Appliance Energy Efficiency Opportunities: China 2013

Appendices

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Contents

Appendix A:

Market Analysis of China Energy Efficient Products (MACEEP)

Extended Executive Summary

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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.

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 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

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

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, and washing machines. If policymakers choose to adopt all of the recommendations for these 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 per 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 7abelling 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, we strongly recommend 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

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.

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

[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

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.

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 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

[3] This study found the difference between analysis results based on sales and models is less than 10%.
[4] Energy Saving Potential (ESP) Study for Nine Appliances in China, CLASP 2013.

study, huge potential energy saving opportunities remain available to policymakers based on existing technology already on the market.

Appendix B:

Product Prioritization & Energy Saving Potential
Based on recent MACEEP-ESP and LBNL studies

Executive Summary

Kevin Lane (Oxford)

Energy consumption by appliances in Chinese homes is increasing rapidly. This is for a variety of reasons, such as the rise in consumer prosperity and the increasing number of households. The Chinese Government, through various agencies, has already begun to address this rise through a series of energy efficiency product policies, such as minimum energy performance standards (MEPS) and energy labeling on new products sold.

Two separate CLASP-funded studies have examined further potential for energy savings from improving appliance energy efficiency in China: *Potential for Further Savings from Appliance Efficiency Programs in China* by the Lawrence Berkeley National Laboratory (LBNL), hereafter referred to as "the LBNL study;" and *Market Analysis of China Energy Efficient Products* (MACEEP) by CLASP and Top10 China, which includes an energy savings potential (ESP) analysis. This will hereafter be referred to as the "MACEEP-ESP" study.

CLASP and its partners presented the MACEEP-ESP and LBNL studies, with accompanying policy recommendations, to the China National Institute of Standardization (CNIS) in 2013. Both were well-received, but CNIS raised some questions and concerns on the connections between both studies and how to reconcile the two different approaches to calculating energy savings. To avoid confusion and maximize the impact of both studies, CLASP and Kevin Lane (Oxford) initiated this study in an effort to summarize the findings of both analyses, provide an integrated overview, and provide recommendations on product prioritization and energy savings potential to Chinese policymakers.

The main objectives of this study are to:

1. Compare the MACEEP-ESP and LBNL approaches;
2. Re-run ESP analyses with scenarios to match LBNL;
3. Develop ESP models for water heaters (electric storage and gas instantaneous); and
4. Explain both sets of scenarios and summarize product prioritization and ESP from both studies.

The LBNL study

In 2012, LBNL, with support from CLASP, initiated a study of the energy savings and greenhouse gas reduction potential for six energy-intensive appliances: air conditioners, clothes washers, electric storage water heaters (ESWH), gas instantaneous water heaters (GIWH), refrigerators, and rice cookers.

The LBNL study describes and develops three scenarios using the Bottom-Up Energy Analysis System (BUENAS):

- Business-as-usual (BAU): what would happen to energy consumption with no further product policy;
- Continued improvement scenario (CIS): where the efficiency of new products improves every few years;
- Reach scenario (Reach): where all new appliances are as efficient as the best products in China or elsewhere by 2014 or 2015. This is not necessarily a realistic scenario.

The assumed efficiency values for the BAU and Reach scenarios are presented below.

Table 1: Efficiency assumptions for BUENAS BAU, CIS and Reach scenarios[5]

End use	BAU in 2015	Reach Target	CIS scenario
Air conditioners	GB-1 - 3.6 EER (market reaches GB-1 in 2012, held at 3.6)	Market Maximum EER=6.14	10% every 5 years from 2014
Clothes washers	0.0219 kWh/cycle/kg Top-Load, 0.193 Front-load - Linear trend for market shares	"GB-0 " - 0.007 kWh/kg/cycle for top-load, 0.15 for front-load	10% every 5 years from 2015
Electric storage water heaters	Efficiency 60.7 % (Linear trend from 2009-2010)	Heat Pump – 250% efficiency	10%** every 5 years starting in 2015
Gas instantaneous water heater	90% Heating Efficiency	96% Heating efficiency in 2030	6%* from 2015
Refrigerators	GB1 - 40% EEI (extrapolating 2009-2010 White Paper data leads to GB-1 in 2014)	19% EEI	4.5%, every 5 years starting in 2014
Rice cookers	82.3%	95%	4% every 5 years from 2015

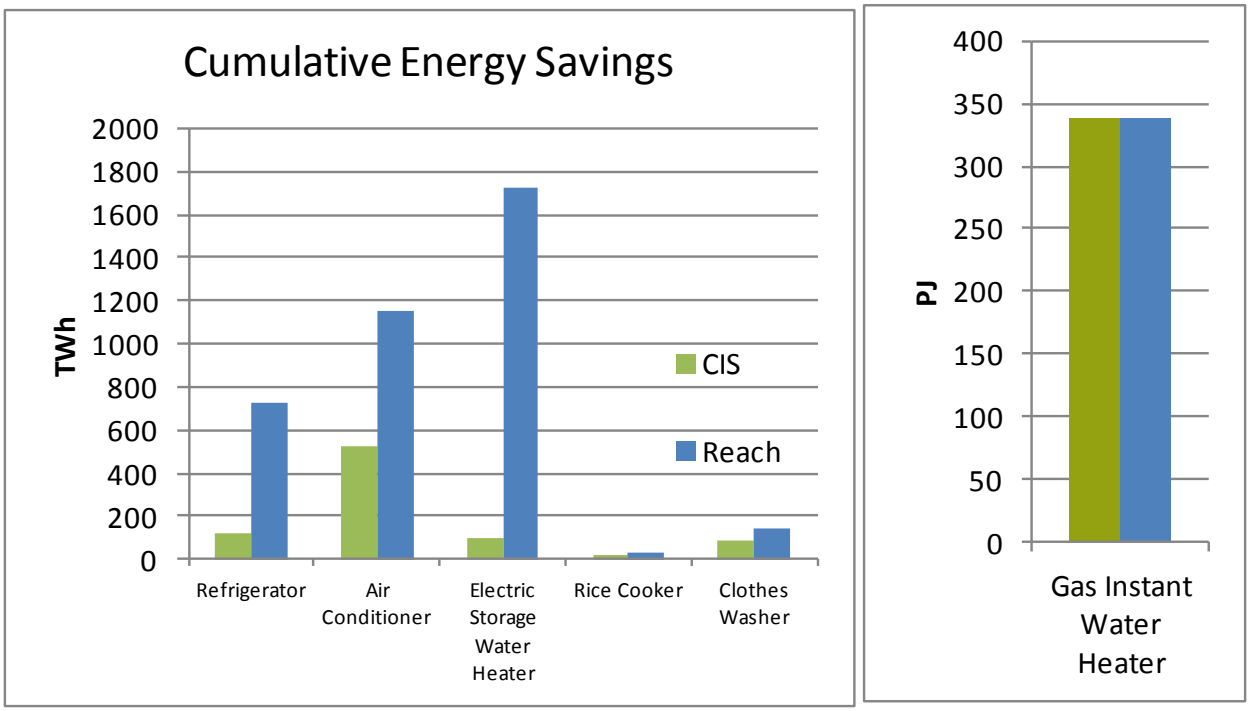
** The change in heating efficiency from BAU, not percent relative to baseline Unit energy consumption, it is first tier of the China GB standard.*

*** This is the reduction in fixed energy efficiency, starting with 50% in 2015.*

[5] Definitions for Table1: Energy efficiency ratio (EER), seasonal energy efficiency ratio (SEER), energy efficiency index (EEI)

The estimated energy savings from these scenarios is presented in Figure 1 below. From the LBNL study the magnitude of savings ranking order is clear. ESWH, followed by air conditioners (ACs) and refrigerators, show the greatest potential in the long term. In terms of improving policy measures, both ESWH and ACs result in more savings if the current labeling schemes were made technology-neutral. That is, variable speed drive (VSD) AC products should be directly comparable to fixed speed equipment. Similarly, electric heat pump water heaters should be compared on the same basis as electric resistant water heaters in any energy labeling scheme.

Figure 1: Cumulative energy savings to 2030



Source: LBNL (2012) study

The MACEEP-ESP study

In 2012, CLASP and Top10 China jointly implemented the MACEEP project. The project used market data to analyze the energy efficiency status of major appliances in the Chinese market and the energy saving potential of different policy interventions. Based on MACEEP data and other nationally available statistics, Kevin Lane (Oxford) conducted an energy savings potential analysis for eight products: fixed speed air-conditioners, variable speed air-

conditioners, induction cookers (or hobs), display monitors, refrigerators (including freezers and combined fridge-freezers), rice cookers, flat-panel televisions, and washing machines (primarily top-loading impeller and front-loading drum types).

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 measures, and the mandatory requirement that they all carry the China Energy Label. All are on sale in the Chinese marketplace.

The MACEEP study seeks to provide a range of national and international audiences with a transparent picture of the levels of efficiency and comparative energy consumption of a number of domestic appliances currently on sale in the Chinese market place. The research also seeks to provide suggestions on the policy interventions that could lead to improved efficiency and/or reductions in the energy consumption of these appliances in the future.

This study is centered on developing scenarios to show the expected impact from different policy measures. The three scenarios examined are:

- Business as usual (BAU): what would happen with no further product policy measures;
- Revised MEPS (MEPS2): what would happen with revised performance levels for standards and labels as recommended in the study;
- Best on Market (BOM): specifically, the most efficient on the current Chinese market. Additionally, the most efficient is weighted for all sizes so is a realistic average figure.

A summary of the market average performance levels of the two main energy-saving scenarios is presented in Table 2 below.

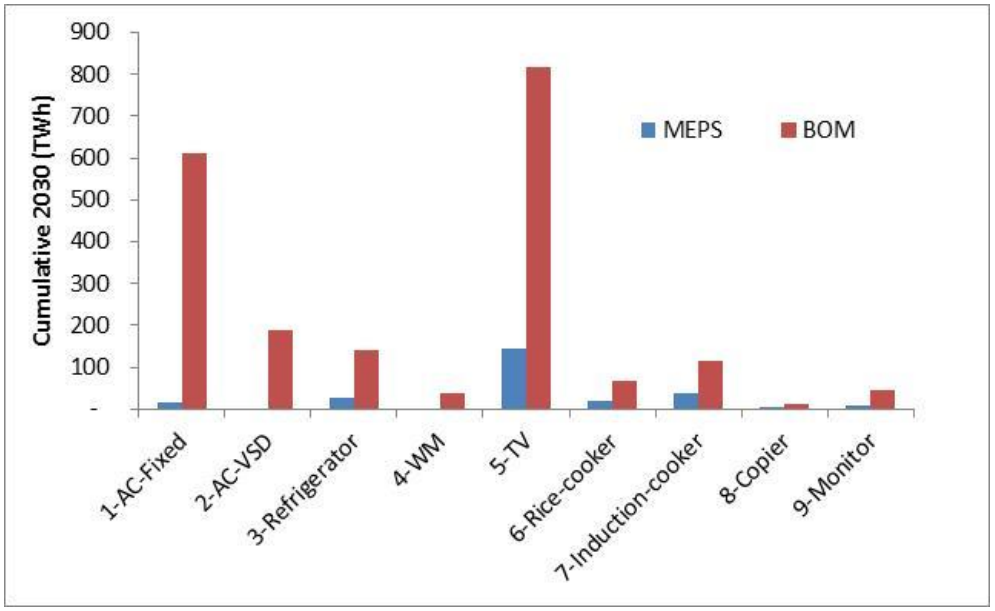
Table 2: Summary of products and scenarios (actual market average values)

Product	BAU (2012)	MACEEP scenario, MEPS2 (2014)	BOM (2014)
1-AC-fixed-speed	3.34 EER	3.45 EER	3.90 EER
2-AC-VSD	4.19 SEER	Na	6.45 SEER
3-Refrigerator	0.5kWh/day	0.45 kWh/day	0.3kWh/day
4-Washing-machine	Drum: 0.19 kWh/kg	-	Drum: 0.153 kWh/kg
	Impeller 0.018 kWh/kg	-	Impeller 0.011 kWh/kg
5-Television	On-mode 134 W Standby 0.5 W	On-mode 123W Standby 0.3 W	On-mode 89 W Standby 0.1 W
6-Rice-cooker	81%; 48Wh.h; 1.46W	83%, 48Wh.h; 1.5W	88%, 20Wh.h; 0.5W

7-Induction-cooker	86.2%; 2.1W	88.1%; 1W	90%; 1W
8-Copier	TEC= 5.96 kWh/week	TEC= 4.24 kWh/week	TEC= 2.43 kWh/week
9-Monitor	EEI=1.1; 0.62W	EEI=1.14, 0.5W	EEI=1.35; 0.16W

Based on the models developed, the estimated cumulative savings were identified, as shown below.

Figure 2: Cumulative energy savings to 2030, MACEEP-ESP study



From the MACEEP-ESP study the magnitude of savings ranking order is clear. However, not all of products examined were considered for further policy measures (MEPS) in this study. According to the MACEEP study, the largest theoretical potential (where all products sold from 2014 onwards reaches the best on the market) is to be found with televisions, followed by air conditioners, then refrigerators. Rice cookers and induction cookers provide less significant savings, with washing machines, monitors and copiers showing the smallest potential. When realistic next step policy options were examined by MACEEP, the achievable savings in the short term are significantly less than the theoretical BOM savings – quite understandably. In this MEPS case televisions show the largest potential, with AC equipment, refrigerators, induction and rice cookers all showing similar levels of achievable savings.

Further examination by the ESP study, provided additional important observations for policy makers:

- Incremental, single-iteration, short-term policies do not result in large amounts of energy savings, certainly not the theoretical savings from all products reaching the best on the market.

- Since the short term policy measures (MEPS) for ESWHs only realise a small potential shown by the BOM scenario, policy makers should be consider additional supporting policy measures, beyond simple ratcheting up of standards and labels, to significantly promote the efficiency in the longer term.
- Television savings are harder to realize and distinguish from multi-national policy and drivers. Efficiency improvements in televisions have been driven by the demand for slimmer televisions, which has coincided with lower energy consumption. Much of the efficiency improvement seen in televisions over recent years has been fortuitous, rather than a result of policy.
- The uptake of best practice AC-VSD could save significant amounts of energy, though care should be taken to only promote VSD technology, and not ban lower efficiency VSD products (which may be better than AC-fixed speed products still on the market).

Comparing the LBNL and MACEEP-ESP Approaches

As can be seen; the two studies were aiming to undertake similar tasks but were done on a slightly different basis. The main differences between the two studies are:

- The product coverage in each approach does not fully overlap. Two additional ESP water heater models were generated by Kevin Lane (Oxford) to ensure that the ESP models covered all the end-uses in both the MACEEP-ESP and LBNL studies.
- The LBNL and MACEEP models use different assumptions about ownership, sales, product use, etc., such that the two baselines may not match exactly (especially the water heating and refrigerator products).
- The energy-savings scenarios are conceptually different:
    - The BOM scenario represents the best (most efficient) products in China, while the Reach scenario represents the most efficient products in the world.
    - The MACEEP-ESP approach is a realistic, onetime policy analysis that is tied to practical policy suggestions, whereas the CIS scenario is designed to show continued improvement; thus, multiple iterations of policy analysis would be needed to deliver this scenario. These multiple policy iterations are not made explicit.

The scope and coverage of the products and scenarios by the two studies are shown below.

Table 3: Comparison of products and scenarios

Product	BAU (ESP)	MACEEP-ESP (ESP)	BOM (ESP)	BAU (LBNL)	CIS (LBNL)	Reach (LBNL)
1-AC-Fixed	X	X	X	X	X	X
2-AC-VSD	X		X			
3-Refrigerator	X	X	X	X	X	X
4-WM	X		X	X	X	X
5-TV	X	X	X			
6-Rice-cooker	X	X	X	X	X	X

7-Induction-cooker	X	X	X			
8-Copier	X	X	X			
9-Monitor	X	X	X			
10-ESWH	X		X	X	X	X
11-GIWH	X		X	X	X	X

Re-running savings scenarios

In order to compare all the products and scenarios on the same basis, they should be run using the same model. Where the MACEEP-ESP and LBNL products overlap, we have developed ESP models incorporating the LBNL CIS and Reach scenario values as best as possible.

The products that were identified as having the highest energy savings potential in the LBNL and MACEEP-ESP studies are evident here, though it is easier to read the savings from the equivalent table below.

Table 4: Cumulative energy savings to 2030 (TWh)

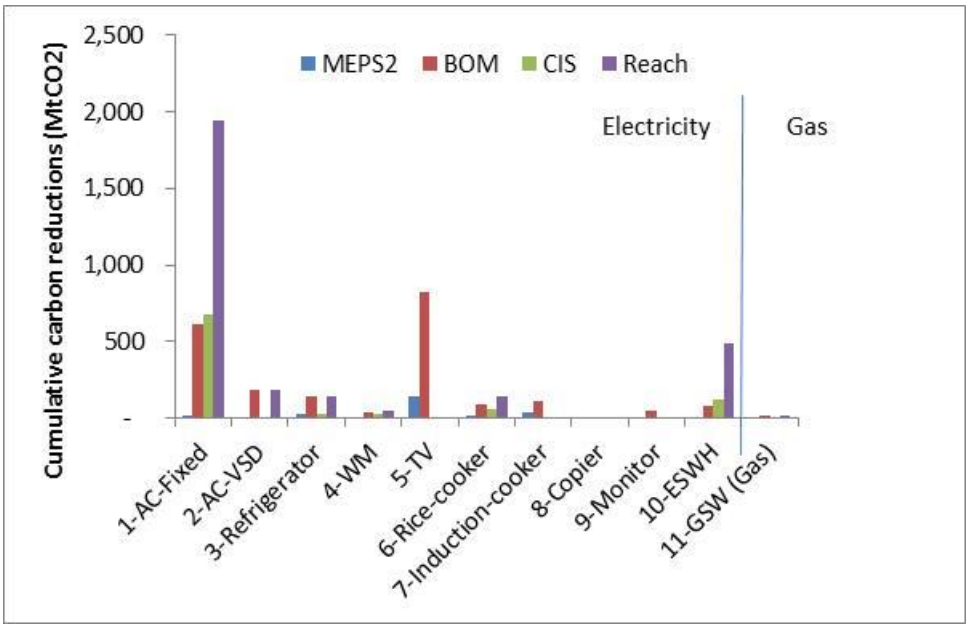
	MEPS2	BOM	CIS	Reach
1-AC-Fixed	18	610	673	1,933
2-AC-VSD	-	189	-	189
3-Refrigerator	28	142	23	142
4-WM	-	37	27	44
5-TV	147	816	-	-
6-Rice-cooker	21	89	58	148
7-Induction-cooker	40	117	-	-
8-Copier	6	11	-	-
9-Monitor	9	45	-	-
10-ESWH	-	82	120	490
SUM (ELEC)				

	269	2,139	901	2,946
11-GIWH (Gas)	-	95	60	95
SUM (ELEC, GAS)	269	2,234	961	3,041

Note that gas consumption by gas water heaters is also shown in TWh. The gas and electricity figures are shown as delivered or final energy consumption (not primary energy). Also, note that these scenarios are now calculated on the same basis. As a result, the AC-fixed cumulative energy savings are much larger than the LBNL approach implies, while for ESWH and GIWH, the LBNL model shows higher figures than displayed here.

Since the carbon emissions factor is higher for electricity than gas, it is useful to show the savings as CO_2 emission reductions, which is done in the chart below. Figure 3 demonstrates that the relative impact of gas is less than when comparing on a delivered energy (GWh) basis.

Figure 3: Cumulative carbon reductions to 2030



Main priorities

In theory, the three largest potential energy savers (as shown in the BOM and Reach scenarios above) are:

- ESWHs using heat pump technology;
- ACs, where the fixed speed units will be replaced by units using variable speed technology and VSD AC equipment will also be more efficient; and
- Televisions.

However, realizing many of these potential savings is challenging, and realizing the BOM or Reach target values for ESWH (especially) and the market uptake of AC-VSD will take longer. Additionally, current policy is not strongly driving improvements in the efficiency of TVs. There are other reasons (such as desirable slim-line displays coinciding with lower energy consumption) why televisions are increasing in efficiency, and they may continue to do so with less policy effort. Simply 'ratcheting up' energy performance levels by a fixed amount every few years is not the most efficient way of delivering the technology for these three products, and policy makers may need to consider other measures. These products are characterised by technology that has yet to become popular in the market, mainly due to high costs, which will fall over time, especially with policy support.

For these technology switches, other policy support measures should be considered. At a minimum, it is recommended that energy labels are made technology-neutral, so that products may be compared on the same basis. Both ESWHs and ACs would benefit from this type of change. That is, variable speed AC products are directly comparable to fixed-speed products. Similarly, electric heat pump water heaters should be compared on the same basis as electric resistant water heaters in any energy labeling scheme.

Given these considerations, we recommend that policy makers prioritize products for policy actions as shown above in Table 4, with AC and water heaters being the highest priority.

Furthermore, from this analysis, washing machines, rice cookers, copiers, and monitors do not provide many short term savings. However, if the changes to regulations are easy to make (from a policymaker perspective) then these product policies could still be considered for revision.

Note that this prioritization assessment is based on the size of energy savings and carbon emission reductions, as well as the likelihood of those savings being realized. However, policymakers may also take other factors into account in choosing to prioritize products and policy measures, which include:

- The product's impact on peak load (not just total energy consumption), since this implies additional plant for only short periods of time. In this instance air conditioners become more important for China, where there are summer peaks in load;
- Ease of the supply side (manufacturers) to meet the challenge of improved performance levels;
- Secondary benefits, which support other policy targets (such as social programmes on thermal comfort, employment in certain manufacturing industries);

- Costs to government or consumers for the raised performance levels (whether up-front costs or life-cycle); and
- Time and effort of regulators.

Finally, there is also a need for improved evidence. This is especially the case for understanding the in-home use of appliances, with the greatest emphasis on water heaters which has a large variation in likely use and significant energy savings potential.

Appendix C:

Impacts of China's Energy Efficient Appliance Subsidy Program on Customer Behavior

Executive Summary

Yang Yu, CLASP
All China Marketing Research (ACMR)

Over the past few decades, China's burgeoning economy has resulted in significantly accelerated urbanization and a notable increase of disposal income among Chinese citizens. With the rapid economic development, China's energy consumption has risen at an extraordinary rate. Domestic electricity consumption grew 43% between 2008 and 2012,[6] and sales of appliances have skyrocketed. In 2010, China surpassed the United States as the world's largest energy consumer.

The Chinese Government recognizes household appliances as one of the primary contributors to overall energy consumption. Since the 1980s, it has implemented a series of measures to improve household appliance energy efficiency and facilitate market transformation towards more energy efficienct products. To date, China has implemented 48 minimum efficiency performance standards (MEPS) for energy-using products. In 2005, the government introduced the China Energy Label, a categorical mandatory energy information label adapted from the EU's categorical energy label. The label categorizes appliances into three or five tiers of efficiency, with Tier 1 being the most efficient and Tier 5 (or Tier 3) being the least efficient. Tier 5 (or Tier 3) aligns with the minimum energy efficiency required for a product to enter the Chinese market. As of 2013, the China Energy Label is displayed on 29 types of products, covering all major household appliances.

In order to further facilitate market transformation, the Chinese government also launched a series of incentive programs. In the past, such programs included the *Appliances to the Rural Areas Program* in 2008, the *Promoting Energy-Efficient Appliances for the Benefit of People Program* in 2009, and *Appliances Trade-in Program* in 2009. In the executive meeting chaired by Premier Wen Jiabao on May 16, 2012, the State Council decided to commit 26.5 billion RMB ($4.26 billion) to the newest phase of the *Promoting Energy-Efficient Appliances for the*

[6] Enerdata, Global Energy Statistical Yearbook 2013. http://yearbook.enerdata.net/electricity-domestic-consumption-data-by-region.html

Benefit of People Program –hereafter referred to simply as "the subsidy program." This program aimed to subsidize energy-efficient appliances – specifically Tier 1 and/or Tier 2 products. It covered six categories of household appliances, including air conditioners, TVs, refrigerators, clothes washers, water heaters and desktop computers. It was launched on June 1st, 2012 and scheduled to end on May 31st, 2013.

This program was the latest and by far the largest incentive program implemented by the government that aimed to improve the energy efficiency of end-use electric products and promote their use. However, no studies had been conducted to assess the effectiveness and impact of this or similar programs from the perspective of consumers. In 2012, CLASP and All China Marketing Research (ACMR) aimed to fill this gap by conducting a consumer survey in 10 cities across different socioeconomic strata in China.

The primary objectives of the survey were:

- To investigate consumers' behavioral characteristics in energy efficient appliance purchases;
- To assess the levels of awareness the subsidy program raised; and
- To study the relationship between the size of the subsidy and consumers' expectations under different purchase scenarios.

Based on the results and analysis of the survey, we attempted to formulate a set of practical policy recommendations for future policy design and implementation.

Methodology

The project team designed a detailed questionnaire to evaluate the impact of the subsidy program among consumers. The questionnaire consisted of three major components. The first component examined consumers' purchase behaviors. This encompassed the factors that consumers consider the most when purchasing an appliance, whether or not they purchased energy efficient (EE) appliances,[7] and the primary reasons for consumers to choose or not choose EE appliances.

The second component assessed consumers' level of awareness about the subsidy program. Consumers were asked whether or not they had heard of the program, whether they could name all six subsidized product categories, whether they knew the size of the product subsidies, and their general response to the subsidy programs. The third component investigated consumers' willingness to pay for efficient appliances and attempted to quantify consumers' expectations about the size of the subsidy under different purchase scenarios. The questionnaire was distributed to consumers in ten cities across China. The total number of consumers interviewed was 15008, among which 2630 completed the survey. These 2630

[7] Energy efficient appliances are defined in this study as appliances with Tier 1 and/or Tier 2 energy ratings.

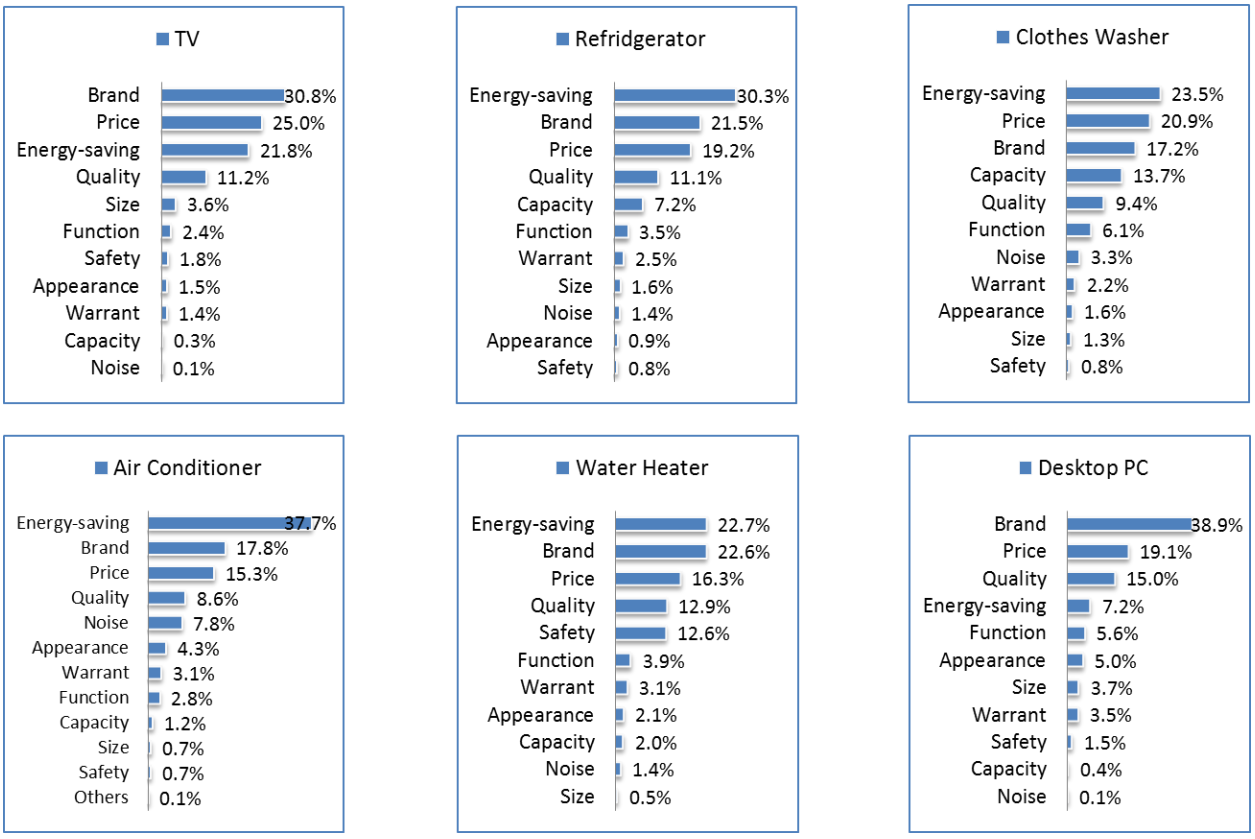
respondents will be referred as “successful samples” in the following sections; most of the analysis was performed based on the successful samples.

Results & Discussion

Behavioral Characteristics of Consumers

A number of important factors that could potentially influence a consumer’s purchase decision about particular types of appliances were investigated. For each type of appliance, survey participants were asked to select the most important factor they would consider when making a purchase. Generally, energy saving was among the top three factors for all appliances, except for desktop computers and televisions. Brand and price were the top considerations for most consumers on TVs and desktop personal computers (PCs), while a large proportion of consumers considered energy saving to be most important factor for heavier energy-consuming appliances such as refrigerators and air conditioners.

Figure 4: Factors influencing consumer purchasing decisions



Numbers are in percentages of consumers, where N=2630

Of the surveyed consumers, 75% had purchased appliances in the past six months, while 25% planned to purchase a new appliance in the next three months. Among those who had purchased appliances (1723), 87% of participants chose energy efficient appliances. A majority of these consumers (53%) considered electricity saving to be the primary reason for choosing efficient appliances, whereas 26% of consumers indicated that they would choose an efficient appliance due to their awareness of environmental and energy conservation.

It appears that Chinese consumers' decisions about whether or not to purchase energy efficient products was not greatly affected by the subsidy program. Only 13% of consumers who participated in the subsidy program (1723) indicated that the subsidy program was the primary reason for them to purchase energy efficient appliances. Saving energy appears to be the primary reason for most Chinese consumers to select energy efficient appliances, because they can save money on their electricity bills. The subsidy program, on the other hand, was not a top consideration for consumers. The continual increase in electricity prices[8] and the long life-span of the appliances stood out as two potential reasons for this result.

However, when consumers were asked to rate the influence of the subsidy program on their purchase decisions, the average ratings were between 3.7 and 4.1 (5 being the highest influence), indicating that the subsidy program still constituted a significant influence on consumers' decisions. Subsidies could act as a catalyst in energy efficient appliance purchases and speed up planned purchases. Sometimes the mere existence of a rebate made consumers more willing to choose higher efficiency practices because they could feel more comfortable about the promised energy efficiency.[9]

Program Recognition and Awareness among Consumers

Among the 15008 consumers interviewed in total, 62% had heard of the subsidy program. Among the successful sample, 58% had seen the subsidy program label. However, most of participants were found to lack in-depth knowledge of the subsidy program. Only 10% were able to name all six types of appliances covered by the program, while most only knew the subsidy size for one type of appliance or did not know the subsidy size at all. We also found that consumer awareness of the subsidy program was lower in fourth-tier cities compared to others, indicating that regional and socioeconomic status could potentially affect the consumer awareness.[10]

These results indicate that while the subsidy program raised a considerable level of awareness among consumers, there were still a large number who were not aware of the program or lacked detailed knowledge of it. It should be recognized that increasing awareness

[8] Huang, S. (2009). Review and outlook of china's electricity tariff reform - dedicated to the thirtieth anniversary of reform and opening-up. [In Chinese] *Price: Theory & Practice*, (5)
[9] Train, K. E., & Atherton, T. (1995). Rebates, loans, and customers' choice of appliance efficiency level - combining stated and revealed-preference data. *Energy Journal*, 16(1), 55-69.
[10] Chinese cities are classified into four tiers, with the first tier comprising the most socioeconomically advanced cities, such as Beijing, and the fourth tier comprising smaller cities such as Jiangmen.

about energy efficiency programs has historically been a gradual process. In 2000, for instance, only 40% of American consumers were aware of the US ENERGY STAR program, but this awareness increased to 60% by 2005 and exceeded 80% of the population in 2011. Compared to the progress of the ENERGY STAR program, current consumer awareness of China's subsidy program is satisfactory but still has room for improvement.

In terms of communication channels about the subsidy program, a majority of participants learned about the program through media in retail stores and/or referral from friends or relatives. Retail store media included program posters, signage, advertisements, pamphlets, and introduction by sales staff. Although the online shopping boom continued during the past few years in China, consumers still chose to visit retail stores to shop for appliances. Therefore, enhancing program promotion and dissemination in retail stores could potentially improve the program's effectiveness.

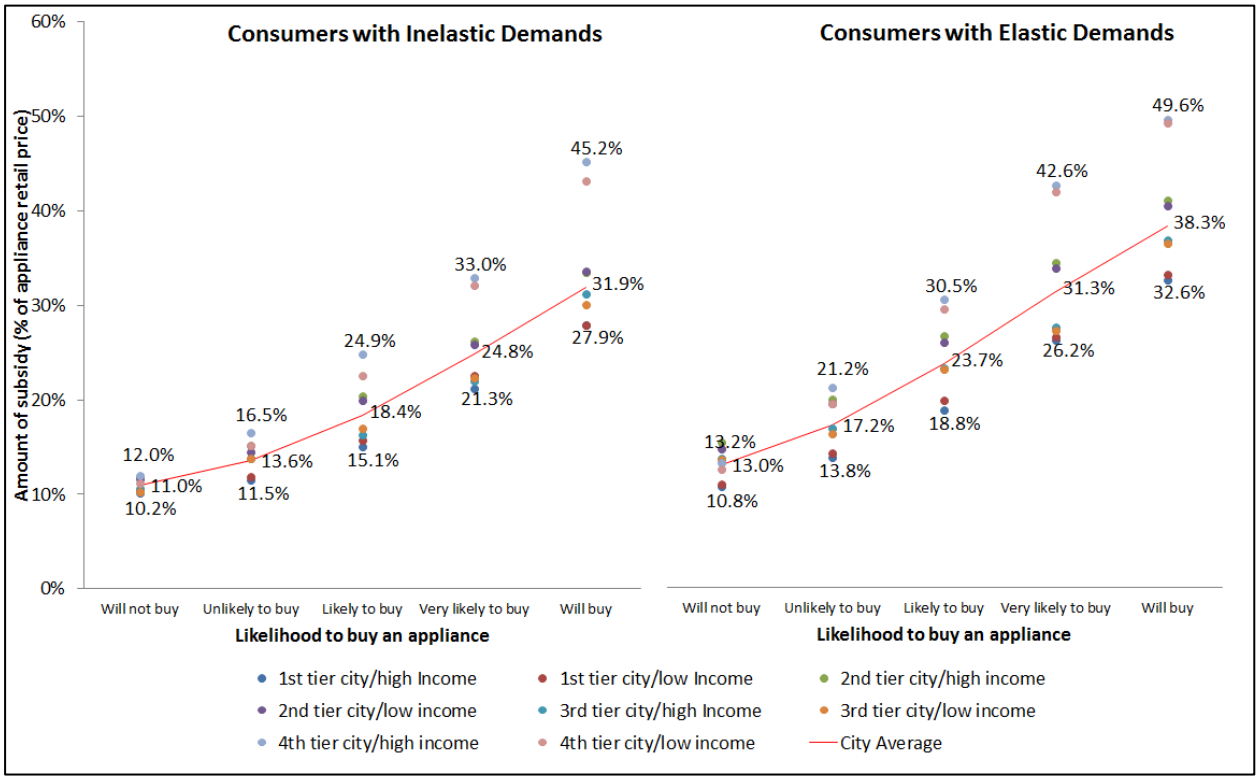
Size of the Subsidy and Consumer Expectations

Consumers were first asked whether they were willing to pay more for energy efficient appliances and then asked about their expectation of subsidy's size. Compared to inefficient appliances, 86% of Chinese consumers claimed that were willing to pay extra for energy efficient appliances in various amounts. The extra cost that most consumers were willing to pay was below 10%. Hence, we expect that a larger incentive will be needed to actually alter Chinese consumers' purchase decisions.

When studying the expectations for the subsidy size, all surveyed consumers were given two hypothetical scenarios. The first was inelastic demand, under which the consumers needed to purchase new appliances, possibly for the reason that their old appliances broke down or they needed new ones for a new home. The second scenario was elastic demand. Under this scenario, consumers had the flexibility to choose whether or not to purchase new appliances. For example, they might consider replacing a functioning old TV with a new one, or they might consider adding a secondary TV for their bedroom.

The likelihood that consumers would purchase energy efficient appliances was found to increase with the size of the subsidy under both scenarios, as illustrated in **Error! Reference source not found.** below. The consumers with elastic demands required more incentive than those with inelastic demands. On average, when the size of the subsidy reached 24.8%, consumers with inelastic demands would become very likely to buy energy efficient appliances. In comparison, consumers with elastic demand expected a 31.3% subsidy before they become very likely to buy energy efficient appliances. Strong regional effects were also apparent; the expectations of consumers in smaller cities were much greater than those in bigger cities.

Figure 2: Likelihood for consumers to buy appliances under different scenarios



The size of the subsidy used in the program ranged from 4% to 12% for refrigerators, air conditioners, and TVs. In a study conducted in June 2012, Top 10 China suggested that consumers will have a clear propensity to purchase efficient appliances when the size of the subsidy is equivalent to 20%~30% of the retail price.[11] An Austrian appliance turn-in program offered both initial investment rebates and payments for kWhs saved, and the rebate was the greater value of either 20% of the initial electricity bill or 20% of the cost of the new appliance.[12] It appears that the 2012-2013 Chinese subsidies were rather small compared both to the expectation of Chinese consumers and other international practices.

Conclusions and Recommendations

Overall, our analysis suggests that the Chinese National Subsidy Program raised a moderate level of awareness among Chinese consumers about available subsidies, but in general consumers lacked in-depth knowledge about the program. As such, we recommend that Chinese policymakers enhance marketing, advertising, and outreach of the program by taking the following actions:

[11] Top10 China, http://www.top10.cn/news/110/256/Top10-265.html
[12] Haas, R. (1996). Some empirical findings of an Austrian appliance turn-in program. *Energy 21(1), 55-60. doi: 10.1016/0360-5442(95)00085-2*

Allocate more resources to public outreach

A sufficient budget for public awareness campaign is essential for the success of an energy efficiency program. As noted above, the U.S. ENERGY STAR program cumulatively spent over $2.5 billion USD on advertising through December 1999, reaching over 1 billion consumers. To achieve similar success, Chinese policymakers should set a sufficient budget for expanded outreach activities.[13]

Use various types of media

Although the program has achieved success by reaching out to consumers who shop in retail stores, policymakers should diversify communication channels for the program – e.g. print media and television commercials – in addition to expanding retail store promotions. Such a campaign would not only increase public awareness of the subsidy program, but also promote greater recognition and purchase of efficient appliances generally, which would greatly contribute to the eventual transformation of the appliance market towards higher energy efficiency.

Increase outreach to lower-tier cities

Compared to other cities in higher tiers, consumers in 4th tier cities have a lower level of awareness of the program; therefore, we recommend that policymakers enhance the promotion of energy efficiency programs in 4th tier cities.

Additionally, we found that Chinese consumers' willingness to pay for more efficient appliances was low, and their expectation for subsidy levels was high. Compared to their expectations, the current size of subsidies is rather small. As such, we recommend that Chinese policymakers:

Only subsidize appliances with efficiencies at Tier 1 or higher

With the total program budget on incentives unchanged, it would be more cost-effective to only subsidize appliances with Tier 1 or higher energy efficiency instead of subsidizing both Tier 1 and Tier 2 appliances; and

Increase subsidy amounts to 20% - 30% of the retail price

to meet the consumer expectations.

[13] The budget allocation of China's subsidy program was not available to the public, and whether or not the program had specific budget for public awareness is unknown.

Appendix D:

Benchmarking of Refrigerator-freezers and freezers among China, the UK, and Canada

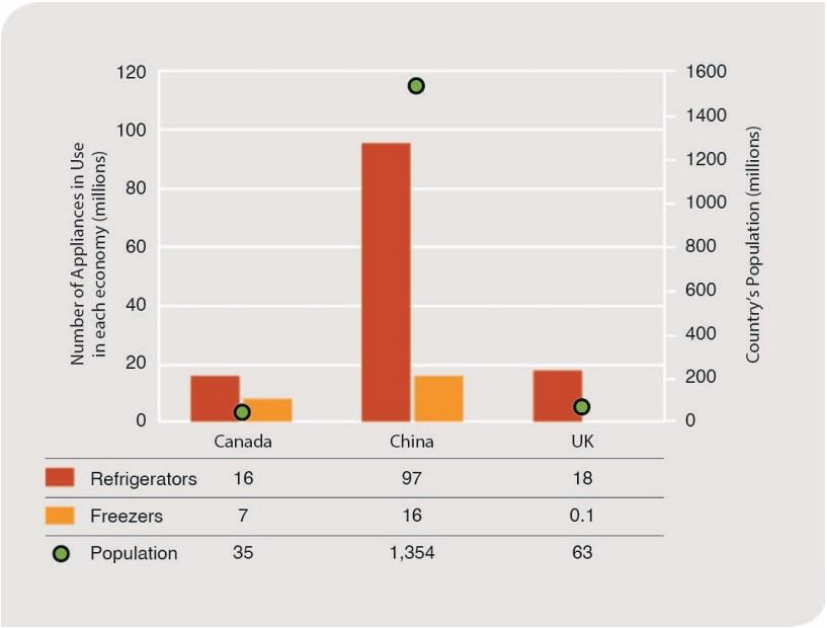
Summary for Policymakers

Stricker Associates, Inc.

Defining the maximum allowable energy consumption for refrigerators, refrigerator-freezers, and freezers is challenging because of variations in size, configuration, operating modes, controlled temperature, ambient operating temperature, and power input voltage and frequency. Moreover, it is difficult to compare refrigerator energy performance and efficiency policies across economies due to variations in test procedures and efficiency metric formulas.

Although many countries have selected international standards for measuring the performance and efficiency of these products, others have adopted their own systems of rating and labeling them according to their energy consumption. CLASP and Stricker Associates conducted this benchmarking analysis to provide comparison of test procedures and calculation methods used in China, the United Kingdom, and Canada.

Figure 1. Number of refrigerators and freezers in use and country populations (2008)

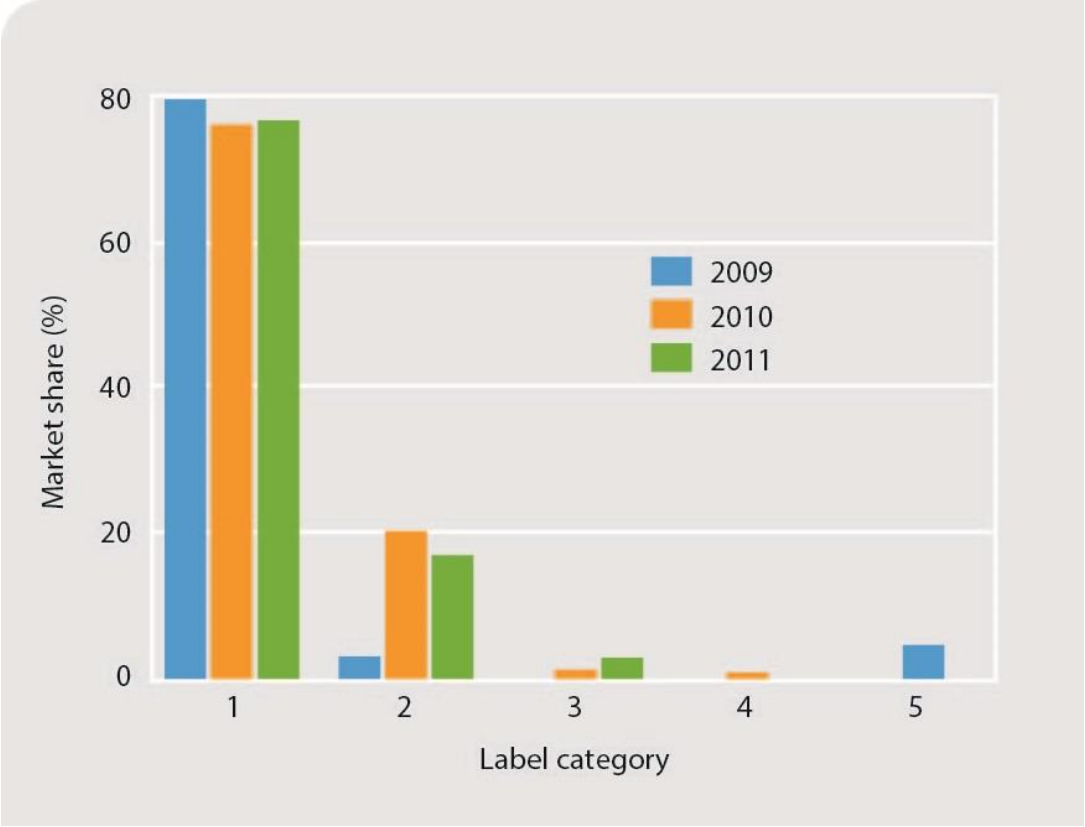


Based on IEA 4E Mapping Documents for Canada, China, and the UK

Rationale for improving refrigerator efficiency in China

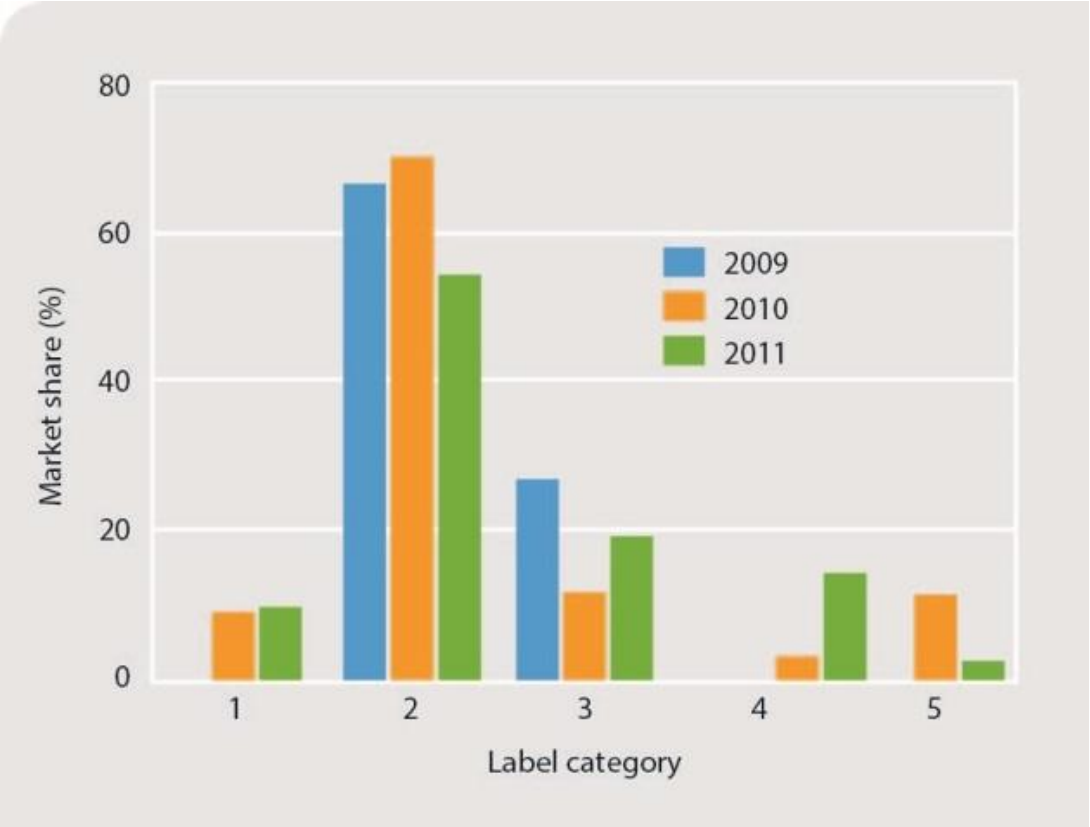
Benchmarking China's refrigerated appliances is important because China's manufacturing base and market for refrigerators are the largest in the world, and are expanding at a fast pace. Refrigerator performance has improved slightly in China since the last revision of minimum energy performance standard (MEPS) levels and labeling in 2009. As shown in Figures 2 and 3 below, the vast majority of currently available models qualify for the two most efficient levels, Tier 1 and Tier 2.[14] This indicates that readjusting Tier levels would further differentiate the energy efficiency of models, and thus encourage the industry to further improve efficiency.

Figure 2: China refrigerators-freezers energy efficiency level distribution from 2009 to 2011



[14] CNIS White paper for the energy efficiency status of China energy-using products, 2011-2012.

Figure 3. China freezer energy efficiency level distribution from 2009 to 2011



Refrigerator Test Procedures

Several main factors affect the 24-hour energy consumption of a refrigerated appliance:

- Ambient temperature;
- Controlled temperatures;
- Loading of the freezer compartment; and
- Power supply to the unit.

In general, refrigerator test procedures in all countries included in this study have the following elements in common:

- Measurement of the 24-hour energy consumption of refrigerated appliances under a standard set of conditions;
- Particular calculation protocols to specify the minimum energy performance allowable for each product according to its class, size, and features;

Differences in test protocols can cause variations in results. Each country sets minimum energy performance requirements according to their own criteria, resulting in different calculations of the base or standard energy consumption.

Refrigerator test conditions in China, the UK, and Canada

The differences in test conditions between China and the UK are small: mainly, there is a difference in loading of the freezer compartment for the 24-hour energy consumption test. However, the variation of consumption between partly and fully loaded freezer compartments is likely to be small. Therefore, a good correlation can be developed between the Chinese standards and the UK standard for Chinese product types 4, 5, and 7.[15]

Correlating Chinese standards and the Canadian standard is much more challenging. The main differences in test conditions are:

- Supply voltage and frequency;
- Controlled temperature settings;
- Ambient temperature;
- Use of the anti-sweat heater;
- Consideration of type of defrost control used in the calculation of 24-hour energy consumption; and
- Two factors — the "usage factor" and "adjustment factor"— that are used in the Canadian test procedure but not in the Chinese test procedure.

[15] In China, there are 7 types of refrigerated appliances for domestic use; the most popular types are 4, 5 and 7. These categories are used to define maximum allowable values of energy consumption and classifications in the energy efficiency label.

Type 1 - Refrigerator only

Type 2 - Refrigerator with a 1-star compartment*

Type 3 - Refrigerator with a 2-star compartment*

Type 4 - Refrigerator with a 3- star compartment*

Type 5 - Refrigerator-Freezer with a 3-star compartment

Type 6 - Frozen food holding cabinet (has very limited freezing capability)

Type 7 - Freezer (with a specific food freezing capability)

Variations in calculating minimum allowable energy performance

In addition to differences in the test conditions for measuring the 24-hour energy consumption across the three countries, there are also variations in the methods for calculating the minimum allowable energy performance for each category in each country.

The general formula provided in regulations to calculate the minimum allowable energy performance (or Base Energy Consumption) for a product type begins with the linear equation:

Base Energy Consumption (BEC) = M * "adjusted volume" + N

In this formula, the slope "M" determines how much more energy is allowed as the adjusted volume increases, and "N" is the y-intercept. The slope "M" of the line representing the BEC has a significant effect on the relative efficiency of small versus large appliances.

Regulators can then apply simple "adjustments" to this formula by adding or multiplying factors to account for various energy-consuming features built into certain appliance models, such as icemakers or adjusted volume thresholds that affect energy performance.

By using different product type classifications and adjustments for energy-consuming features, regulators can meet requirements for flexibility, fairness and clarity of the regulations.

Comparison of MEPS levels across economies

The two following figures compare MEPS in China with requirements in other major economies around the world.

For refrigerator-freezer combinations, the MEPS in China falls near the average for small appliances, but for large appliances the China MEPS allows more energy consumption than the other economies.

For chest freezers, the MEPS in China allows more energy consumption for all size appliances. Because the slope of the MEPS in China is steeper than the other economies, the gap between China and the other economies is bigger for larger appliances.

Figure 4. Normalized maximum allowable energy consumptions for refrigerator/freezer combinations

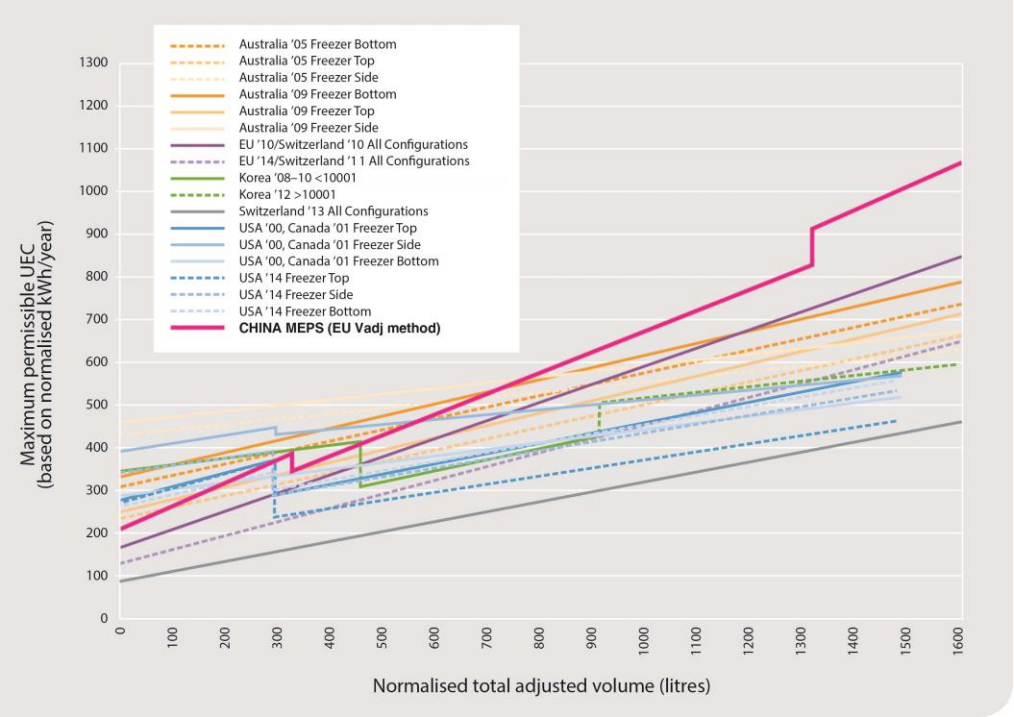
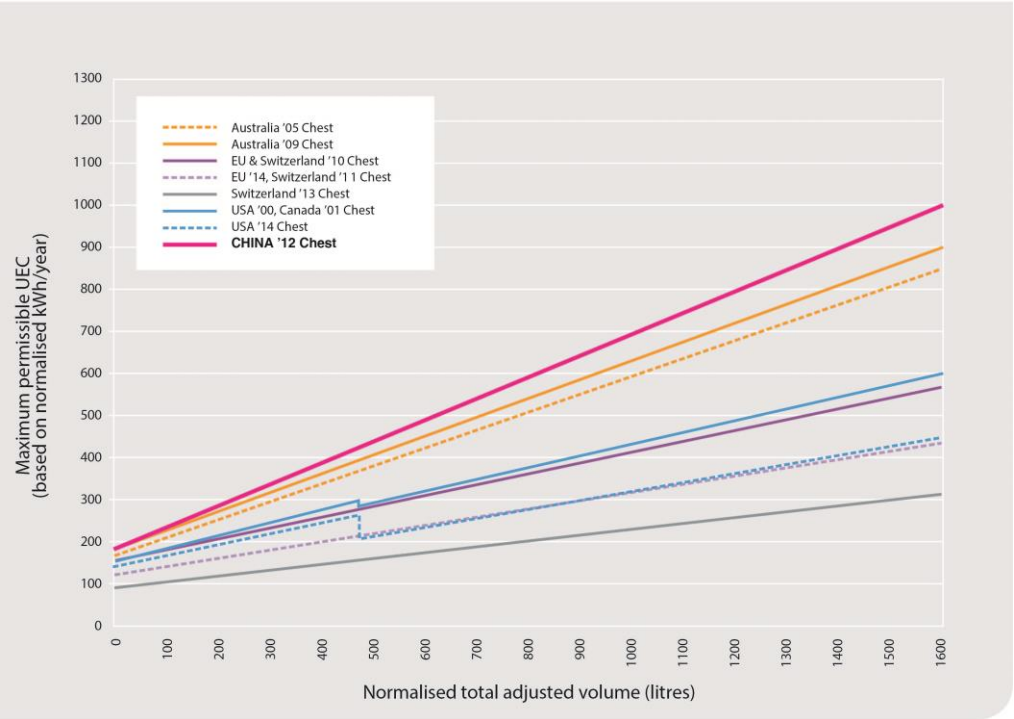


Figure 5. Normalized maximum allowable energy consumptions for chest freezers



Energy performance criteria are more stringent in the UK

For both refrigerator-freezers and chest freezers, comparing the daily energy consumption requirement for the highest grade levels, the UK (A+++) is the lowest, followed by China (Tier 1), and last by Canada's "high energy efficiency" level (ENERGY STAR).

BEC values are quite different between China and the UK, and the energy efficiency classes for labeling purposes use different levels in each country. In addition, the slope "M" is steeper in China, suggesting that the China levels are less stringent for the large volume units than the smaller volume units.

Recommendations for Policymakers

Based on the findings of this analysis, CNIS may wish to consider the following recommendations.

1. The MEPS levels for China should become more stringent over time. The slope of the line representing MEPS and Tier levels in a way determines the relative "efficiency" of small vs. large appliances. The difference in the slope of efficiency requirements between China and other countries suggests that the China levels are less stringent for large volume units than smaller volume units.

2. We recommend the adoption of suitable, common international standards and/or test methods in order to avoid re-testing products for export markets, as well as to facilitate the comparison of performance across economies.

3. China should consider adopting more stringent tier levels that closely match the UK's A+++ level for both refrigerator-freezers and chest freezers.

4. A classification of refrigerator-freezers by configuration (top- side- or bottom freezer) should be considered because there are definite differences in efficiency levels among the various configurations.

5. Ice-making and through-the-door ice service should also be considered as an additional basis for classification, considering that these features are growing in popularity with consumers.

6. Tropical climate appliances, if fairly common for use in China, should also be considered for a separate set of classifications. Otherwise, just rating a product as being "T" class can provide a loophole to manufacturers to produce less efficient models.

Recommendations 4 through 6 could result in the elimination of three adjustment factors. China currently has seven product types, the UK 10 types, and Canada 22 types (to be increased to 42 types in 2014). In general, when more appliance types are defined, then

fewer adjustment factors need to be developed and applied for calculating the base performance and tier level. When built-in models become more popular in China, a new built-in category should be considered.

7. If an adjustment factor is needed, it is recommended that it be formulated to apply to the entire linear equation rather than to the calculation of adjusted volume to avoid a further volume bias.

8. The measurement of performance should include the use of anti-condensation heaters during testing not only to provide a more realistic measurement, but also to motivate the industry to employ more efficient or effective means to control surface condensation.

Appendix E:

Benchmarking of Clothes Washers between the Chinese and European Markets

Executive Summary

Christopher Evans, Consumer Research Associates (CRA)
My Ton, CLASP

Since China's first minimum energy performance standard (MEPS) for domestic clothes washers was issued in 2004, the rapid development of technology and aid of government financial incentives has significantly driven up the energy efficiency (EE) levels of products currently available on the Chinese market. As a result, the 2004 standard is no longer keeping pace with market shifts, and a more stringent standard is required to continue pushing the clothes washer market towards higher energy efficiency.

In 2012, CLASP and Consumer Research Associates (CRA) partnered to conduct a benchmarking comparison of clothes washer energy efficiency performance, policies, and test methods. The main objective of this benchmarking analysis is to assist the China National Institute of Standardization (CNIS) in revising efficiency requirements for future clothes washer energy performance standards in a transparent and technically valid manner that is consistent with international best practices. This study also provides CNIS with an opportunity to compare Chinese test methodology, laboratory practices and EE policies with those in the EU. The results of the comparison will assist CNIS in determining whether the adoption of an international standard or test method could become appropriate for China in the future.

Many countries and regions, including the European Union (EU), use International Electrotechnical Commission (IEC) test standards and methodology as the basis for measuring the performance of clothes washers in developing MEPS and labeling requirements. Others, including China, have adopted their own systems for testing methodology, rating and labeling washers according to their energy consumption levels. Variability among products between the Chinese and EU markets, as well as the differences in test methodology and performance metrics, make the evaluation of washer energy efficiency and performance across markets a very complex task.

Due to the absence of reliable data about the Chinese market, a benchmarking comparison of clothes washers between China and other economies has not been undertaken previously. For

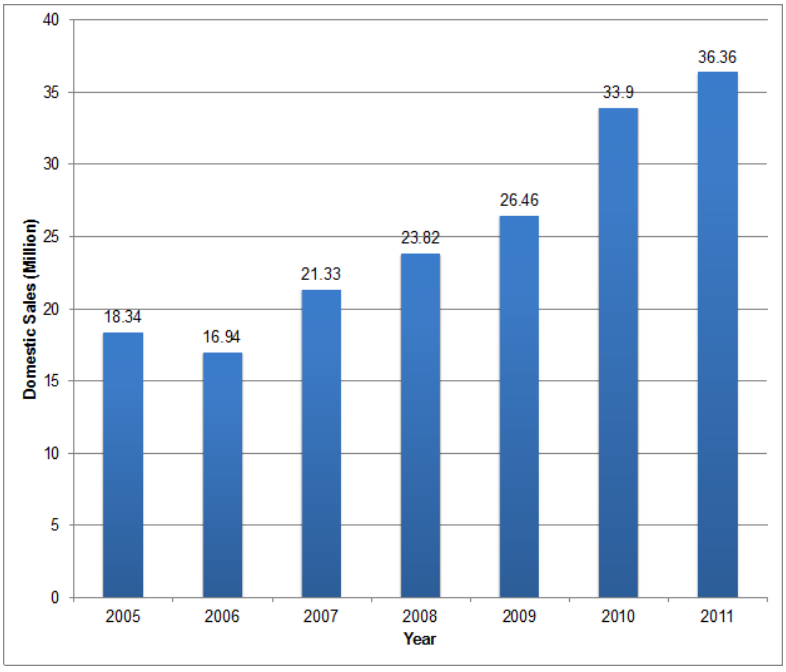
the purposes of this study, CLASP, CRA, and CNIS mapped the Chinese and EU clothes washer markets, selected representative machines, and conducted cross-market testing for the first time. CNIS also wished to compare China's test methodology with the EU's and wanted their testing staff to be trained in the EU methodology so that it could be replicated in CNIS' clothes washer test laboratory. A training component was therefore included in the testing phase for this study.

Comparing clothes washer performance across the EU and Chinese economies requires that tested models have comparable functionality, and that equivalent performance bases are used – e.g. energy consumption, water consumption, and cleaning performance. Our study achieves this equivalent basis by comparing test procedures and calculation methods *for front-loading washers only*, using the Chinese test methodology (GB/T 4288-2008 - GB 12021.4-2004) and the EU test method (EN60456:2011, which is based on IEC 60456:2010).

China's Clothes Washer Market

Washing machines are an important product, as households in China increasingly consider them a necessity. Consequently, as income levels rise, particularly in rural areas, the total stock of installed washing machines continues to rise. Based on projections by CLASP and Top10 China, approximately 367 million washing machines were installed across China by the end of 2012. This stock is expected to rise to 474 million in 2030.[16] Figure 1 below demonstrates the increasing annual sales of clothes washers between 2005 and 2011.

Figure 1: Annual sales of washing machines in China (2005-2011)



Source: China Industry On-line (www.chinaiol.com)

[16] *Market Analysis of China Energy Efficient Products*, CLASP and Top10 China, 2013.

There is some variation between the EU and Chinese markets for domestic washing machines (hereafter referred to as "clothes washers" or simply "washers"). The EU market has long been dominated by front-loading, horizontal drum washers with integrated water heaters. Top-loading (impeller) machines with no integrated water heaters are currently the most popular washers in the Chinese market, accounting for 57% of sales reported in 2012. Like many countries elsewhere, however, China's clothes washer market is now seeing increasing sales of front-loading washers – 32% of sales reported in 2012.[17] These appliances are known to offer improvements in energy efficiency when combined with high washing (cleaning) performance. Sales of twin-tub washers, which used to be very popular in China, are falling, accounting for only 11% of sales reported in 2011.[18]

Under the business-as-usual scenario, washing machines are projected to consume approximately 15 TWh of energy per year in 2030.[19] Such projections demonstrate the need to address the energy efficiency and overall consumption of washing machines.

Clothes Washer Test Standards

A number of specific components are required to measure and evaluate the energy performance of a clothes washer. These are as follows:

- A test procedure that dictates a specific set of conditions to measure energy consumption, water consumption, and, according to the applicable regulations, possibly other performance factors such noise, spinning efficiency, and so on. The various test methods are important to ensure reliable, accurate, and repeatable test results for specific washing cycles of the particular model being tested.

- A calculation method – normally included energy efficiency regulations and currently not included in the IEC standard – is required to verify that the product complies with the applicable minimum energy efficiency performance requirement for that particular washer. This second component, the standard consumption of the product, determines if an appliance consumes less than a certain amount of electricity during a specified wash cycle.

- A third component, that of the washer meeting a minimum washing (i.e. textile cleaning) standard under the same specified test conditions is present in both the Chinese and IEC standards. This requirement exists to ensure that washing performance is maintained at the same time as energy efficiency is improved.

The comparison between the actual measured daily consumption and the limit set by the energy efficiency regulation establishes not only whether the product complies with the minimum requirement, but also the appropriate class level for a product's energy label.

[17] *Market Analysis of China Energy Efficient Products*, CLASP and Top10 China, 2013.
[18] China National Institute of Standardization , 2011 White Paper.
[19] *Market Analysis of China Energy Efficient Products*, CLASP and Top10 China, 2013.

The standards used for measuring the energy performance of domestic washers in each economy are listed in Table 1, below.

Table 1: Test standards used in each economy

Economy	China	EU
Standard	GB/T 4288-2008 and GB 12021.4-2004	EN 60456:2011
Scope	Energy consumption, water consumption, and wash quality of clothes washers	Energy consumption, water consumption, and wash quality of clothes washers

The Chinese standards describe test conditions, procedures and calculations to determine information for reporting requirements, including energy consumption under pre-specified loading and operating conditions.

Comparison of Washer Test Methods between China and the EU

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

- Top loader (impeller) washer performance is tested using "cold" (or, more accurately, warmed) water at 30±2°C. This water is heated from ambient to the test temperature externally, and the energy to heat the water is not included in the declared unit energy consumption. (Note that this method was not used during the testing for this study)

- Front loader (drum) washer performance is tested using cold water at 15±2°C for units with an integrated water heater and run at the default standard hot washing setting.

Clearly the difference in the Chinese test methods creates substantially differing results. The tested energy consumption of the impeller units is purely the mechanical energy to agitate and spin the laundry, plus the energy used for water pumping. However, the overall energy consumption of the drum machines not only includes the mechanical energy, but also includes the energy required to heat the water, which can be a significant additional factor in energy consumption relative to the mechanical energy element.

The test method in the EU is EN 60456:2011. It has some similarities to that used in China for front loader (drum) washers. For example, performance is tested using cold water at 15±2°C

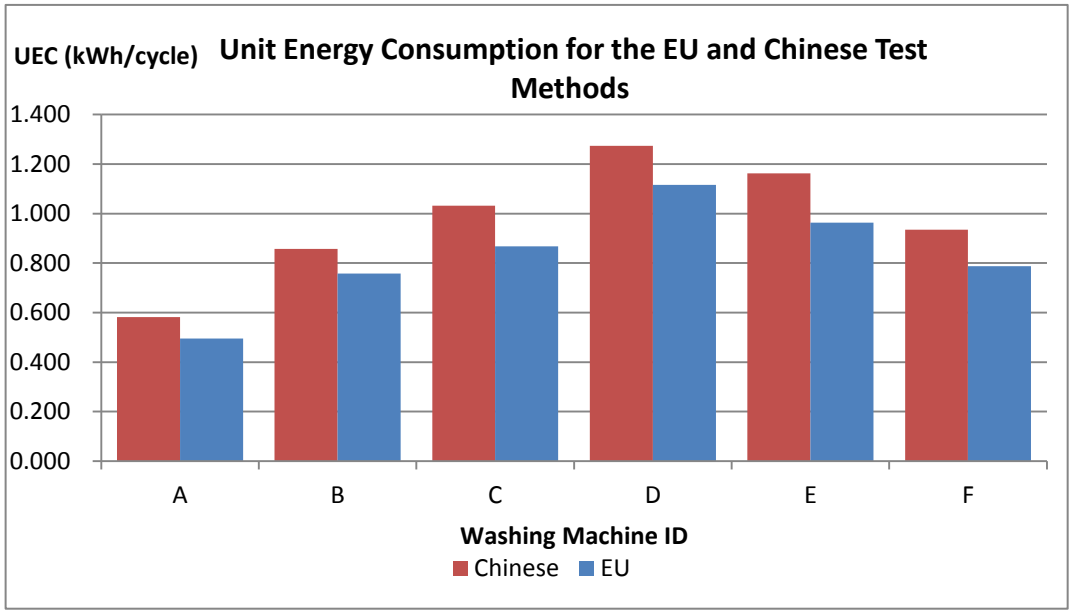
for units with an integrated water heater. But there are also substantial dissimilarities. In particular, the Chinese standard requires just one load (full) size to be tested on one setting (60°C cotton), whereas the EU standard requires a full load and a half load to be tested on the same program (60°C cotton) and a half load to be tested on another program (40°C cotton).[20]

Testing and Analysis

Two representatives from CNIS and Intertek tested six different washer samples in accordance with the Chinese and EU standards at CNIS' test laboratory in Beijing and Intertek's laboratory in Milton Keynes, United Kingdom. Simultaneously, a training process took place between Intertek's expert trainer and CNIS' test engineer, including an exchange of documentation – particularly result sheet formats.

Figures 8-10 show comparisons between the results obtained when testing the same samples in accordance with both the Chinese and EU test methods.

Figure 8: Data from combined tests for energy consumption



[20] Experts working on the IEA 4E Mapping & Benchmarking Annex have previously attempted to benchmark washers in the Chinese markets with those in other major national markets. In their published report, the authors explained that due to the level of qualities of comparative data they could access and the high level of normalization that needed to take place, it was not possible to include China in its benchmarking outputs.

Figure 9: Breakdown of energy consumption by test type

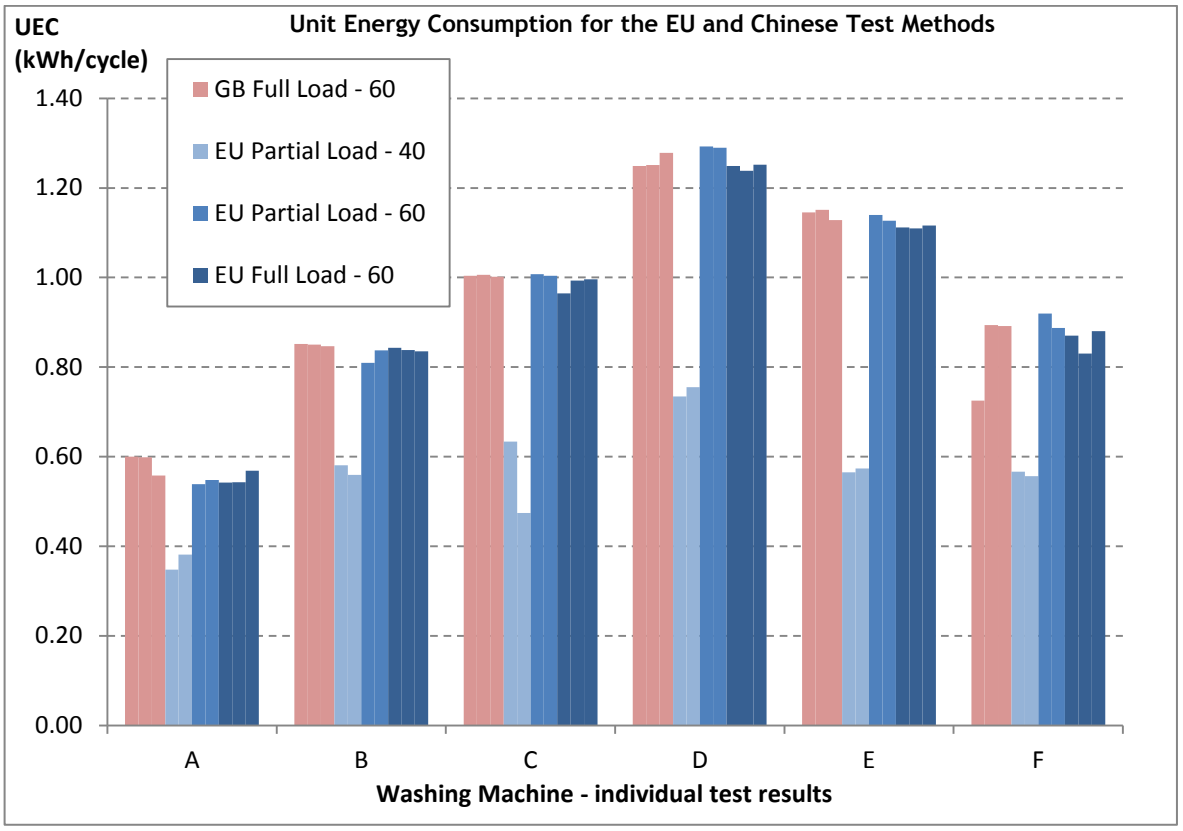
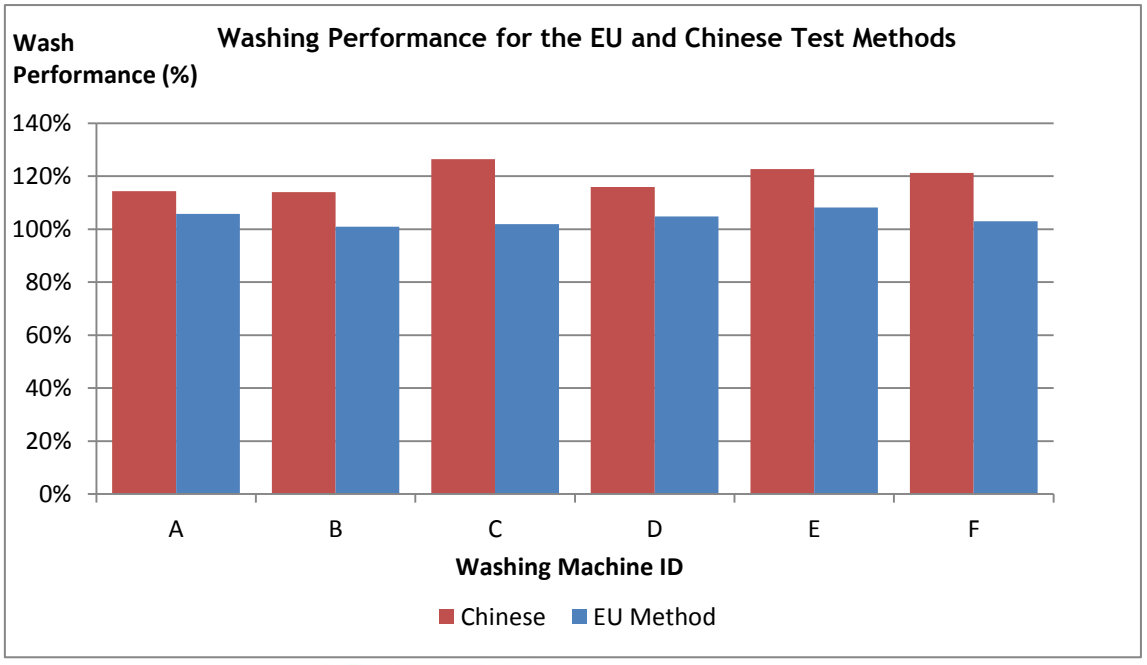


Figure 10: Data from combined tests for washing performance



Visually, these charts appear to show a fairly consistent relationship between the results obtained from the two different test methods – implying that the methods are comparable. The project team conducted a statistical analysis to determine the possibilities of calculating a conversion factor to enable the results obtained from one test method to be "normalized" into the results that would have been obtained if the other test method had been used.

Another useful indicative benchmark was established by applying the results to the levels required for energy labeling in each of these markets. Table 2 provides the results of this direct comparison.

Table 2: Labeling comparison between the Chinese and EU markets[21]

Model	Label - China	Label - EU
Haier HW70-1482-F	Tier 1	A+++
Haier HW80-BD1626	Tier 2 (Energy consumption satisfies Tier 1 requirement, but wash performance does not)	A+++ (but wash performance non-compliant)
Haier XQG60-1079	Tier 3	A+ (but wash performance non-compliant)
Haier HW60-1275	Tier 3	A+ (but wash performance non-compliant)
Haier XG70-10266A	Tier 3	A
Haier XQG80-HBD1626	Tier 3	A (but wash performance non-compliant)

The comparison of labeling standards provided in Table 2 demonstrates that there is a fairly close correlation between the energy efficiency standards being applied in both the Chinese and EU markets for front-loading washers. This is backed up by the consistency of the calculated conversion factors.

Conclusions & Recommendations

This study is the first attempt to benchmark front-loading clothes washers using the test methodologies and standards applicable in the Chinese and EU markets. Previous attempts to benchmark these two markets had not been possible due to the paucity of available data. As washing machines are projected to consume approximately 15 TWh of energy per year in 2030 based on the expected consumer demands and energy use trends,[22] there is a clear need to

[21] Note that this table is only indicative of the energy efficiency tiers, or performance thresholds, included in the Chinese and EU energy labels. A more complete table that compares the actual minimum energy performance values for each tier is provided in the main report and verifies that the tiers are comparable.

[22] *Market Analysis of China Energy Efficient Products*, CLASP and Top10 China, 2013.

address the energy efficiency and overall consumption of washing machines, and to rapidly bring the market to the most stringent levels feasible.

The comparison of energy efficiency labeling specifications in both the Chinese and EU markets for the same washer samples demonstrates two things. Firstly, it shows that there is a close correlation between the test standards being applied in both markets for front-loading washers. The current Chinese test standard employs fairly similar test conditions to those required by the international (IEC) and EU test standards.

These results can give CNIS confidence that adopting test methods based on IEC 60456 and performance standards similar to those used in the EU would be likely to be acceptable to domestic stakeholders such as manufacturers and their associations, test laboratories, and advocates. It should be a straightforward task for test laboratories in China to adapt to methods based on the IEC standard if the authorities adopted a version of that standard in the future.

Secondly, the comparison demonstrates that China's current EE labeling thresholds for front-loading washers are on par with those in the EU. It is important to note, however, that front-loading washers only account for about 32% of China's clothes washer market. China's test procedure and energy efficiency performance standard differ for the more common impeller (top-loading) machines, which are not covered in this study. Moreover, the alignment between EU and Chinese standards for front-loading washers does not necessarily indicate that either standard cannot be improved. [23]

Based on the project team's testing experience and subsequent analysis, CLASP and CRA recommend the following actions for Chinese policymakers:

- Results intended for use in establishing conversion and correction factors in test programs such as this should be subjected to expert statistical analysis. This, and any other expert analyses, should take place concurrently with testing to ensure any additional checks can be made and/or tests repeated whilst the samples and facilities are still available; and
- Testing to establish correction factors should take place in a single expert laboratory in order to minimize inconsistences in the application of testing procedures.

In terms of the training program that took place between CNIS, Intertek, and the project team's testing experts, we learned the following:

- If the recipient laboratory only requires familiarization training to enable it to undertake testing to another method in its own, already well-equipped test laboratory,

[23] Other studies have examined this point. CLASP's *Market Analysis of China Energy Efficient Products* (2013) assesses the market distribution, energy efficiency requirements, and test procedures for both impeller and drum type washing machines, and makes recommendations for their improvement.

then a suitable expert can provide all the essential training on a single visit lasting 5-10 days; and

- Reinforcement training can be provided through a return visit by the trained staff to the laboratory of the expert trainer and by re-testing the same samples at that laboratory. This is desirable, though not essential, for familiarization training. However, it is likely to more than double the cost of the training program.