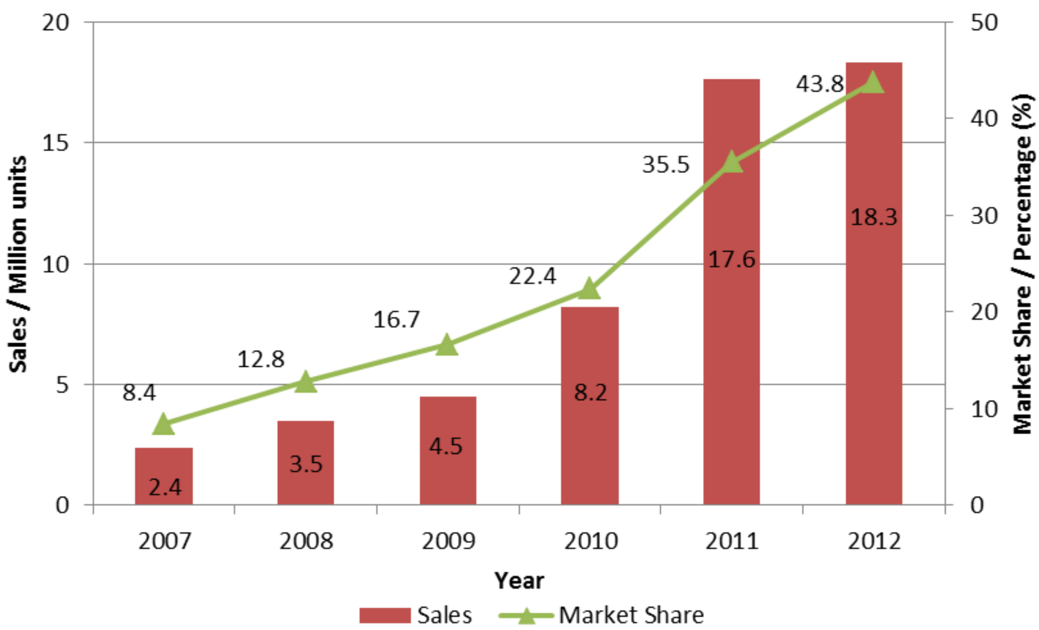
Rapid economic development and urbanization within China has led to sales of room air conditioner units (both fixed and variable speed) increasing significantly over the last ten years.

Variable speed air conditioners were introduced into the Chinese market in the 1990s. Sales remained low until 2009. In 2010 and 2011, sales doubled on an annual basis, with the variable speed air conditioner market share growing from 16% in 2009 to 35% in 2011 (see Figure 127). It appears that at least part of this growth was the introduction was potentially due to the increased consumer confidence in the product performance caused by the introduction of the efficiency standard and energy label for air conditioners in 2008 and 2009 respectively.

Sales plateaued in 2012, but the overall market share increased to 44% as a result of declining sales of fixed speed units (refer to section 8.1.1).

[118] Energy Saving Potential (ESP) Study for Nine Appliances in China, CLASP 2013

Figure 127: Sales and market share of variable speed air conditioner in China[119]



9.1.2 Usage patterns

Refer to section 7.1.2.

9.1.3 Energy Efficiency Standard

Fixed speed air conditioners were first regulated in 2005 under GB 12021.3-2005. Variable speed air conditioners were not included in this first regulation but were subsequently regulated separately in 2008 by the Energy Efficient Standard (EES) GB21455-2008, implemented in September 2008. During the final stages of this study, a revised draft of the EES (GB 21455-201X) was proposed, and is currently available for comment[120].

The current (2008) standard set five energy performance Tiers (EETs) for variable speed air conditioners as detailed in Table 37. The lower boundary of Tier 5 formed the minimum energy performance requirements (MEPR) that any variable speed air conditioner was required to meet in order to enter the market.

Table 37: Minimum efficiency requirements in variable speed air conditioner standard (GB 21455 – 2008)

Cooling capacity range (W)	Tier 1 SEER requirement	Tier 2 SEER requirement	Tier 3 SEER requirement	Tier 4 SEER requirement	Tier 5 SEER requirement
CC≤4500	5.20	4.50	3.90	3.40	3.00
4500<CC≤7100	4.70	4.10	3.60	3.20	2.90
7100<CC	4.20	3.70	3.30	3.00	2.80

[119] Data source: AVC Market Research, http://www.avc-mr.com/

[120] Unfortunately there was insufficient time to fully integrate these new proposals into the current version of this report. Hence, readers should be aware that some information and recommendations may have been superseded.

9.1.4 Energy labeling of variable speed air conditioners

Variable speed air conditioners were first required to use the China Energy Efficiency Label in March 2009. The label shows basic product identification information, the EETs as defined in the EES, and the indicator showing the efficiency level achieved by the product. It also displays the seasonal energy efficiency ratio (SEER) value and the rated cooling capacity and power input. Unlike other labels, the variable speed air conditioner label also includes actual annual energy consumption. This consumption value is based on cooling only. The standard assumes a cooling season of 1,136 hours.

Figure 128: China Energy Label for variable speed air conditioners

9.1.5 Test Method

GB/T 7725 - 2004 "Room air conditioners" is the testing method for air conditioners and defines the performance indicators. The energy efficiency standard for variable speed air conditioners uses a seasonal energy efficiency ratio (SEER) as the main indicator of energy efficient performance. This requires the testing of the air conditioners at full and half load operating conditions. Note the metrics used for the regulation of fixed speed air conditioners is the energy efficiency ratio (EER) and hence differs from variable speed units (refer to section 8.2.3).

It is worth noting that the test procedure also includes methods to measure the heating seasonal performance factor (HSPF) for units where a heating function is available. However, this indicator is used only on a voluntary basis by manufacturers.

9.2 Subsidy program

In 2009, fixed speed air conditioners became one of the first products to be subsidized under the Chinese national subsidy program (refer to section Policy Interventions). However, variable speed units were not included in the program until July 2012. As Table 38 shows, for a given cooling capacity, variable speed air conditioners received higher subsidies than the fixed speed units.

Table 38: 2012 fixed and variable speed air conditioner subsidy levels

Cooling capacity (W)	Fixed speed air conditioner (RMB/Unit)		Variable speed air conditioner (RMB/Unit)	
	Tier 1	Tier 2	Tier 1	Tier 2
CC≤4500	240	180	300	240
4500<CC≤7100	280	200	350	280
CC>7100	330	250	400	330

9.3 Product analysis

The analysis examines the performance, energy and market related properties outlined in Table 39. In addition to the generic cautions provided in the Approaches and Methodology section of the Introduction, readers should note that not all performance and other parameters were available for all models identified as available in the market. Where not all products are included in a particular analysis, this is noted in the associated text. However, it has not been possible to estimate the bias this has introduced into the analysis for any given parameter.

Table 39 Overview of data used for variable speed air conditioner analysis

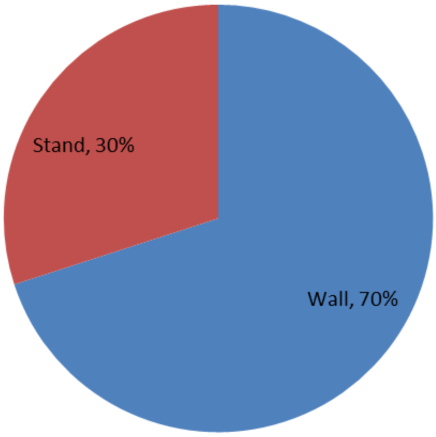
Data type	Notes	
Total Number of Models*	CC**≤2800	315
	2800<CC**≤4500	379
	4500<CC**≤7100	174
	7100<CC**	136
Cooling capacity	Range: 2300 - 12500	
Energy efficiency Tier	Range: 1 - 5	
Seasonal energy efficiency ratio (SEER)	Range: 2.84 - 7.33	
Price/RMB	Range: 1750 - 14489	
Heating capacity	Range: 2600 - 10500	
Co-efficiency of the performance (COP)	Range: 2.10 - 5.00	

**Note the EES does not use the CC≤2800* category. However, given the large number of models in this group, this extra categorization assists in product analysis.
***CC= cooling capacity.*

9.3.1 Market distribution of variable speed air conditioners by product type

In line with fixed speed air conditioners, variable speed air conditioners can be segmented into two product types: wall-mounted and stand-alone floor units, “stand.” Wall-mounted air conditioners are mainly used in smaller rooms such as bedrooms, and stand-alone units are used in bigger rooms like living rooms and some offices and restaurants. The market share of two types of conditioners based on product availability in July 2012 is shown in Figure 129.

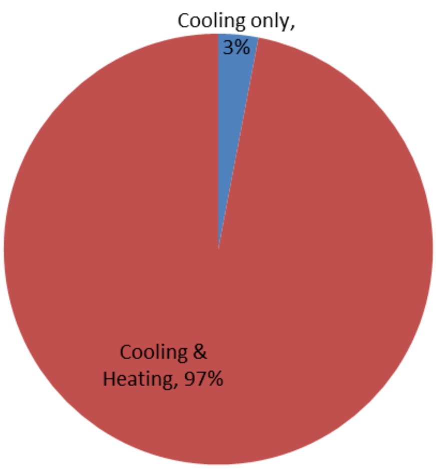
Figure 129: Share of variable speed air conditioner types available in the market (July 2012)



9.3.2 Market distribution by cooling and heating capacity

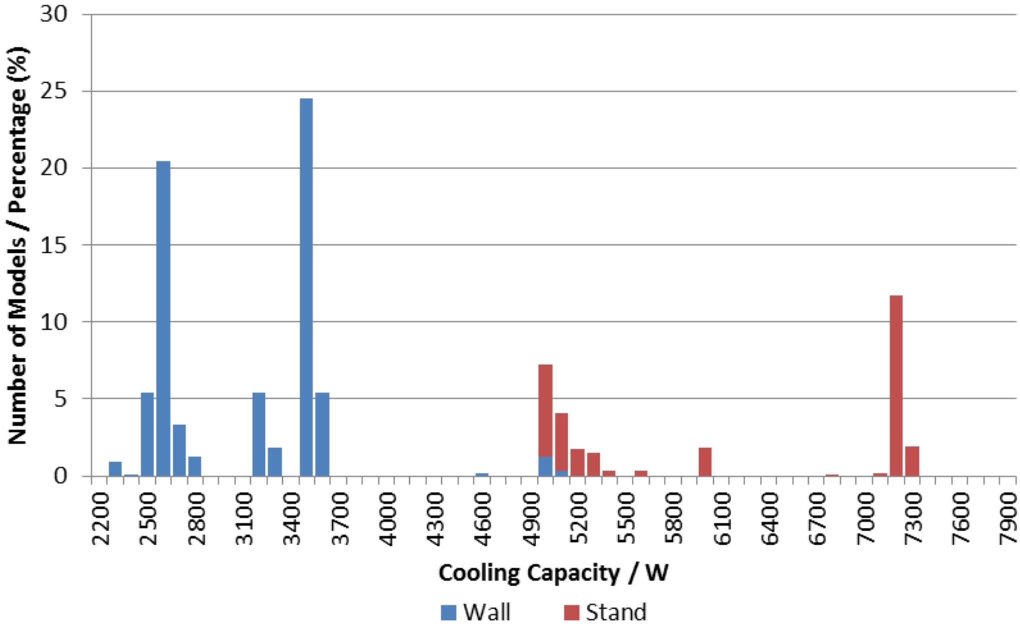
The market for variable speed air conditioners can also be segmented into units that provide cooling only and units that provide both heating and cooling. Figure 130 shows the variable speed air conditioner market has almost completely migrated to units that both heat and cool (97%). This compares with 75% of fixed speed units that provide both heating and cooling (refer to section 8.4.1).

Figure 130: Model shares of cooling and heating functions



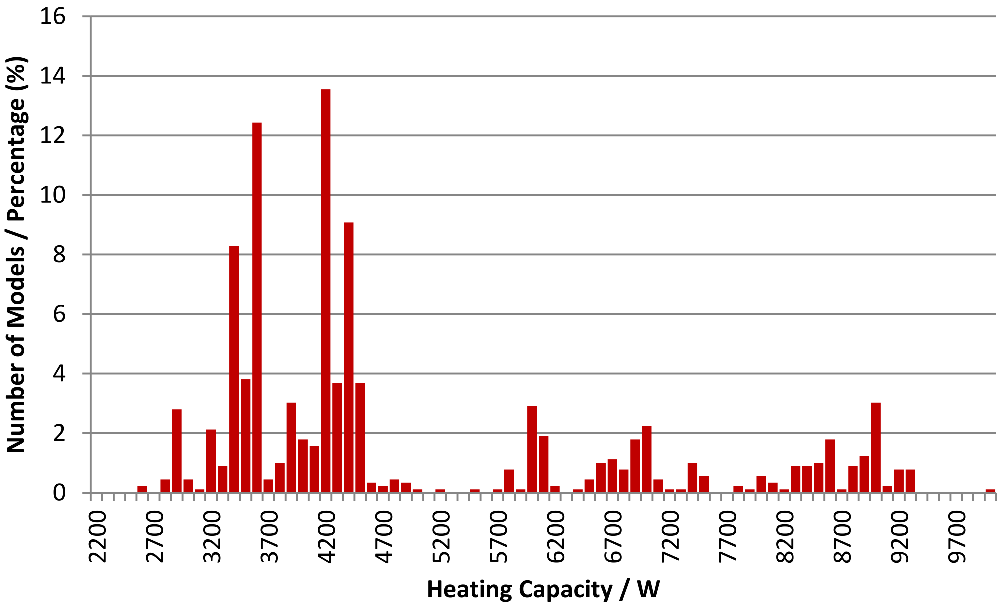
Cooling capacity is the main indicator of the ability of the air conditioner. The market distribution of variable speed air conditioners in July 2012 is similar to the distribution in cooling capacity of fixed speed air conditioners (refer Figure 107). The distribution groups largely around four cooling capacities, 2600W, 3500W, 5000W and 7200W. Within this distribution, the two smaller capacities are made up entirely of wall-mounted units, and the two larger capacities are almost entirely stand-alone units.

Figure 131: Variable speed air conditioner cooling capacity distribution (July 2012)



As almost all variable speed air conditioners have a heating function, analysis of the distribution of heating capacity is also appropriate, as shown below.

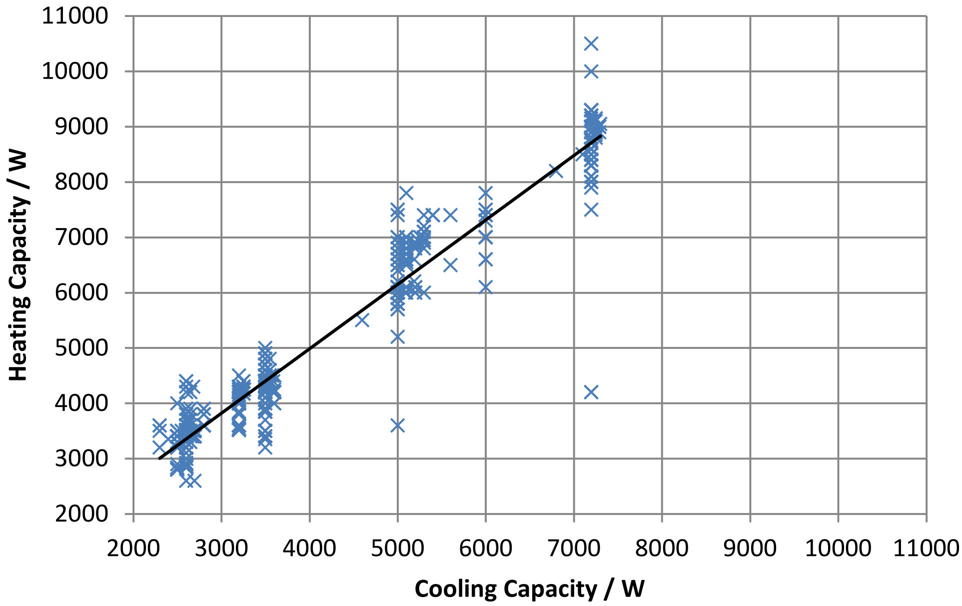
Figure 132: Variable speed air conditioner heating capacity distribution (July 2012)



The distribution of the heating capacity is very similar to the cooling capacity distribution, although with the groupings at slightly higher capacities: 3600W, 4300W, 6000W, and 9000W.

The linear relationship between heating and cooling capacity is shown in Figure 133, the co-efficient of correlation being 0.873.

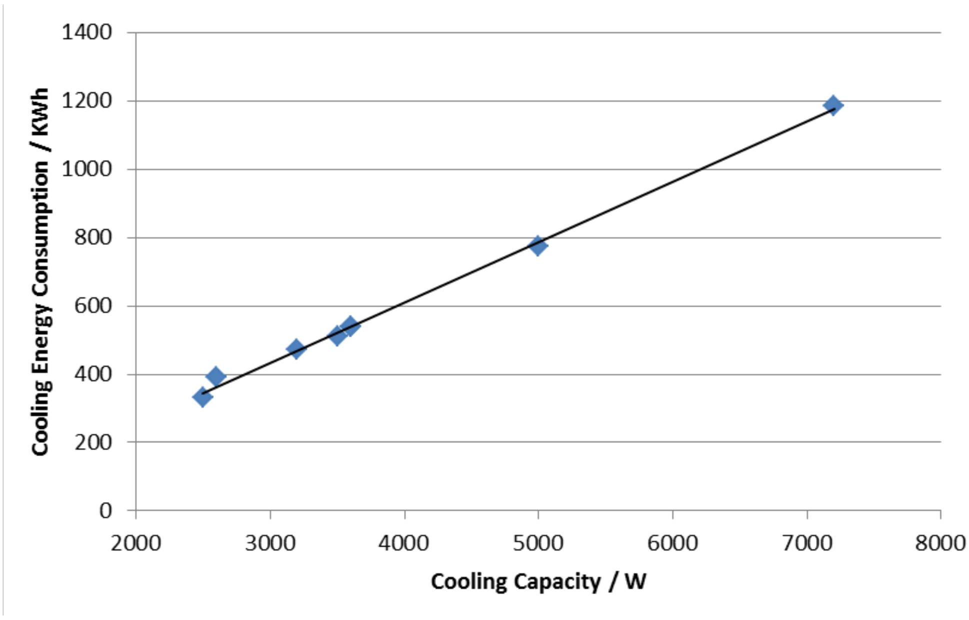
Figure 133: Correlation between the cooling and heating capacity of variable speed air conditioners (July 2012)



9.3.3 Relationship of variable speed air conditioner rated power to energy consumption

Unsurprisingly, there is a close relationship between the rated cooling capacity of variable speed air conditioners and their energy consumption. Figure 134 shows this relationship based on the power rating and energy consumption values declared on the product labels.

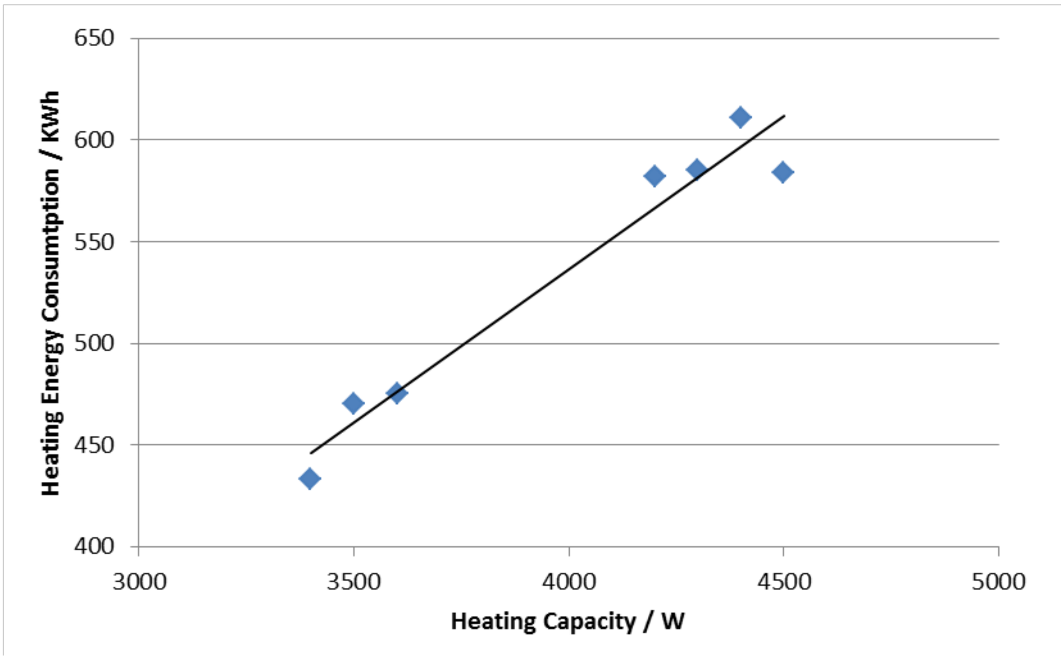
Figure 134: Relationship between variable speed air conditioner rated cooling capacity and labeled cooling season energy consumption (July 2012)*



** Samples of each point ≥50*

Similarly, the relationship between power and heating energy consumption is close, as shown below. Note that the heating season energy consumption is calculated based on the rated heating power and operation of 433 hours. The 433 hour heating season is drawn from the newly-drafted EES for variable speed air conditioners (GB 21455-201X), which is currently available for comment.

Figure 135: Relationship between variable speed air conditioner rated heating capacity and heating season energy consumption* (July 2012):**



** 433 hours annual heating based on GB 21455 - 20XX, which introduces the heating season (currently a draft for revision).*
***Samples of each point ≥50*

9.3.4 Market distribution of variable speed air conditioners related to energy efficiency

By July 2012, the EES for variable speed air conditioners had been in effect for four years. The resulting distribution of variable speed air conditioners between the EES efficiency Tiers is shown in Figure 136. As can be seen, Tier 3 products dominate the market, with over 50% of all models. EET Tier 5 models have been almost eliminated. 31% of the market is from Tier 1 and 2 models, which are defined as energy efficient air conditioners and eligible for subsidy support (refer to section 9.2).

Breaking this distribution down into the major cooling capacity groupings, as shown in Figure 137, the overall EET distribution remains broadly the same, with the minor additional observation that a higher proportion of Tier 1 products are in the two smaller capacity ranges.

Figure 136: Variable speed air conditioner energy efficiency Tier distribution (July 2012)

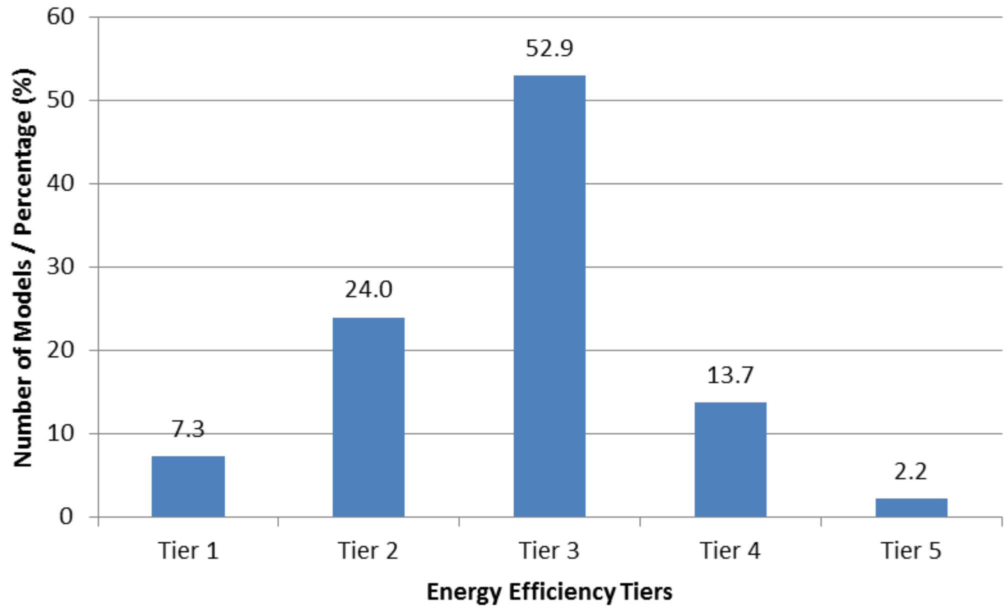
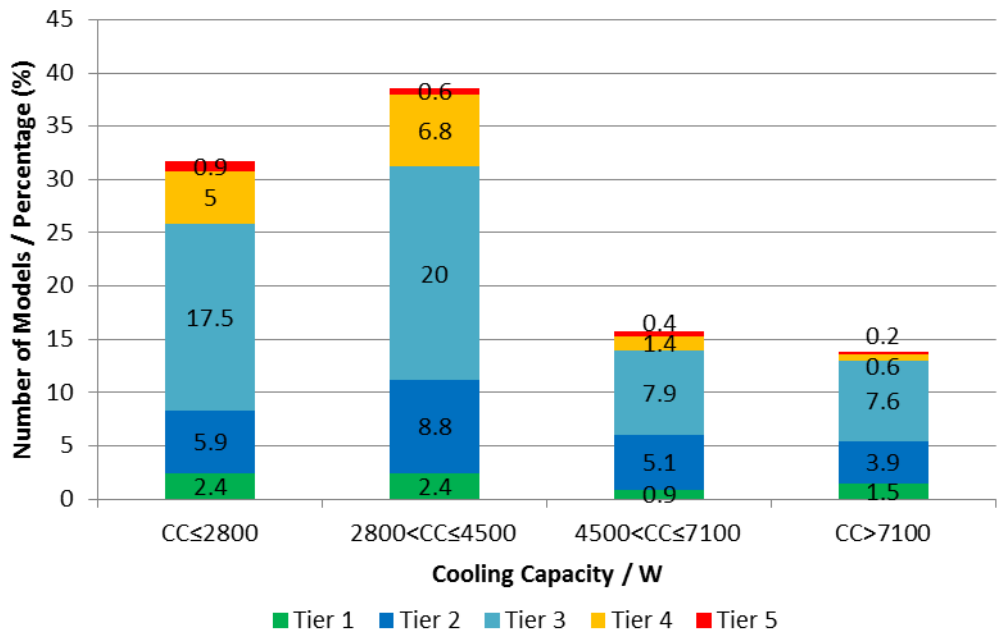


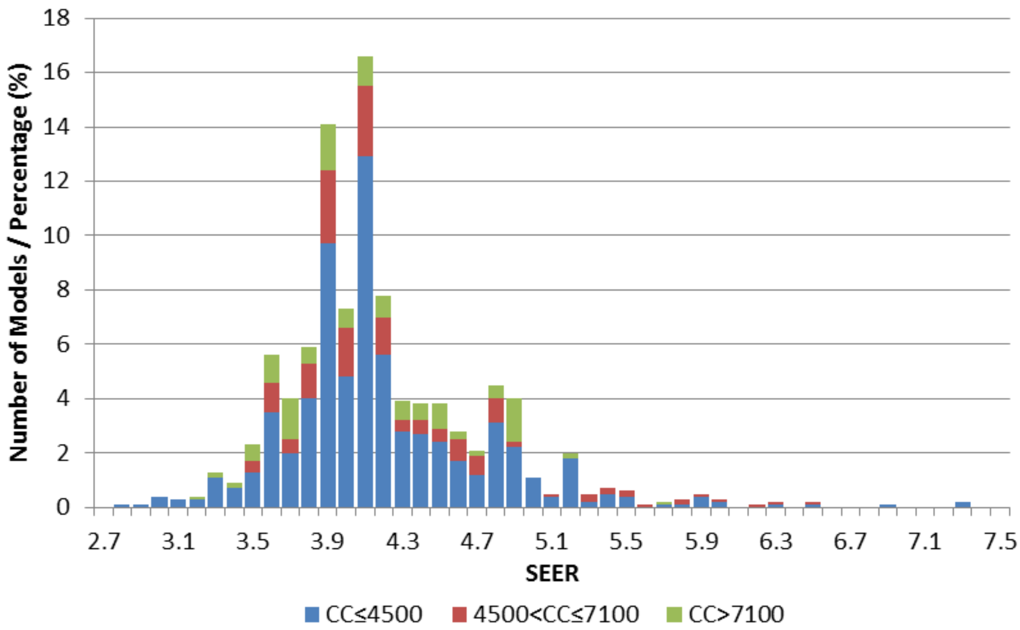
Figure 137: Variable speed air conditioner energy efficiency Tier distribution broken down by capacity range (July 2012)



As Tier 4 and 5 products account for approximately 16% of the market, this indicates that there is significant potential to revise the EES and reset the MEPR to remove these products from the market without causing limitations in product supply in any capacity range.

Figure 138 shows the July 2012 market distribution of variable speed air conditioners based on their SEER. The spread of products broadly forms a normal distribution, although the majority of products are on the Tier 2 and Tier 3 boundary levels as defined in the EES.

Figure 138: market distribution of variable speed air conditioners by SEER (July 2012)



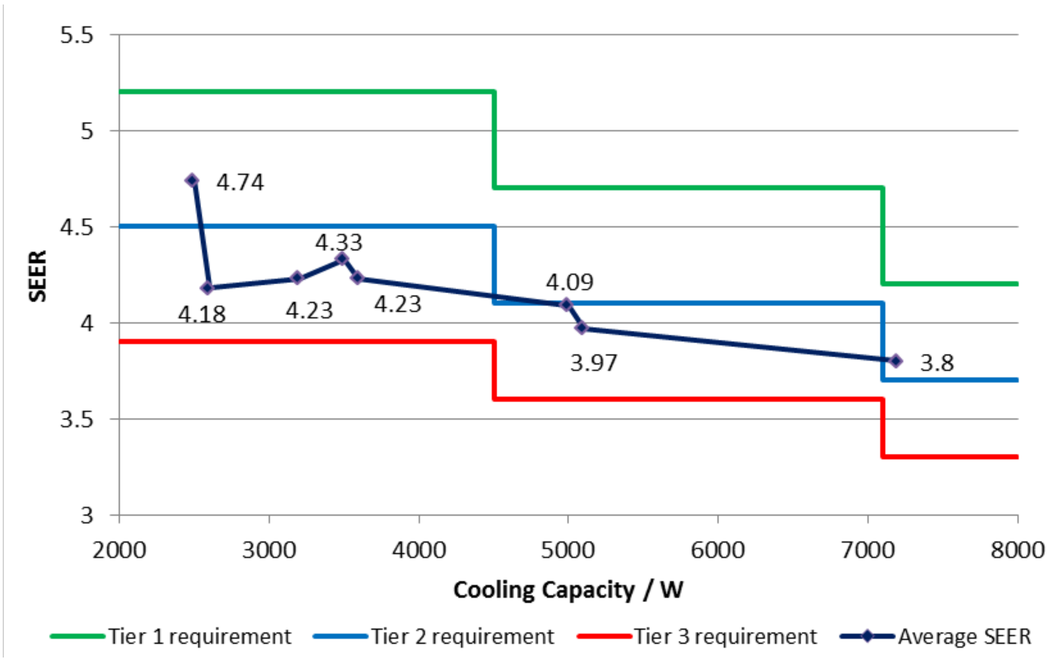
Interestingly, products are available with SEER values in excess of 7. This indicates that the current Tier 1 thresholds are relatively low compared with the range of products on the market. Therefore, there appears potential for policymakers to revise the current Tier 1 thresholds to a higher level, enabling consumers to identify premium efficiency products more readily. This approach worked well for fixed speed air conditioners when the premium products were supported with high subsidy levels.

As shown in Figure 139, the minimum SEER threshold value required in the EES decreases with as cooling capacity increases. It depicts this relationship graphically, and is overlaid with the average SEER of models at each cooling capacity.

Interestingly, the average SEER for 2600W products is the lowest in the range of products below 3500W. The significant drop in SEER from 2500W, followed by an increase from 2600W to 3500W, may indicate that the large number of products competing in this capacity range is driving down price at the expense of efficiency. This is investigated further in section 9.3.4.

Average SEER value in each Tier by capacity is shown in Figure 140. In the cooling capacity range below 2800W, Tier 1 and Tier 2 products have very high average SEER values of almost 6 with large steps toward lower Tier values. As capacities rise, the overall average SEER values fall, and the steps between average SEER values in each Tier decrease.

Figure 139: Average SEER of variable speed air conditioner models at each cooling capacity in relation to energy efficiency Tier thresholds (July 2012)



** Number of samples for each ≥50*

Figure 140: Average SEER of variable speed air conditioner models at each cooling capacity within each energy efficiency Tier (July 2012)

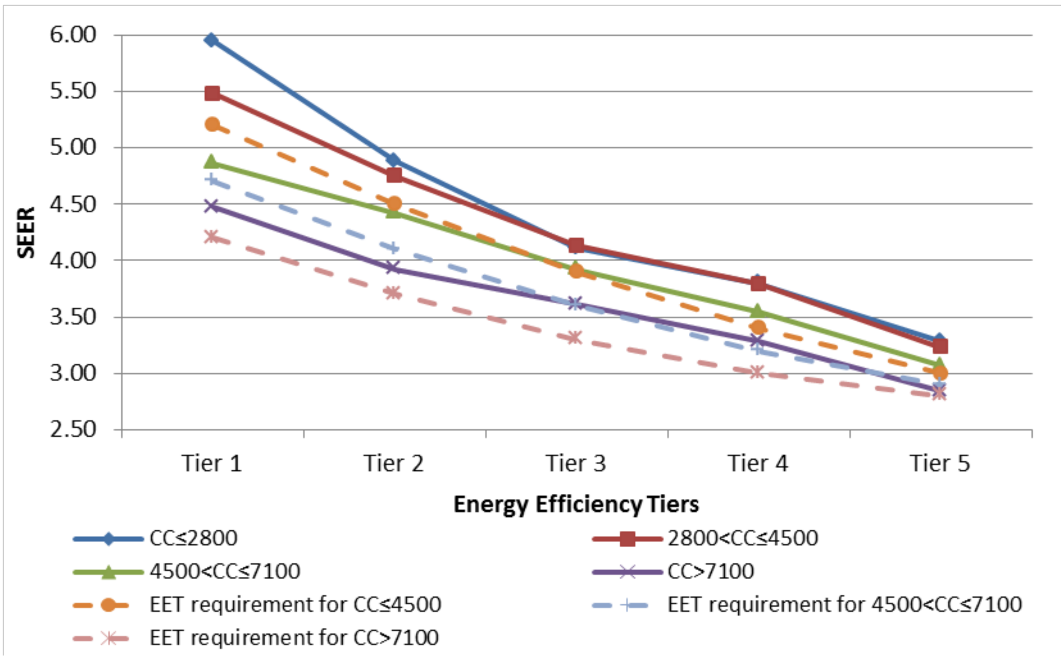
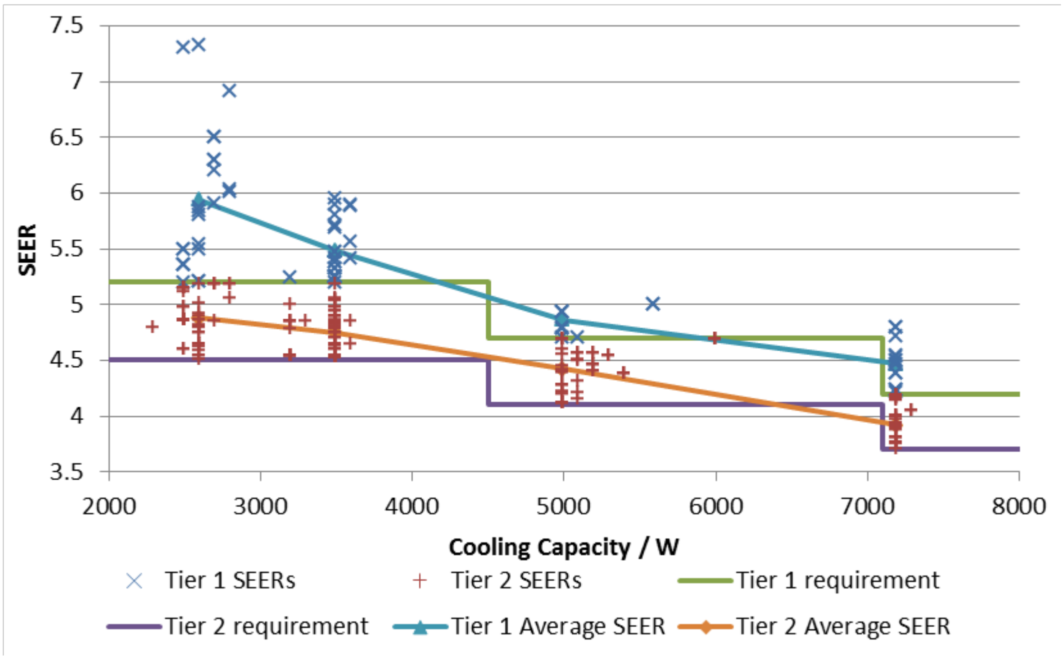


Figure 141 shows the distribution of average SEER values at each capacity for Tier 1 and 2 models in relationship to the EET thresholds. As noted previously, the majority of energy efficient products (Tiers 1 and 2) come from the product group with cooling capacity below 2800W. Fewer Tier 1 models are available as the cooling capacity increases.

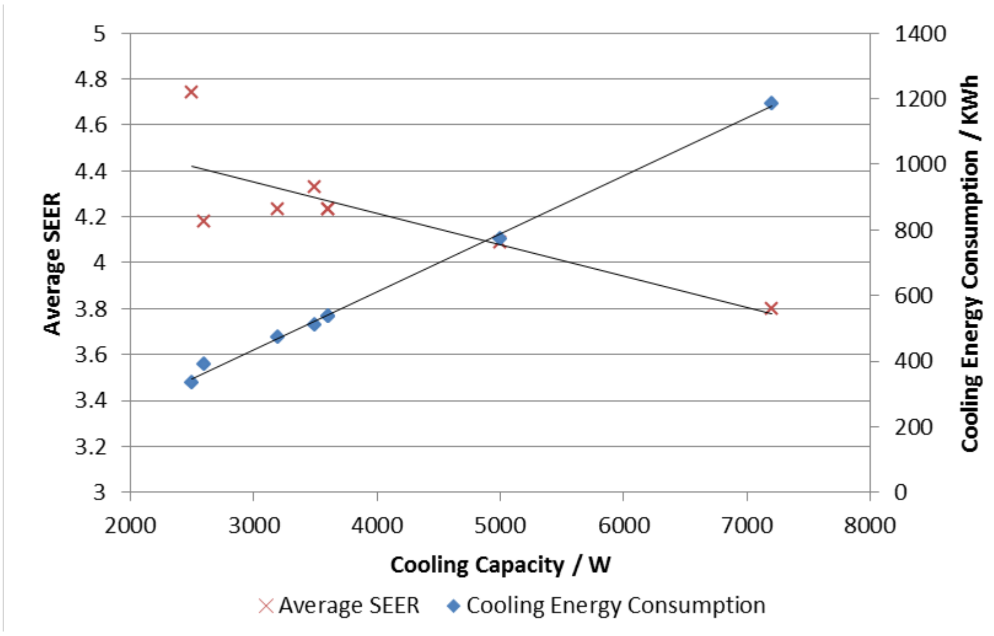
Figure 141: Distribution of energy efficiency standard Tier 1 and 2 variable speed air conditioner by SEER (July 2012)



9.3.4.1 Relationship between variable speed air conditioner rated cooling capacity, labeled cooling season energy consumption, and SEER

Bringing together the average SEER and cooling energy consumption values at each capacity, Figure 142 clearly demonstrates the inverse relationship between SEER value and energy consumption. However, it is worth noting that while average annual cooling energy consumption has an almost linear relationship to capacity, the SEER values are more erratic, particularly at lower cooling capacities.

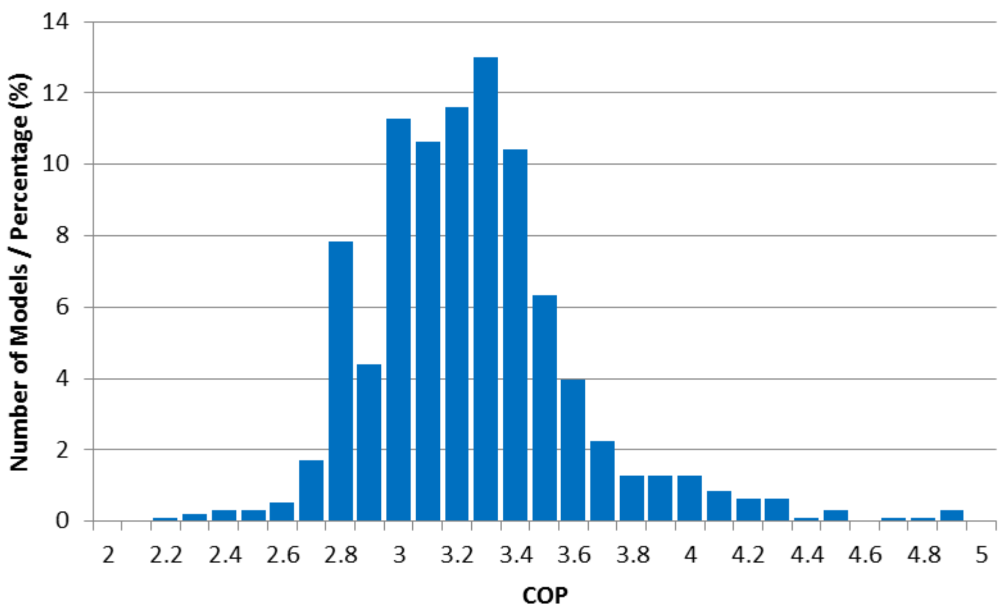
Figure 142: Relationship between variable speed air conditioner rated cooling capacity, labeled cooling season energy consumption, and SEER (July 2012)



As noted in section 9.1.4, GB/T 7725-2004 defines the testing method for air conditioners and includes a test for a heating seasonal performance factor (HSPF). However, declaration of this value is voluntary for manufacturers and is rarely displayed. Therefore, the calculation of the co-efficient of performance (COP) used in this analysis is based on the rated heating capacity of the air conditioner and the derived heating power consumption.

Figure 143 shows that, based on this method, the COP of variable speed air conditioners available in the market in July 2012 follows a broadly normal distribution ranging from 2 to 5, with the majority of products in the 3 to 3.5 range.

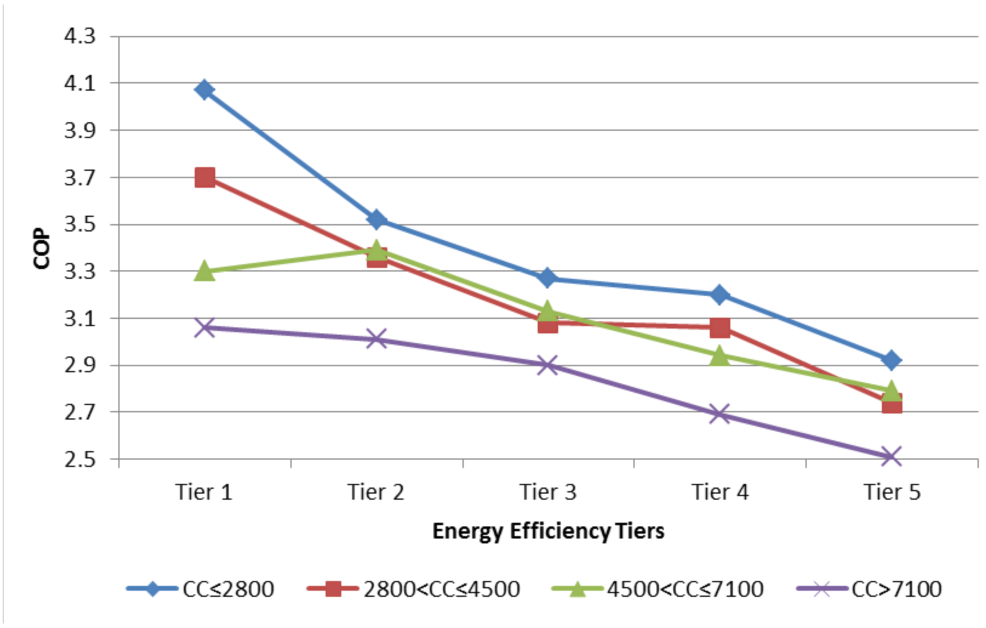
Figure 143: Market distribution of variable speed air conditioners by co-efficient of performance (July 2012)



9.3.4.2 Relationship of variable speed air conditioner SEER to cooling capacity and energy efficiency Tiers

Although the EET of a given product is currently only decided by the cooling efficiency, given the relationship of heating and cooling performance of units, there is still a very close relationship between the COP of the models and the energy efficiency Tier (Figure 144). As would be expected from the previously presented data, the average heating performance declines with capacity and Tier.

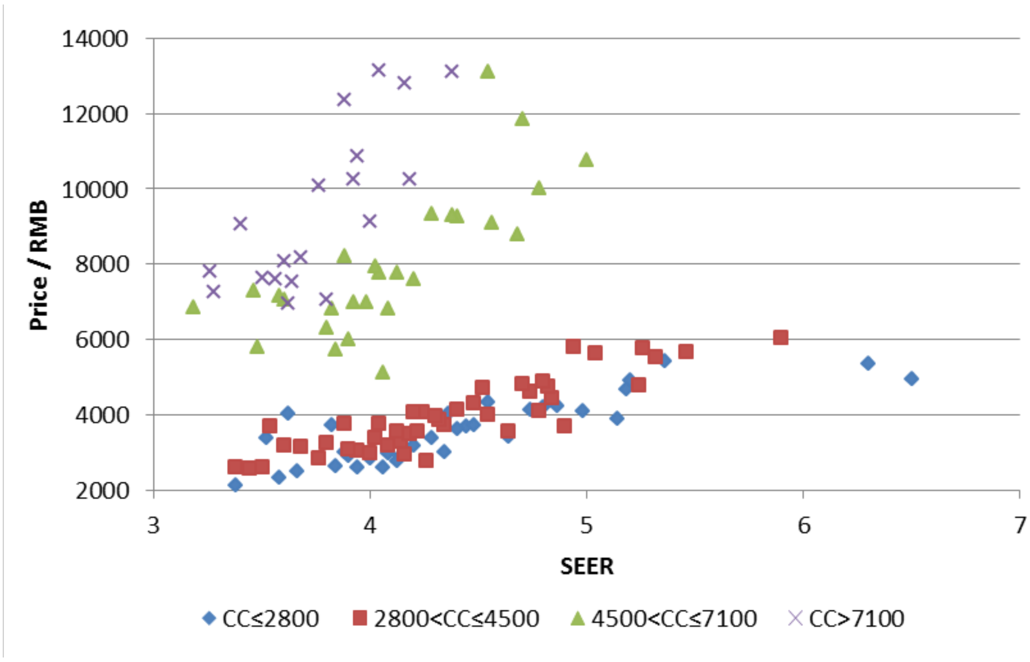
Figure 144: Average the co-efficient of performance of variable speed air conditioner models at each cooling capacity within each energy efficiency Tier (July 2012)



9.3.5 Relationship of price to other variable speed air conditioner parameters

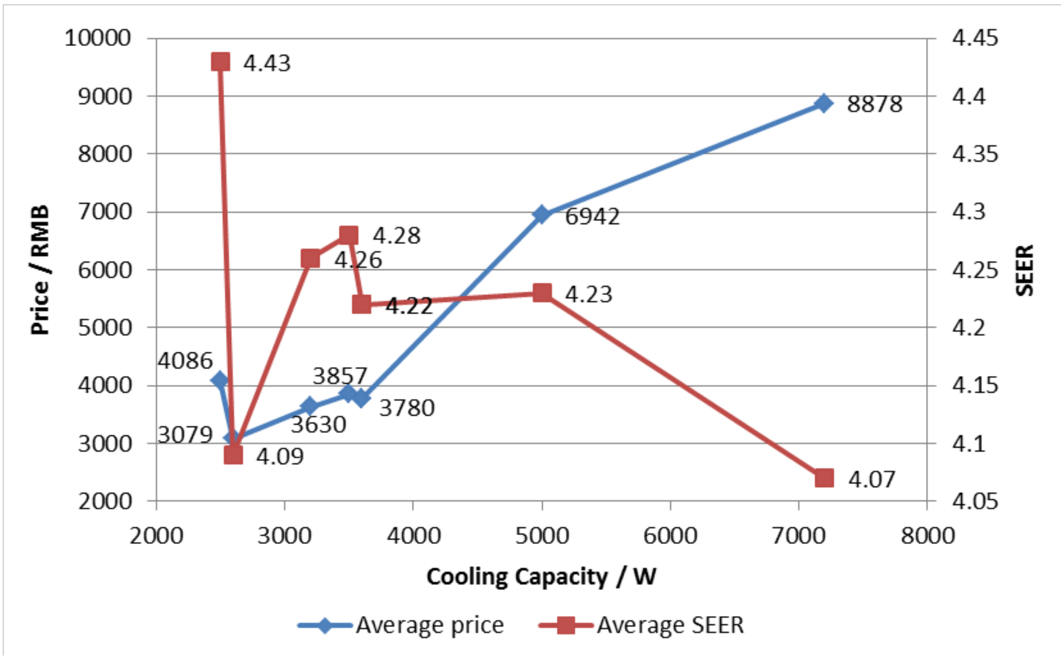
Figure 145 shows the average price of models at increasing SEER levels for the four capacity bands. In every capacity range, the price increases with the SEER, and higher cooling capacity units have higher average prices. Figure 146 reinforces this outcome (and those found in preceding sections); in general, the price of variable speed air conditioners rises with increases in cooling capacity, while the SEER falls.

Figure 145: Relationship of variable speed air conditioner price to cooling capacity and SEER for a range of cooling capacities (July 2012)



**Minimum of two models required for each data point*

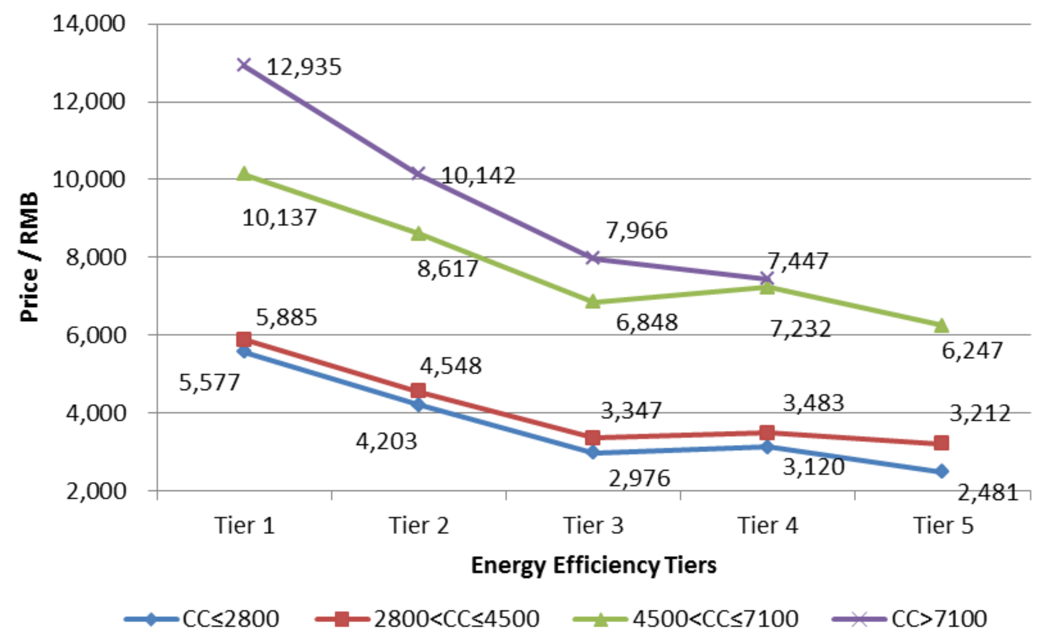
Figure 146: Relationship of variable speed air conditioner price to cooling capacity and SEER (July 2012)



However, Figure 146 shows a distinct fall in SEER performance at capacities of 2600W and, to a lesser extent. These falls in SEER values align exactly with peak product availability (as shown in Figure 131) and with dips in the product price. Thus, it appears that manufacturers are pricing products based on capacity (with the associated inverse relationship to SEER), but at cooling capacities where competition is high, prices are being reduced at the expense of air conditioner efficiency as defined by SEER.

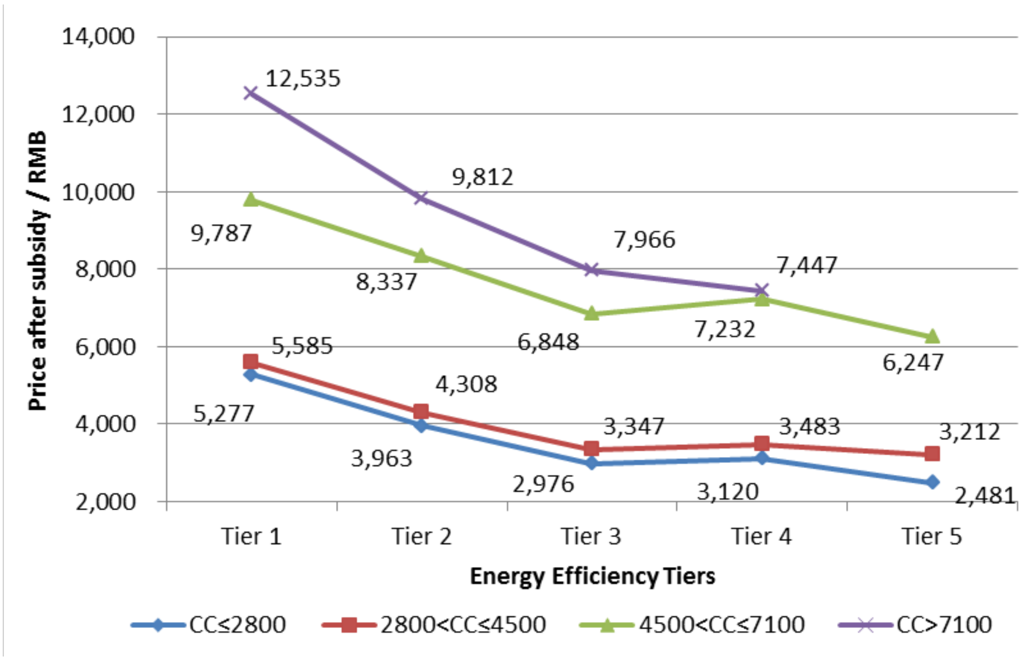
There is a significant price differential between Tier 1 and Tier 2 models, and a similar price differential between Tier 2 and 3 models in each capacity range. However, the fall in price flattens rapidly for Tier 3, 4, and 5 products, and in some cases there is actually a small rise (Figure 147). This seems to imply manufacturers are charging a price premium for Tier 1 and 2 products, although it is not possible to know if this is simply pricing strategy, or whether there is a significant cost penalty in producing higher efficiency products.

Figure 147: Average purchase price and the energy efficiency Tier of variable speed air conditioners for a range of cooling capacities (July 2012)



One of the goals of the national subsidy program (refer to the Policy Interventions section of the introduction) is to close the price differential between high efficiency products and less efficient alternatives. However, Figure 148 shows that this is far from being achieved for variable speed air conditioners with the post subsidy price for Tier 1 and 2 products still being substantially higher than the lower efficiency Tier 3, 4 and 5 products which receive no subsidy..

Figure 148: Average purchase price (adjusted for subsidy support) and energy efficiency Tiers of variable speed air conditioners for a range of cooling capacities (July 2012)



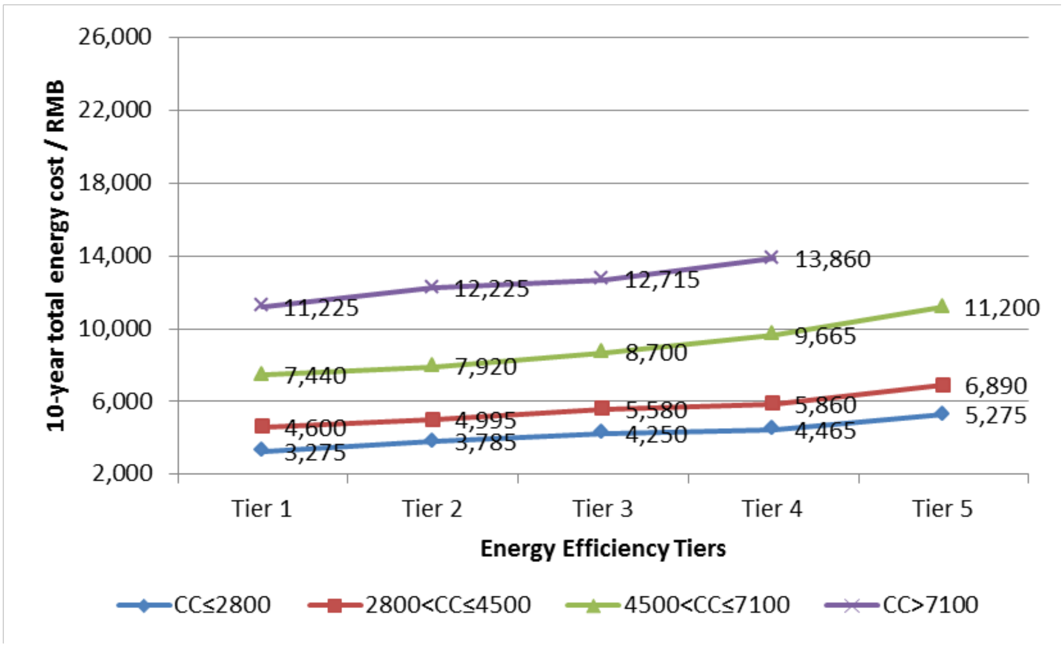
9.4 Cost and benefit analysis

Based on an expected lifetime of ten years, the lifetime ownership of an air conditioner can be calculated as the sum of the purchase cost plus ten years of operation costs based on the cooling and heating energy consumption.

Looking first at the operational costs, the cost of energy consumed over ten years by variable speed air conditioners of differing cooling capacities and EETs is shown in Figure 149. As would be expected, the cost of energy consumed increases as models become less efficient (i.e. as the Tier goes from 1 to 5), and with increasing cooling capacity.

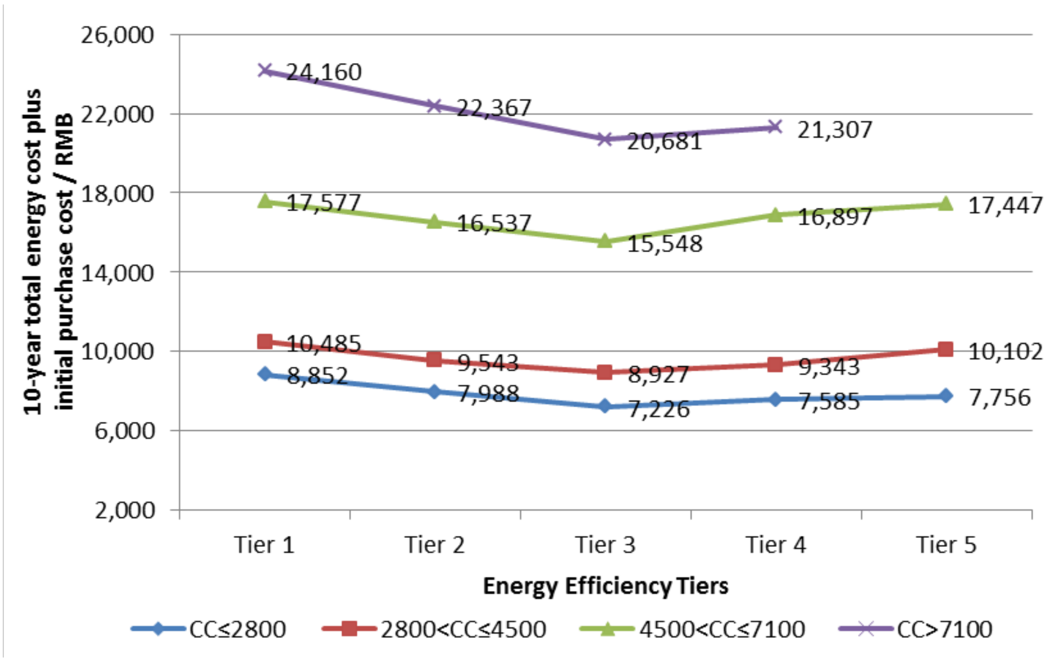
However, the picture becomes very different when the model purchase price is added to the operational cost to give total cost of ownership (Figure 150). Due to the relatively high initial purchase price of EET tier 1 and tier 2 products, total cost of ownership is minimized for EET tier 3 products in all capacity ranges. Figure 151 shows that the subsidy support for EET tier 1 and 2 products has very little impact on this outcome and tier 3 products still have the lowest lifetime cost to the consumer.

Figure 149: Ten year operational lifetime* cost of ownership for variable speed air conditioners based on combined cost cooling and heating (July 2012)**



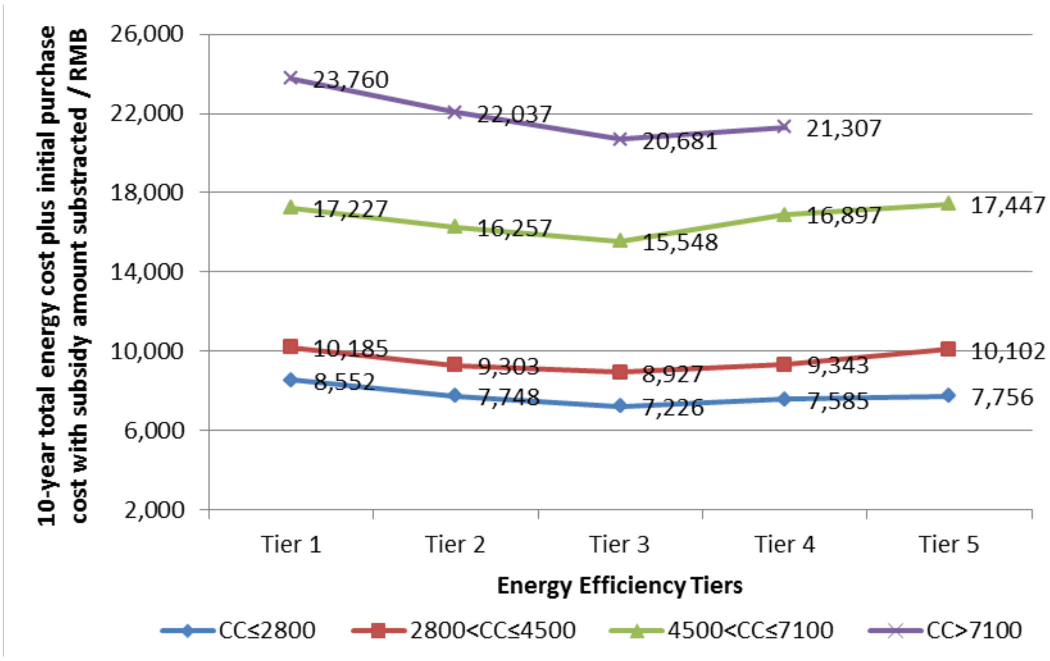
** Using declared annual cooling consumption and 433 hours annual heating (based on GB 21455 - 20XX, which introduces the heating season, currently a draft for revision) at rated capacity.*
*** Assumed electricity price: 1kWh = 0.5 RMB.*

Figure 150: Ten year total lifetime* cost of ownership for variable speed air conditioners based on the combined cost of purchase, cooling and heating (July 2012)**



** Using declared annual cooling consumption and 433 hours annual heating (based on GB 21455 - 20XX, which introduces the heating season, currently a draft for revision) at rated capacity.*
*** Assumed electricity price: 1kWh = 0.5 RMB.*

Figure 151: 10 year total lifetime* cost of ownership for variable speed air conditioners based on the combined cost of purchase adjusted for subsidy support, cooling and heating (July 2012)**



** Using declared annual cooling consumption and 433 hours annual heating (based on GB 21455 - 20XX, which introduces the heating season, currently a draft for revision) at rated capacity.*
*** Assumed electricity price: 1kWh = 0.5 RMB.*

Refer to section 8.5.1 for a lifetime cost and benefit comparison of fixed and variable speed air conditioners.

9.5 Conclusions and recommendations

From the analysis above, policymakers may wish to consider the following measures.

Revise the energy efficiency standard and efficiency label

The energy efficiency standard for variable speed air conditioners has not been revised since the introduction in 2008, although a review process is currently underway[121]. Over the intervening years, a number of anomalies have appeared in the market, such as:

- Only 16% of models in the market remain in Tiers 4 and 5, as evidenced by the current EET distribution. This presents an opportunity to strengthen current MEPR levels.
- Variable speed air conditioners with SEER values in excess of 7 are present in the market. This far exceeds the current Tier 1 threshold levels; thus, the most efficient units are not clearly indicated to consumers at the time of purchase.
- Currently the EES for variable speed air conditioners is based only on the cooling efficiency (SEER) of the unit, even though almost all variable speed models have the capacity to heat spaces. Therefore, there is a risk that only the cooling functions of units are optimized and do not maximize energy reduction opportunities during heating functions.

Therefore, policymakers may wish to consider:

1. Revising the 2008 EES to set a new MEPR level at the lower threshold of the existing current Tier 3 boundary, thus removing approximately 16% of models from the market.
2. A revision of the Tier 1 threshold to, for example, a SEER level of approximately 6 for smaller capacity units would help to clearly identify the most efficient products in the market. Note that it may be possible to combine such a revision with a more aggressive revision of the MEPR level to the lower threshold of the existing Tier 2 boundary. This approach worked well in driving the efficiency of fixed speed air conditioners when the premium products were supported with high subsidy levels.
3. Including heating within the overall performance measure for variable speed air conditioners, thus ensuring the most efficient operation across all operational conditions.

Revise the subsidy program for variable speed air conditioners

The current subsidy level is insufficient to cover the marginal cost of Tier 1 and Tier 2 products. From a consumer perspective, this means that Tier 3 products still have

[121] During report preparation, proposed revised EES requirements for variable speed air conditioners have been issued, which include measures to address a number of our recommendations.

the lowest lifetime costs. Additionally, the marginal difference in subsidies between Tier 1 and Tier 2 products provides little incentive for consumers to purchase Tier 1 products in preference to Tier 2, nor any for manufacturers to produce more Tier 1 products, which would increase competition and reduce retail price.

Therefore, policymakers may wish to consider:

4. Completely removing the subsidy for Tier 2 variable speed air conditioners[122] and significantly increasing the subsidy for Tier 1 products to a level where the cost differential between Tiers 1 and 2 (and ideally, Tier 3) products is removed, thus ensuring Tier 1 products have the lowest lifetime cost to the consumer. Given the experience with fixed speed air conditioners, such an approach is likely to be particularly effective if combined with increasing the MEPR to the current Tier 2 level as recommended above.

For additional recommendations related to both fixed and variable speed air conditioners, please refer to section 8.6.

[122] And all fixed speed air conditioners; refer to section 8.6.

Section 10: Energy Saving Potential Analysis

In line with most countries and regions, a significant element of Chinese appliance efficiency policy development relies on projections of current and future energy consumption under a number of different regulatory and market scenarios. However, such projections are by their very nature subject to the limitations of the data available on which to make the projections, and the assumptions necessarily made during the development of the projections. Therefore, there is a degree of uncertainty introduced into the policymaking process that is difficult to resolve.

However, the production of a second independent set of projections provides a basis for comparison, and increases the likelihood of identifying areas where projections may be refined to more accurately project the likely future impact of any policy intervention. Thus, in addition to the individual product analyses undertaken in this report, a parallel study has been conducted on the energy savings potential (ESP)[123].

Taking into account factors such as projected growth in product ownership, changes in consumer usage patterns, product lifetimes and so on, the ESP's present projections of total Chinese energy consumption to 2030 for each product analyzed in this report is based on three scenarios:

- **Business as usual:** An estimate of future national energy consumption from each product based on the current Chinese national energy efficiency standard Tier requirements, minimum energy performance requirements, energy labeling, and other associated policy interventions already in force.
- **MACEEP:** Building on the business as usual projections, the MACEEP scenario estimates the potential energy savings that would likely result from the adoption of proposals for the revision of energy efficiency standards detailed in each of the individual product analysis reported in sections 1-9 above.
- **Best available product:** Again building on the business as usual projections, the best available product scenario estimates the energy savings that are possible should all future appliance sales be of the efficiency of the most efficient (representative) model identified in the Chinese market at the time of data collection in July 2012. This projection is designed to highlight the huge potential energy saving opportunities available to policymakers based on existing technology already on the market.

Full details of the outcomes of the individual energy savings projections under each scenario, and the associated assumptions used in the deriving the projections, are contained in the parallel *"Energy Savings Potential: China"* report[123]. However, the following subsections provide a summary of the report's outcomes for each scenario.

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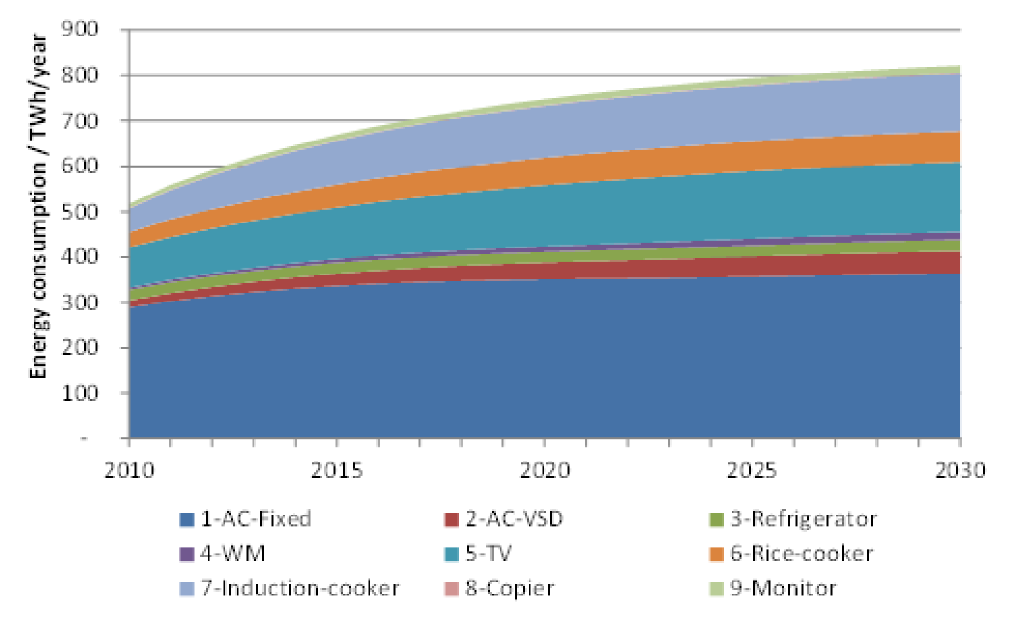
[123] Energy Saving Potential (ESP) Study for Nine Appliances in China, CLASP 2013

10.1 Business as usual scenario

The business as usual scenario has two functions. Firstly, it is designed to be a projection of the energy consumption of the appliances analyzed in this report to provide Chinese policymakers with an independent comparison of their existing models. This may assist in further refinement of national models to more accurately project the likely future impact of any policy intervention. Secondly, the business as usual scenario is used as the basis for other projections made by the ESP.

As can be seen from Figure 152, the projected total energy consumption in China of the nine appliances analyzed in this report is anticipated to rise from 591 TWh per year in 2012 to 821 TWh per year in 2030. This projected steep rise in appliance energy consumption clearly highlights the need for ongoing active policy intervention in the appliance market to assist China in meeting its short, medium, and long term energy conservation objectives.

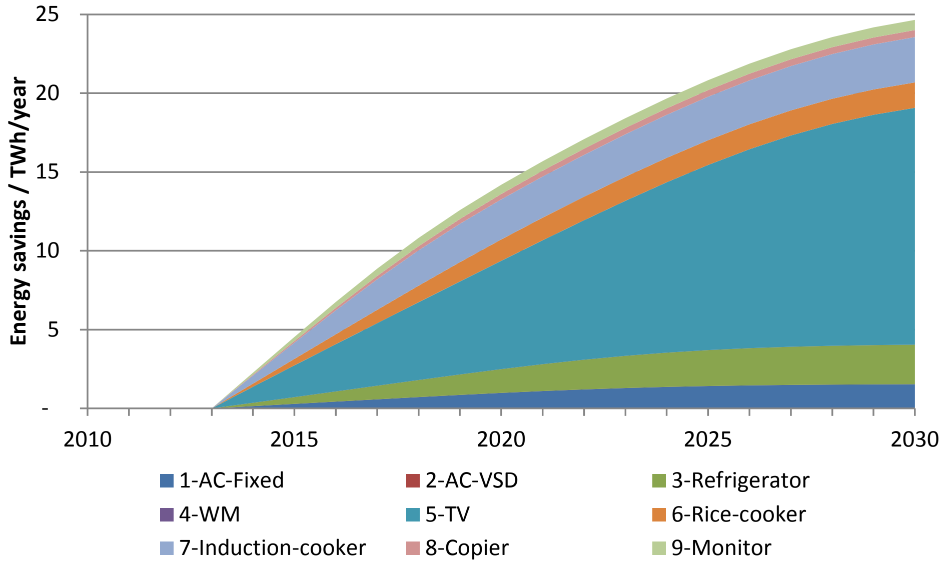
Figure 152: Current and projected energy consumption of selected domestic appliances in China under a business as usual scenario



10.2 MACEEP Scenario

Should Chinese policymakers adopt the proposed revisions to the appliance energy efficiency standards recommended in the individual product analysis above (sections 1-9), it is estimated that total energy consumption in 2030 would be 25 TWh less per year or 3% below the business as usual scenario. This represents a cumulative energy saving of 269 TWh over the 17 year period.

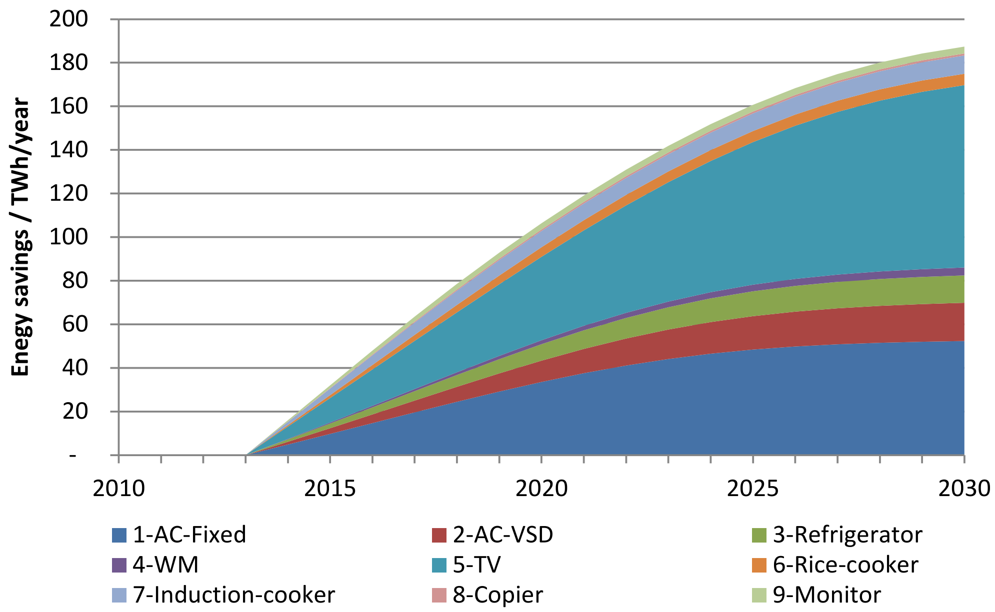
Figure 153: Projected energy savings from selected domestic appliances in China through the adoption of revisions to the appliance energy efficiency standards made in this report MACEEP scenario



10.3 Best on Market Scenario

Projections made under the best-on-market scenario are designed to highlight the huge potential energy saving opportunities available to policymakers simply based on technologies that are already present in products available in the market. Figure 154 shows that a shift to consumers obtaining the most efficient appliances currently available on the Chinese market would result in total annual energy savings of 187 TWh per year in 2030, with cumulative energy savings of 1,057 TWh over the 17 year period.

Figure 154: Projected energy savings from selected domestic appliances in China if future sales were of the efficiency of the most efficient appliances *available* in the market in 2012 (projection to 2020)

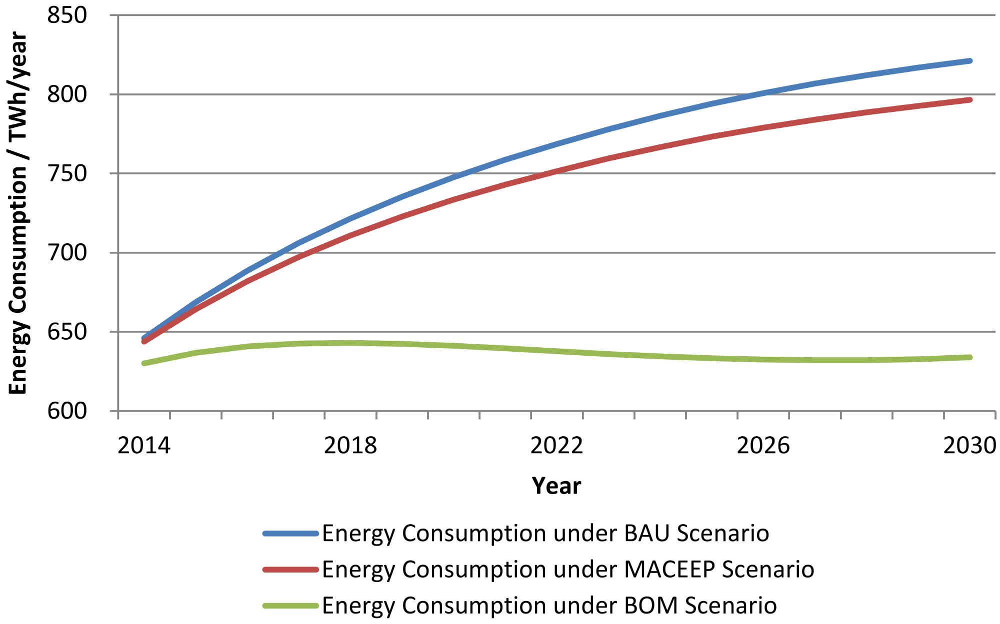


We recognize that attempting to adjust policy to reach these “best product” levels of efficiency is unreasonable immediately due to the probable adverse effect on some manufacturers, and possibly prohibitive product costs for the majority of consumers. However, it is useful to note that such products are already on the market and hence policymakers can be confident that they may adjust policy to set challenging targets for appliance efficiency and that such policies will not require the development of new technologies that are as yet unproven in the market, nor will the supply of products be unnecessarily restricted.

10.4 Summary

Figure 155 brings together the Business as Usual, MACEEP and Best on Market Scenarios to clearly demonstrate the magnitude of the potential savings should appropriate policy routes are followed.

Figure 155: Projected energy savings from selected domestic appliances in China if future sales were of the efficiency of the most efficient appliances available in the market in 2012 (projection to 2020)



Conclusions and Recommendations

Within the individual appliance analyses conducted above, we have made over 90 recommendations for improving energy efficiency policy on the nine products covered in this study. In each case these recommendations are specific to the appliance and justified on the evidence presented in the analysis of that appliance.

However, when reviewing the individual appliance conclusions and recommendations all together – and in combination with the parallel energy saving potential analysis detailed in Section 10, there are a number of overarching themes that may be of significant interest to policymakers. These summary conclusions and recommendations are as follows.

Immediate energy saving opportunities

Significant energy saving opportunities are immediately available through relatively simple revisions to the minimum energy performance requirements for fixed speed air conditioners, induction cookers, copiers, monitors, refrigerators and rice cookers. Potentially appropriate minimum energy performance requirements are proposed in the relevant appliance analyses above. If policymakers choose to adopt all of these proposals immediately, the revisions would result in cumulative energy savings of at least 269 TWh by 2030.

Policymakers should be reassured that there is little evidence to suggest such revisions would have an adverse impact on product price. However, it may be necessary to support some manufacturers in adapting to higher performance requirements if a change in production is necessary – such as switching from compact fluorescent (CCFL) to light-emitting diode (LED) television technology.

Revise current strategy for developing energy efficiency Tiers

The current strategy being pursued by Chinese policymakers when developing energy efficiency standards has resulted in a large proportion of products qualifying for the higher efficiency levels, or "Tiers," with little apparent difference in efficiency. This means that consumers do not have the opportunity to preferentially select the most efficient products at the point of purchase. Moreover, there is limited incentive for manufacturers to develop higher efficiency products, since they will not be distinguished in the market.

Policymakers face challenges in revising the energy efficiency Tiers, as there is relatively little spread in efficiencies between products. Consequently, the lack of additional efficiency requirements makes it difficult to effectively implement additional policy support measures (such as subsidies) or to promote the most efficient products.

Therefore, policymakers may wish to consider a strategy whereby future revisions to the energy efficiency Tiers for all appliances will introduce new performance requirements such that:

- Tier 1 requirements are set at the efficiency level of the best performing appliance in the market at that time, thus creating the equivalent of a "Top Runner" target– i.e., the top 5% of products in terms of energy efficiency – to encourage the development of new high performance products; and as desired by policymakers under separate initiatives;
- The Tier 2 requirements dictate that only the top 10% of efficient appliances are eligible for qualification at the time the standard is introduced; and,
- The remaining products are evenly distributed across the remaining labeling categories.

Furthermore, an automatic revision of the Tier requirements should be initiated when 10% of products in the market achieve Tier 1 performance, or 25% of products achieve Tier 2 performance. This would ensure that higher efficiency products are continually differentiated from other appliances on the market.

Such a strategy would allow consumers to choose higher-efficiency products and allow policymakers to more effectively pursue other policy support measures that target the best performing products. This strategy is also in line with current (or likely) developments in other countries such as Australia, Canada, Korea, and Japan – where premium products are effectively identified in the market, or automatic standards revisions are undertaken when approximately 25% of products reach a level considered to define premium efficiency.

Reorient the focus of future subsidy programs

There is little doubt that the use of subsidies in support of efficient appliances has achieved the primary goal of stimulating national demand for the appliances and increasing their penetration into rural areas. However, there is some evidence to suggest that these subsidies have been less effective in promoting the development and adoption of higher efficiency products due to the large number of products that are typically eligible to receive subsidy support. In some cases, the subsidies have been supporting products that are highly efficient, yet still consume very high levels of energy. For example, LED-backlit televisions with very large screens may be highly efficient, but will still consume over twice as much power as a television of half the screen size.

Therefore, if policymakers want to continue the use of subsidies to promote energy efficient products, they may wish to consider:

- Only providing subsidy support for Tier 1 or higher products; or, if the current standard-setting strategy is revised in line with the study recommendations, including Tier 2 products if Tier 1 products are restricted to "Top Runner" status; and
- Setting a maximum cap on total energy that can be consumed by the appliance. This introduces the concept of sufficiency in addition to efficiency – i.e. not subsidizing expensive products of large size or volume, and/or those containing sophisticated but energy-consuming functions.

Make efficiency requirements technology neutral

Currently, a number of appliances with the same functionality qualify for differing energy efficiency Tiers and minimum performance requirements based on different technologies. For example, plasma display panel (PDP) and liquid crystal display (LCD) televisions, ceramic and non-ceramic rice cookers, and impeller and drum washing machines all have differing energy performance requirements – and in some cases, different test procedures. This is very likely to mislead consumers in the relative performance of the various appliance types and is likely to lead to inadvertent purchases of products that consume significantly more energy than necessary.

Therefore, the study strongly recommends that policymakers attempt to ensure that all appliance standards are based on technology-neutral test methods and performance requirements. It should be noted that some manufacturers may require additional policy support to shift production where their existing product range is adversely affected by the switch to a technology-neutral standard.

Research consumer usage patterns

How consumers use a product in real life in their homes directly impacts several factors used in the development of energy efficiency standards. It affects projections of energy consumption and saving potentials, the accuracy and relevance of test methods, and determines the actual energy used by the consumer in their household. Despite this, very little public information appears to be available on current consumer usage patterns for the majority of appliances in China. We therefore recommend initiating a research program to establish how individual appliances are typically used by households and with what frequency.

Revise labels to include actual energy consumption data

Currently, a number of the criteria displayed on energy labels are not assisting consumers in selecting the most efficient or lowest energy-consuming appliance. For example, the declared energy efficiency index (EEI) of televisions and the thermal efficiency of rice and induction cookers have little meaning to consumers and are unlikely to impact their purchasing decisions.

Using efficiency as a measure of comparative performance is not always beneficial. For example, a Tier 1 five-liter rice cooker will almost certainly use *more energy* than a Tier 4 four-liter rice cooker, but that information is not communicated effectively on the label. A consumer aiming to purchase efficient products may purchase the five-liter unit due to its apparent high efficiency, but ultimately that unit will consume more energy.

Therefore, the study recommends that a typical daily, monthly, or (ideally) annual energy consumption figure be included on the label for most products, similar to that which is used for refrigerators and copiers. This is already a nominal requirement of the energy labeling management rules.[124] In the longer term, the

[124] Clause 8 of the "energy label management rules" states "the label should include information of energy consumption."
http://energylabel.gov.cn/NewsDetail.aspx?Title=%e6%94%bf%e7%ad%96%e6%b3%95%e8%a7%84&CID=31&ID=137

calculation of energy consumption should be based on typical usage patterns established by consumer research.

Require energy labels to reflect typical product performance, and review allowable testing and labeling tolerances

There is evidence to suggest that some manufacturers are reporting energy performance values on appliance energy labels that are higher or lower than the typical performance of the model. This has the potential to lead consumers to select an appliance that is not appropriate for their needs or that fails to meet their expectations of energy consumption. It can also lead to the development of inappropriate revisions to the affiliated energy efficiency standard or hamper the development of a more appropriate one.

Therefore, the study strongly recommends that policymakers require declarations of energy efficiency and other performance indicators on an energy label in order to accurately reflect the true performance values reported in the test certificate submitted with the label application. This test certificate must represent the *typical* performance of the model under production conditions. Furthermore, once clarity is achieved in product claims, policymakers may wish to re-examine the tolerances, or allowable level of variance between test results, in test methods and labeling claims to ensure they are appropriate for each appliance type.

Revise some test methodologies and thresholds for performance

A number of potential shortcomings have been identified in the existing test methodologies for TVs, rice cookers, and induction cookers, such as the brightness setting in the television test methodology. Policymakers may wish to encourage revision of these test procedures – possibly through the adoption of existing and accepted international methodologies – to ensure that the performance of the appliance is represented accurately. This information is essential for consumer decision-making and for the development of appropriate policy measures.

Similarly, an issue has been identified in the use of a linear functions and adjusted volumes as the basis for regulation of refrigerated appliances. The current Energy Efficiency Standard is based on a linear function and adjusted appliance volume to derive the energy efficiency performance Tiers and the associated minimum energy performance levels. However, the use of such a linear function *and* adjusted volumes has the effect of increasing the price of smaller units and/or improving the apparent efficiency of larger appliances. Either (or worse both) of these outcomes is giving an incentive for consumers to purchase larger appliances which leads to higher overall energy consumption. The approach used in China is in line with current practice in the majority of countries around the world. However, Chinese policy makers may wish to consider a move to curved exponential functions based on adjusted appliance surface area as a basis for minimum performance and Tier thresholds. Such an approach would more effectively responds to the inherent increase in efficiency as product sizes increase, and removes the potential for the perverse outcome of increased unit volumes improving apparent unit efficiency but increasing consumption.

Consider a technical study examining variations in standby modes

In general, existing energy efficiency standards have some Tier or minimum performance requirement related to the "standby" of the appliance. Typically these standards refer to a single standby mode; for example, "off-mode power" where a unit is plugged into the main power supply but the appliance is switched off. However, with the advent of microprocessor control and additional appliance functionality, an increasing number of appliances have varying standby modes. For example, televisions have "fully off," "standby with no activity," instant "on" functionality, internet connectivity, and so on – all of which have varying levels of energy consumption that are not currently captured by existing Chinese test methodologies.

Therefore, policymakers may wish to conduct a technical study examining appropriate appliances to establish the type and extent of standby modes currently available. This study, in combination with consumer research on typical usage patterns, should identify any additional standby modes that result in significant energy consumption and are commonly used by consumers. The results can then be integrated into the testing and energy efficiency standards for that appliance. Similar research is underway in other parts of the world and there is a potential for Chinese policy makers to collaborate with, or learn from, these studies.

Improve the collection of sales data

The analysis in this report was conducted on a product basis rather than a sales weighted basis due to limited access to sales data. This study found although the results of sales and models analysis come close,[125] this has the potential to distort findings as, for example, particularly efficient or inefficient products may sell in significantly larger quantities than an average product on the market. If policymakers are similarly limited in their access to sales figures for products, it may lead to similar potential distortions in the analyses conducted for the development of energy efficiency standards and associated energy saving projections.

Therefore, policymakers may wish to consider following the examples of Australia, Canada, and Korea, and require suppliers of all appliances registered for sale within China to supply annual sales figures for those appliances, or to formally advise the China National Institute of Standardization that the products are not currently on the market.

[125] This study found the difference between analysis results based on sales and models is less than 10%.