Benchmarking of Clothes Washers between the Chinese and European Markets

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Consumer Research Associates

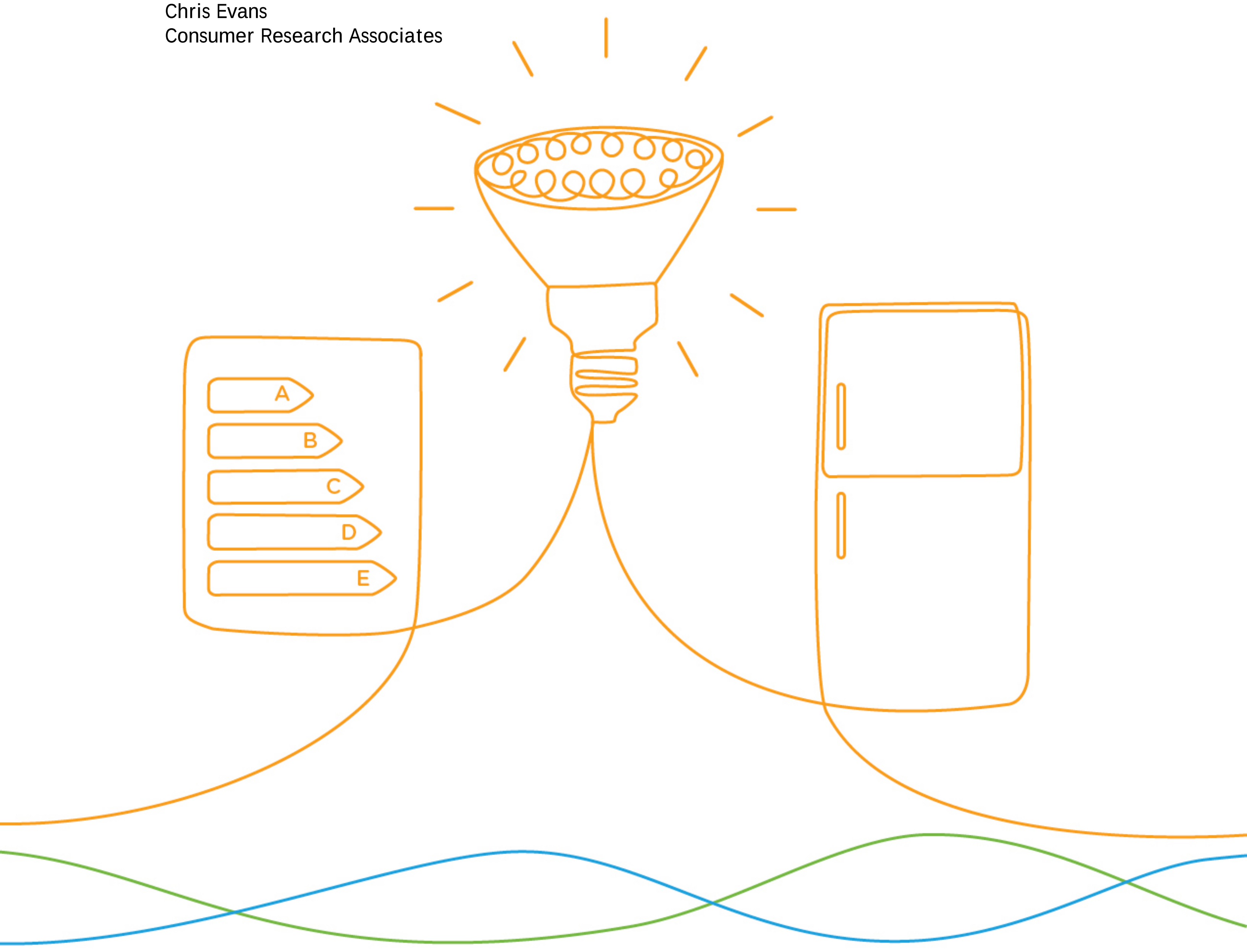

Table of Contents

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The report, *Market Analysis of China Energy Efficient Products* jointly written by CLASP and Top10 China has been used as a source of materials included in this report.

Executive Summary

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.

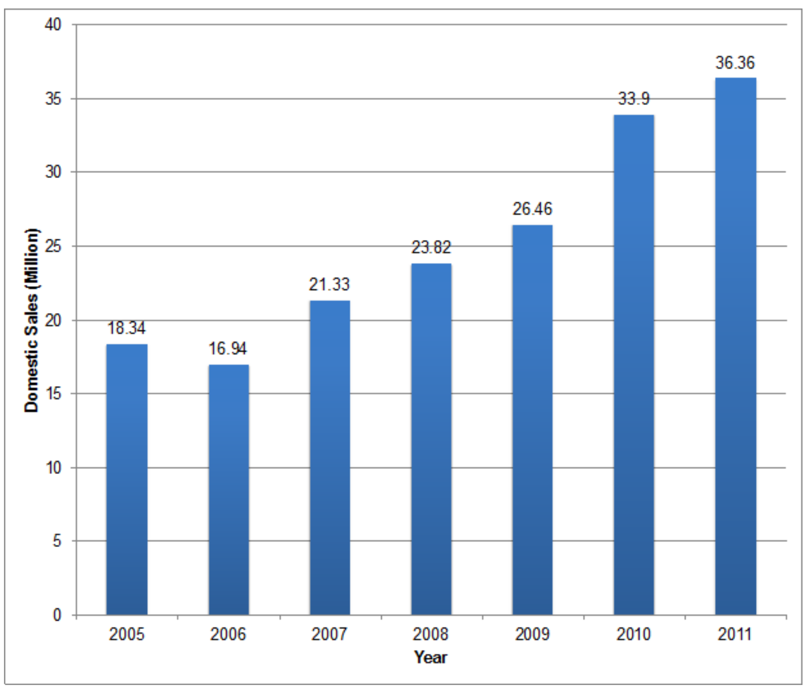
Due to the absence of reliable data about the Chinese market, a benchmarking comparison of clothes washers between China and other economies has not been undertaken previously. For the purposes of this study, CLASP, CRA, and CNIS mapped the Chinese and EU clothes washer markets, selected representative 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.[1] 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)

[1] *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.[2] 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.[3]

Under the business-as-usual scenario, washing machines are projected to consume approximately 15 TWh of energy per year in 2030.[4] 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

[2] *Market Analysis of China Energy Efficient Products*, CLASP and Top10 China, 2013.
[3] China National Institute of Standardization , 2011 White Paper.
[4] *Market Analysis of China Energy Efficient Products*, CLASP and Top10 China, 2013.

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.

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).[5]

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.

[5] 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 8: Data from combined tests for energy consumption

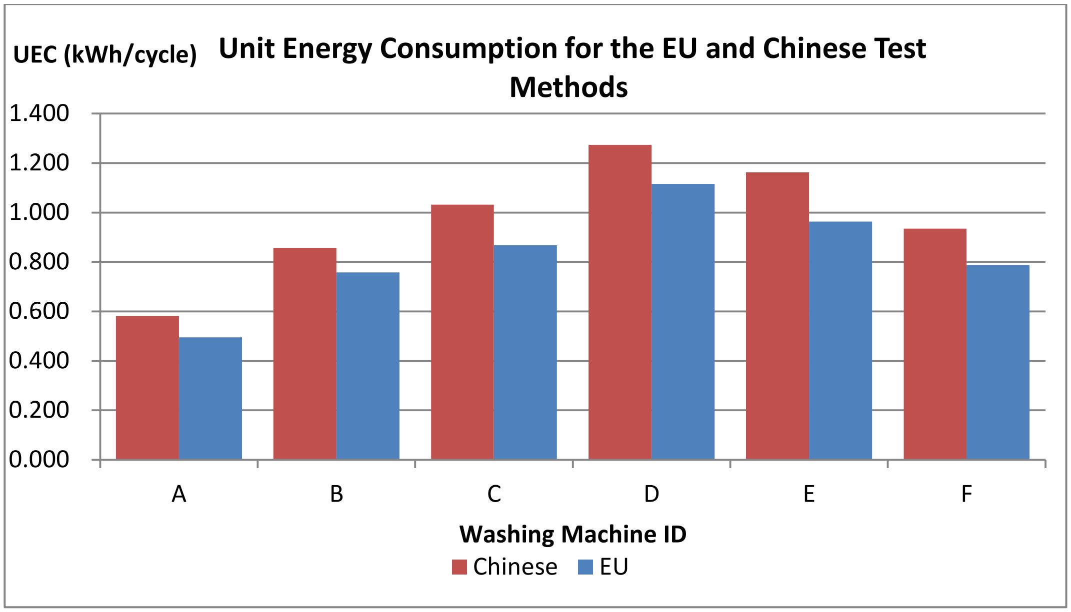


Figure 9: Breakdown of energy consumption by test type

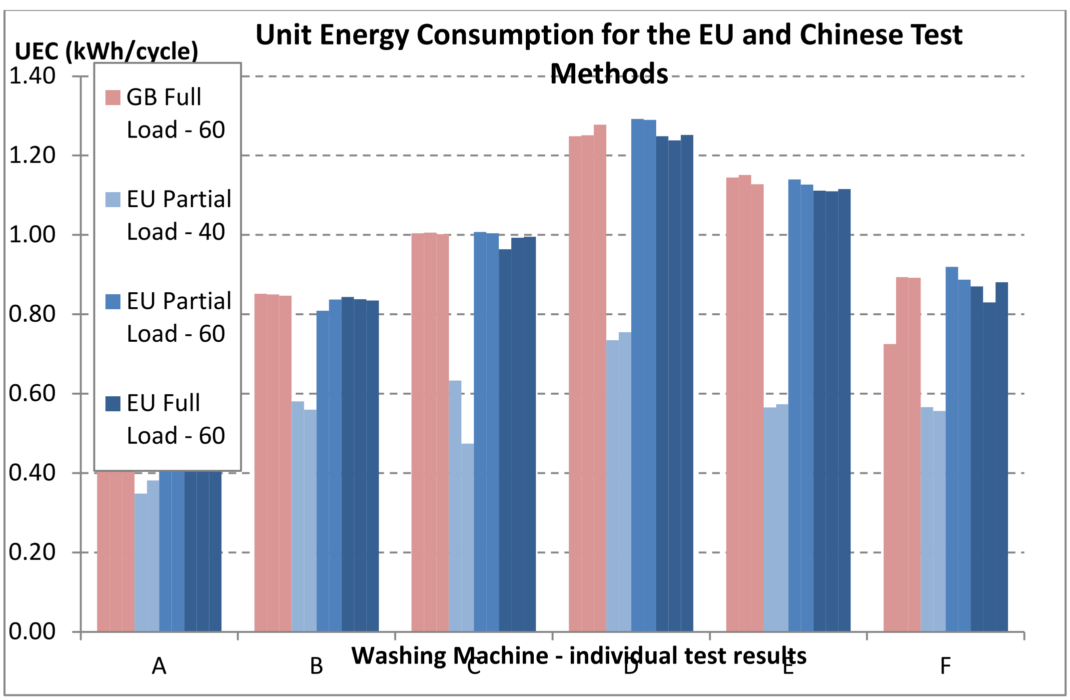
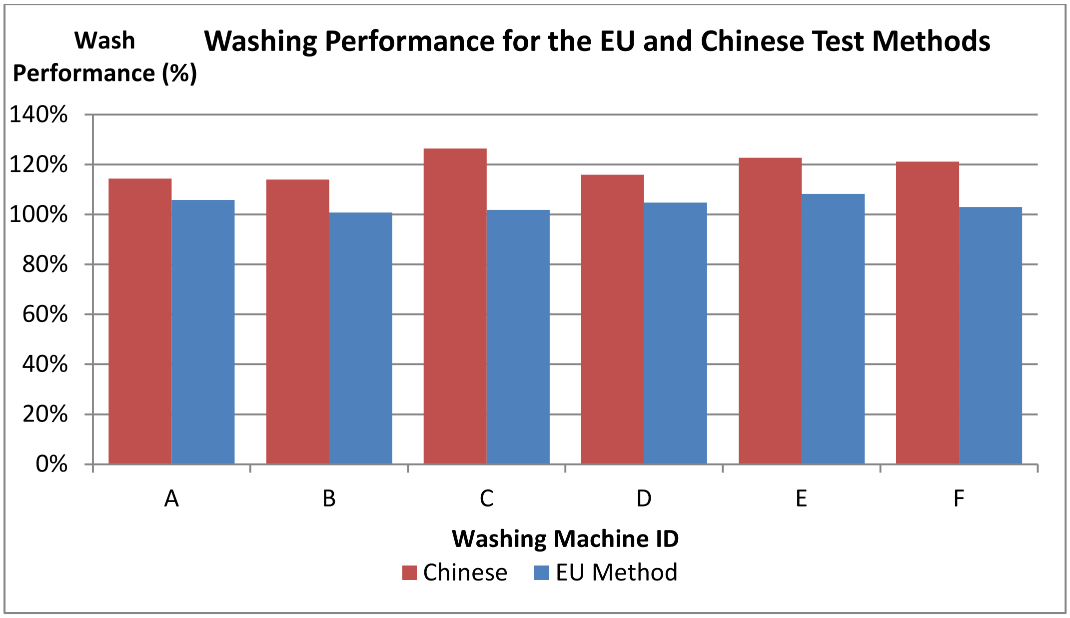


Figure 10: Data from combined tests for washing performance



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[6]

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,[7] there is a clear need to 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.

[6] 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.
[7] *Market Analysis of China Energy Efficient Products*, CLASP and Top10 China, 2013.

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. [8]

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

[8] 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.

- 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.

1. Background for the Program of Benchmarking Washers Between the Chinese and European markets

The main objective of this program was to develop a cost effective mechanism for providing technical support to the China National Institute of Standardization (CNIS) that would assist them to develop future levels of energy performance standards in a transparent and technically valid manner. The program described in this report used clothes washers (known as washing machines in many economies) as its example product.

A secondary objective was to provide illustrative benchmarking data on the comparative performance of clothes washers from the EU and Chinese markets.

There is some variation between the European (EU) and Chinese markets for domestic clothes washers ("washers"). The EU market has been long 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 (57% of sales reported in 2012) but in common with many countries elsewhere, the Chinese washers market is now exhibiting increasing sales of front loading washers resulting in a market share of over 30% by July 2012. The sales of twin-tub washers, which used to be very popular in China, are falling with 11% of sales being reported in 2011.

Although many countries and regions including the EU use international (IEC) standards as the basis for measuring the energy performance and efficiency of washers, others including China have adopted their own systems for rating and labeling washers according to their energy consumptions. Variability among products between the Chinese and EU markets and the differences in performance metrics make the evaluation of efficiency and performance of washers a very complex task. A benchmarking comparison against each other has not previously been possible due to the absence of reliable data about the Chinese market.

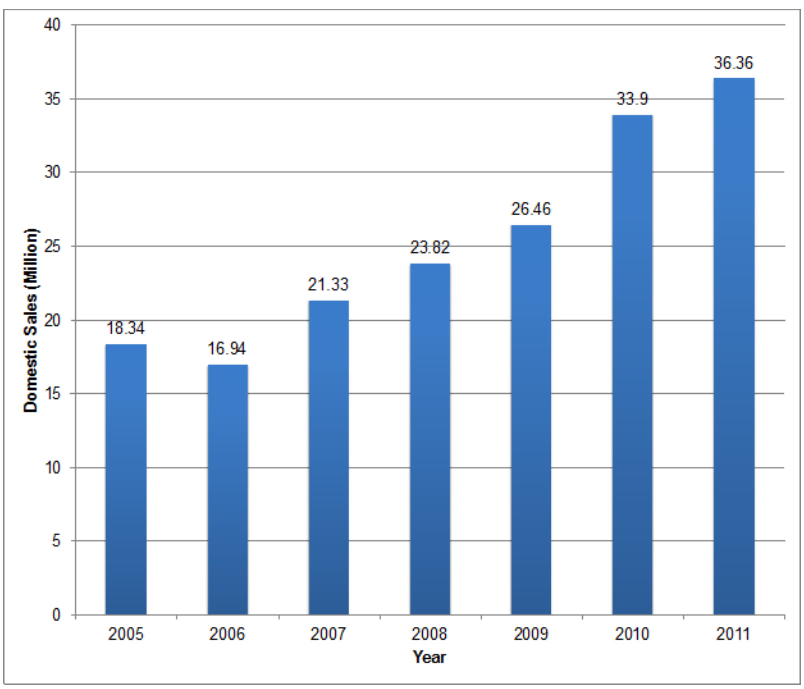
CNIS is the agency in China that is responsible for developing test methodologies and metrics for energy standards. Washers are included in their current review program. Results of the performance comparisons that are one of the outputs of this program could provide insights into their energy efficiency policies and requirements as well as the efficiencies of products available in these markets. This program provides an excellent opportunity for comparing Chinese test methodology with those used in the EU and the results of the comparisons would assist CNIS to judge whether adoption of the international standard could become appropriate for China at some future time.

The comparison of the performance of washers across the EU and Chinese economies required that benchmarked models had comparable functionality, and that an equivalent performance basis could be used – energy and water consumption and cleaning performance. This was achieved - this benchmarking study comparing test procedures and calculation methods *for front-loading washers only* using the incoming Chinese test methodology GB 12021.4-20xx and the EU method EN60456:2011.[9]

2. Rationale for Improving Washer Efficiency in China

Clothes washers 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 washers continues to rise. Based on projections[10], approximately 366 million washing machines had been installed across China by the end of 2012. This stock is projected to rise to 484 million by 2030.

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



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

[9] EN60456:2011 is based on IEC60456:2010, but includes extra requirements including a partial load test.
[10] *Market Analysis of China Energy Efficient Products*, CLASP and Top10 China

Under the business as usual scenario, washers are projected to consume approximately 17 TWh/yr of energy in 2030[11]. Such projections demonstrate the need to address the energy efficiency and overall consumption of washing machines.

3. Washer Standards Review

There are a number of specific components related to measuring and evaluating the energy performance of a washer:

i) A test procedure providing a specific set of conditions to measure energy consumption, water consumption and, according to the applicable regulations, possibly other performance factors too e.g. noise, spinning efficiency etc. The various test methods are important to ensure reliable, accurate, repeatable test results for specific washing cycles of the particular model under test;

ii) A calculation method, normally enshrined in regulations, is required to enable verification of compliance 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.

iii) A third component, that of the washer meeting a minimum washing (textile cleaning) standard under the same specified test conditions is present in both the Chinese (GB) and EN standards. This requirement is there 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 regulation establishes not only whether the product complies with the minimum requirement, but also the appropriate class level for a product's energy label.

The standards used for measuring the energy performance of domestic washers in each economy are listed in Figure 2, below.

[11] 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 2: Test standards used in each economy

Economy	China	EU
Standard	GB 12021.4-20xx	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 standard describes test conditions, procedures and calculations to determine information for reporting requirements, including energy consumption under pre-specified loading and operating conditions. The energy standards for washers currently applicable in China are listed in Figure 3.

Figure 3: Chinese washer energy performance standards

Energy Efficiency Class	**Top-load (impeller) type***			**Front-load (drum) type**		
	Electricity Use kWh/cycle /kg	**Water Use L/cycle /kg**	**Cleaning rate**	**kWh/cycle / kg**	**L/cycle /kg**	**Cleaning rate**
1	*≤0.012*	*≤20*	*≥0.90*	≤0.19	≤12	≥1.03
2(EE level)	*≤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(MEPS level)	*≤0.032*	*≤36*		≤0.35	≤20	

**These figures are supplied for information purposes only. Top loader washers and their applicable standards were not used in this program*

The EU standard, EN60456:2011, specifies test methods. The EN has an additional Annex (ZA), which is not present in the similar international standard (IEC 60456:2010). This Annex specifies additional test parameters and calculations necessary when establishing the energy performance declarations required under EU regulations. The EU regulations that set out the performance levels for energy labeling and MEPS are given in:

- COMMISSION DELEGATED REGULATION (EU) No 1061/2010 implementing Directive 2010/30/EU of the European Parliament and of the Council with regard to energy labelling of household washing machines

- COMMISSION REGULATION (EU) No 1015/2010 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for household washing machines.

The energy standards for washers currently applicable in the EU are listed in Figure 4.

Figure 4: EU washer energy performance standards

Energy Efficiency Class	Energy Efficiency Index
A+++ (most efficient)	EEI ≤ 46
A++	46 ≤ EEI < 52
A+	52 ≤ EEI < 59
A (MEPS level)*	59 ≤ EEI < 68

* MEPS level changes to EEI < 59 from 01/12/2013 for machines with capacities >4kg

Because of differences in test conditions, controlled temperature settings and calculations in some of the standards, some differences in the results of the various test procedures can be expected when the same appliance is tested to the different standards.

4. Comparison of Washer Test Methods Between China and the EU

The test methods for impeller and drum washing machines in China are based on GB 12021. The 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:

- 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 this energy to heat the water is not included in the declared unit energy consumption.

Note: this method was not used during this program

- Front loader (drum) washer performance is tested using cold water at 15±2°C for units with an integral 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 energy consumption of the drum machines not only includes the mechanical energy, but also includes the energy to heat the water – the energy to heat the water being high relative to the mechanical energy element.

The test method in the EU is EN 60456:2011. It has some similarities (and some differences) to that currently being adopted in China for front loader (drum) washers. For example, performance is tested using cold water at 15±2°C for units with an integral water heater and tests are conducted both at full load and partial loads.

The GB standard requires tests to be undertaken at 220V, the test voltage required by the EN is 230V.

5. Previous comparisons of MEPS levels between China and the EU

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[12], 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.

[12] http://mappingandbenchmarking.iea-4e.org/matrix

6. Testing and Training Program Undertaken with CNIS

6.1 Outline Description of Activities

Discussions were held between CNIS and CLASP China to determine the program of activities to be undertaken. CNIS were keen to obtain information comparing their current Chinese test methodology with that used in the EU and they wanted their testing staff to be trained in the EU methodology so that it could be replicated in the CNIS washer test laboratory. UK based Intertek Research & Testing Certification, which had substantial expertise in testing washers to the EU test standard, was commissioned to provide the required training support to CNIS.

Six different washer samples were tested. The supply of these from the manufacturer, Haier, was organized by CNIS. Testing was first conducted by CNIS and part-repeated on the same samples after they had been shipped to the Intertek UK washer test laboratory. It is understood that three of these machines were typical of front loader models available in the Chinese market and the other three were typical of those available in the EU market.

The training process began with an exchange of documentation, particularly result sheet formats, between Intertek's expert trainer and the test engineer appointed by CNIS who was to receive the bulk of the training. These early exchanges were valuable as they established a common ground between the trainer and trainee prior to them commencing the laboratory based training. This ensured that familiarization time on the ground could be minimized prior to commencing the intensive training program.

Formal training began with the trainer attending the CNIS washer test laboratory in Beijing for a period of seven working days. Training needed to cover a wide range of topics in some detail. Close attention to the detailed requirements of the test procedures is important because these can have a significant effect on the results obtained.

The program of training began by the trainer undertaking a review of the testing facilities available at the CNIS test laboratory.

6.2 Test facility requirement

The CNIS facilities were inspected to check whether they met the requirements specified by the EN standard. These included:

- Voltage supply; 230V required by the EN, but 220V available and used for some of the tests conducted at CNIS;

- Hard water, 2.5 ± 0.2 mmol/l;

- Water supply temperature to be 15 ± 2°C for all reference programmes;

- Water supply pressure to be maintained at 240 ± 50 kPa throughout each test;

- Ambient temperature of the test room to be maintained at 23 ± 2°C.

6.3 Test material requirements

Test materials are required in order to establish the quality of the wash performance such as stain removal from textiles and water removal through the spinning process. The requirements specified by the EN were reviewed. These, in outline, are:

- Base loads; cotton bed sheets, pillowcases and towels

- Stain test strips which are attached to the base load. Different soil types are used in order to assess the washing characteristics of scouring (using sebum and a mixture of carbon black and mineral oil), removal of protein (using blood), organic material (using cocoa) and any bleaching effect (using red wine);

- Detergent; the 3 separately stored components of base powder (with enzyme and foam inhibitor), sodium perborate tetrahydrate and bleach activator (TAED) – all aged less than one year from the date of manufacture.

6.4 Test equipment

A variety of test equipment was required to be available so that the testing procedures could be performed in accordance with the EN requirements:

- Reference washer; this needs to be run in parallel with the test washing machine as applying the same procedure to both washers provides a measure of relative performance and reproducible results;

- A spectrophotometer to be used to take optical measurements of each of the different stain test strip pieces at the completion of each washing performance test;

- Equipment for conditioning the base load, either a controlled ambient temperature and humidity room or a tumble dryer capable of drying the load to a “bone dry” state;

- An iron or ironing appliance for preparing the stain test strips after washing and prior to the optical (reflectance) measurements being made;

- Various instruments to measure and, where necessary, record volumes, pressures, energy consumption, temperatures, mass etc.

7. Testing of performance

7.1 Preparation of the test washer and reference machine

Normal practice is to test a new sample of washer that has been installed in accordance with the manufacturer's instructions. Once installed, the washer is run for two complete cleaning runs on a cotton programme with the maximum wash temperature and water levels set. The first wash is done with 50 g of the reference detergent but with no wash load of textiles. The second wash is done with without detergent or wash load.
Thereafter, the washer is only used for the specified test runs and the washing machine kept in the laboratory controlled ambient temperature until the test series is completed.

The reference machine has to be prepared too. This machine, which has to meet a special specification given in the EN standard, is run on its startup program prior to the commencement of any test run.

The correct dose of detergent to be added to the test and reference machines is determined from a formula given in the EN, the size of dose varying according to the mass of the wash load. The three components that together make up the detergent need to be mixed prior to being placed in the respective detergent dispenser on the washers.

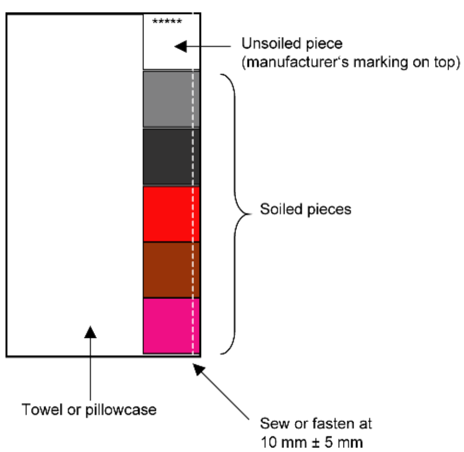
7.2 Preparation of test materials

The requirements set out in the EN standard are complex:

- New base load items have to be treated before their first use by undergoing a special "normalization" comprising of 5 washes in hard water. This is followed by regular normalization that comprises a 60^{o}C wash without detergent followed by drying to 0% moisture content. Thereafter, the textiles are stretched or flattened by hand before being placed to hang freely in a conditioning room at a specified ambient temperature and humidity.

- Age requirements for base load items have to be met. This is necessary to minimize the influence of changes in the characteristics of the base load items that occurs with increasing age. The cotton base load for each test run needs to be of items distributed in age for each different item type to give a weighted average age of the base load between 30 and 50 test runs.
- Determination of test load mass; the EN standard provides a Table (Clause 6.4.6 and Annex ZA.4) enabling the tester to identify how many stain test strips, sheets, pillowcases and towels are required to make up the full cotton base load, which is determined by the manufacturer's claimed capacity of the washer.
- Fixing stain test strips to the base load to make up the appropriate test load prior to each test run. They are attached to towels where the base load is cotton, which is the case for energy labelling. The positioning of attachment is precisely specified by the standard and they are either fastened by secure non-metallic fasteners or by being sewn into position.

Figure 5: Positioning of stain test strips



Source: IEC

7.3 Testing performance

The EN standard provides methods for measuring the following parameters:

- Washing performance;
- Water extraction performance;
- Rinsing performance (soluble components);
- Energy consumption;

- Water consumption;
- Program time.

7.4 EN Test procedure

The procedure applies to the test washer and the reference machine which are run in parallel. It follows a specific sequence of full and partial load tests. The tests are set up in accordance with the detailed requirements set out in the standards. The required measurements are made or set in place and the machines are operated in accordance with their manufacturer's instructions. Instruments continue to measure water volume, water temperature and electrical energy using a data logger or computer to record data from before the programme is initiated until after it finishes.

The test load needs to be removed within 10 minutes of completion of the wash program and the soiled (test) strips detached for measurement. The base load is weighed and then dried in a tumble dryer. The test strips are separately dried and flattened and stored in a dark place until reflectance measurements can be taken.

7.5 Measurement and evaluation of test data

In order to assess washing performance, tristimulus Y reflectance measurements are taken with the spectrophotometer on each of the individual soil types and the unsoiled test piece which make up the stain test strip - the number and positioning of these measurements being as directed by the EN document.

The water extraction performance is taken as a function of the amount of remaining moisture in the base load after the final spinning operation at the end of the program relative to its conditioned mass prior to commencing the wash program.
Note: rinsing performance is not currently required for the EU energy label and did not form part of the training provided.

The results typically recorded when using the EN standard for use in calculating the values required for display on the EU Energy Label can be seen in Figure 6.

Figure 6: Typical EU (EN) results table

Sample details						Relevant
Project Number						
Laboratory sample code						
Manufacturer / supplier						
Model number						
Serial number						
Rated capacity for 60°C cotton programme						
Rated capacity for 40°C cotton programme						
Measured parameter	**Symbol**	**Units**	**Measured value**	**Rated value**	**Difference between rated and measured values**	
Annual energy consumption	AE_C	kWh/annum				EN 60456: 2011
Energy consumption	E_t	kWh				EN 60456: 2011
Program time	T_t	mi				EN 60456: 2011
Water consumption	W_t	l				EN 60456: 2011
Remaining moisture content	D	%				EN 60456: 2011
Spin speed	$\overline{S_{max}}$	rpm				EN 60456: 2011
Power consumption in off-mode	P_O	W				EN 60456: 2011
Power consumption in left-on mode	P_L	W				EN 60456: 2011
Duration of the left-on mode	T_L	mi				EN 60456: 2011
Airborne acoustical noise emissions	-	d				EN 60704
Airborne acoustical noise emissions	-	d				EN 60704
Other energy label parameters		**Units**	**Measured value**	**Rated value**	**Difference between rated and measured values**	
Energy class	-	Letter				EN 60456: 2011
Annual water consumption	Awc	l/annum				EN 60456: 2011
Spin drying efficiency class	-	Letter				EN 60456: 2011
Other Eco-design regulation parameters		**Units**	**Measured value**	**Limit value**	**Difference between limit and measured values**	
Energy efficiency index (maximum)	EEI	%				EN 60456: 2011
Washing efficiency index (minimum)	I_W	-				EN 60456: 2011
Water consumption (maximum)	W_t	l				EN 60456: 2011
Off-mode power	P_O	W				BSEN
Standby power	-	W				BSEN
Standby condition						
Assessed features						
Standard cycles identified on the control panel?						
Standard cycles identified in the instruction book?						

Explanation that actual wash temperatures may differ from stated values?		
Left on mode power consumption declared in the instruction book?		
Off mode power consumption declared in the instruction book?		
Programme time, remaining moisture content, energy consumption and water consumption declared for all main programmes in the instruction book?		
Suitable detergents identified in the instruction book?		
20°C wash programme option available?		

NOTE: NAPD means not applicable at the date when the test sample was purchased

Source:
Intertek

8. Testing and results

Testing to the GB and EN standards was performed at the CNIS test laboratory in Beijing and to the EN standard at Intertek Testing & Certification Milton Keynes, UK. The same samples, listed in Figure 7, were used for all tests.

Figure 7: Samples used for testing

Code used in result sheets	Brand	Model
A	Haier	HW80-BD1626
B	Haier	HW70 – 1482-F
C	Haier	HW60-1275
D	Haier	XQG80-HBD1626
E	Haier	XG70-10266A
F	Haier	XQG60-1079

8.1 Test details

The three washers labeled A, B, & C, which were of designs intended for the EU market, were tested as follows:

1. According to the GB method but at 230 volts by CNIS
2. According to the EN method at 230 volts by CNIS
3. According to the EN method at 230 volts by Intertek

The three washers labeled D, E & F, which were of designs intended for the Chinese market, were tested as follows:

1. According to the GB method at 220 volts by CNIS
2. According to the EN method but at 220 volts by CNIS
3. According to the EN method at 230 volts by Intertek

8.2 Test results

As testing an individual sample to these test standards can yield some 360 individual data points, only the analyzed results are reported here. The results in Figures 8-10 show comparisons between the results obtained when testing the same samples to the GB and EN test methods.

Figure 8: Data from combined tests for energy consumption

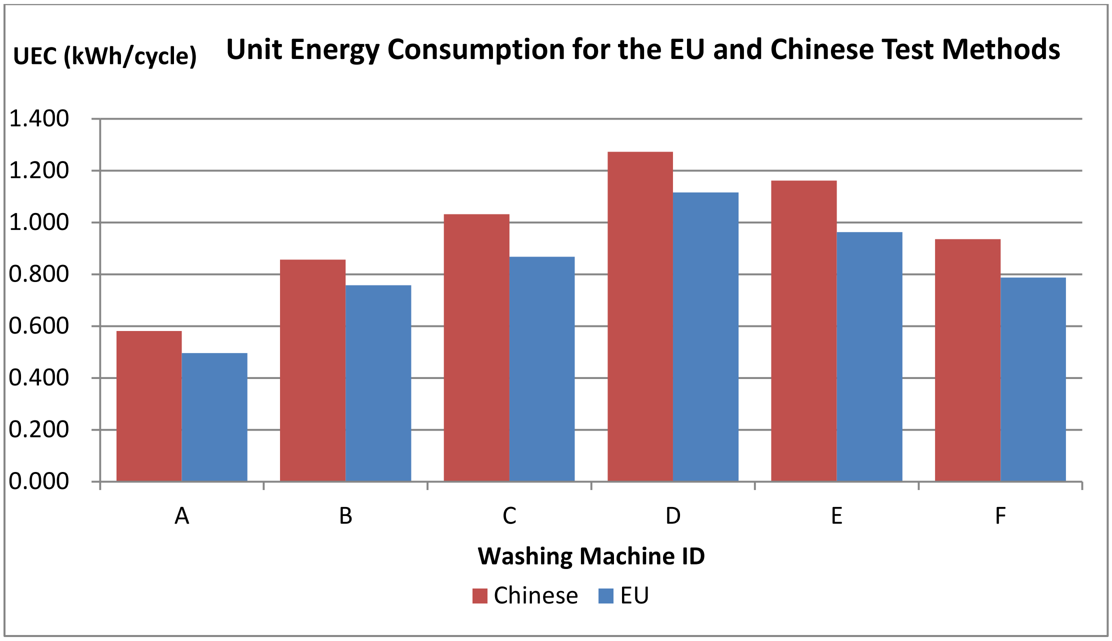


Figure 9: Breakdown of energy consumption by test type

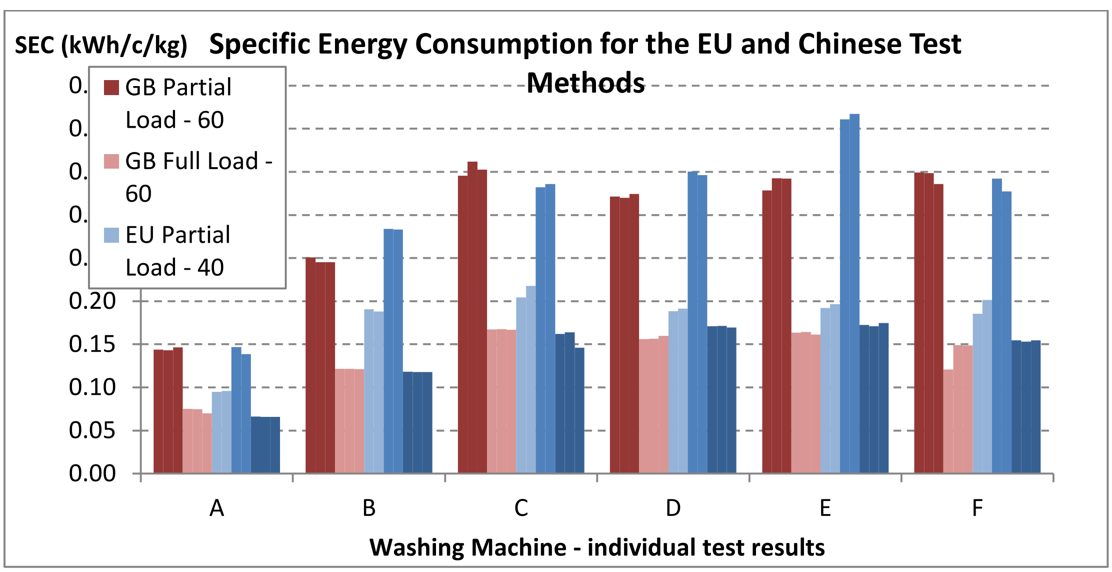
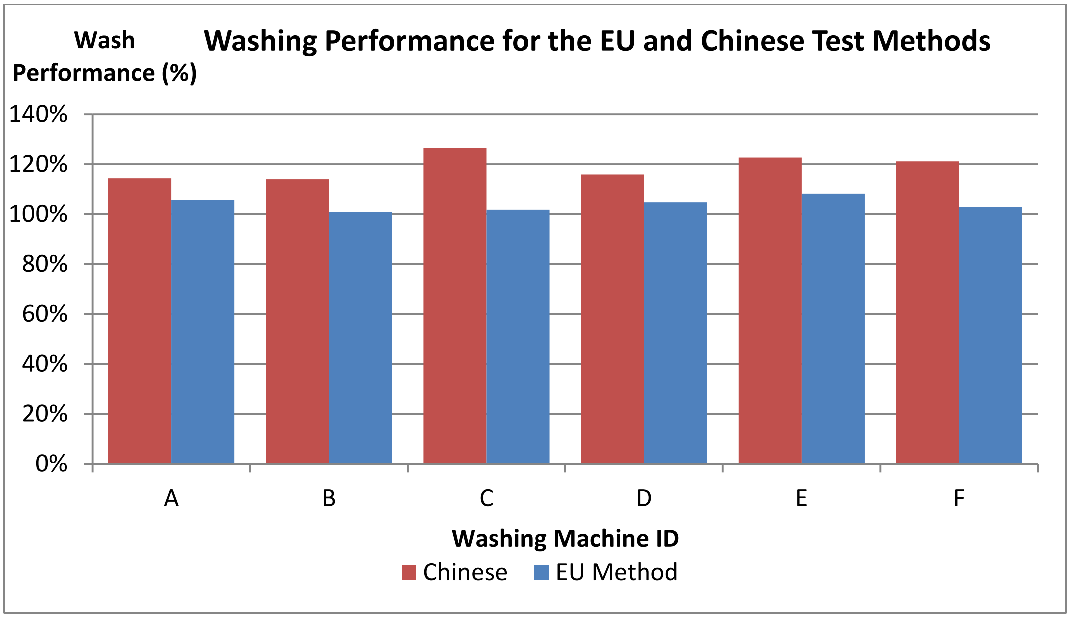


Figure 10: Data from combined tests for washing performance



8.3 Analysis of test results

Visually, the charts shown in the previous section appear to show a fairly consistent relationship between the results obtained from the two different test methods. However, due to the limited number of samples tested and the variation in test voltages used, only very limited statistical analysis could be undertaken to demonstrate 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.

Although there are many similarities between the test methods described in EN 60456: 2011 and GB-12021.4-20xx, there are some substantial differences too. In particular, the GB standard involves testing at full load and half load using the 60 Cotton programme, whereas the EN standard involves testing at full load with the 60 cotton programme and at half load with both the 60 cotton programme and the 40 cotton programme. The GB standard allows the manufacturer to specify different programmes for the half load test and the full load test whereas the EN standard specifies that the same programme setting is used for both full load and half load. Testing to the GB standard is done at 220 volts whereas the EN standard requires testing to be done at 230 volts.

The test results were analyzed to try to answer two questions:

A. If China were to substitute the EN method in place of the GB method would the results obtained for energy and water consumption be comparable?

B. Could the data from these tests be used to provide factors to convert energy and water consumption data measured by the GB method to the equivalent of what would have been obtained using the EN method?

As previously stated, the analysis was severely hampered by the small number of washing machines tested and the use of different test voltages in different labs. The conclusions cannot be applied widely with any certainty because of the small number of samples and because all samples were provided by just one manufacturer and so would not be representative of the variety of designs in the markets.

The approach taken was

1. Compare CNIS results with Intertek results for the washing machines tested to the EN method at 230 volts (washers A, B & C).
2. Compare the CNIS results for the GB method with the CNIS results for the EN method using 220 volts (washers D, E & F).
3. The assumption was then made that if close agreement was found in Step 1 and in Step 2, then Intertek EN results at 230 volts could be compared to CNIS GB results at 220 volts.

The analysis of Step 1 above is shown in Figure 11 below.

Figure 11: Analysis of CNIS EN 230v and Intertek EN 230v (Codes A, B and C)

		Percentage difference between the two labs			
Code	washing machine	Unit water consumption/L	Unit Energy Consumption (UEC): kWh/cycle	Specific water consumption/L	Specific energy consumption (SEC): kWh/cycle/kg
A	HW80-BD1626	12.2%	0.4%	11.3%	1.9%
B	HW70-1482-F	6.8%	0.2%	5.1%	0.8%
C	HW60-1275	0.9%	0.5%	3.9%	1.9%
Average percentage difference		6.6%	0.4%	6.7%	1.6%

The results show that the calculated unit energy consumptions in the two labs were very similar with an average percentage difference of 0.4%. The difference in the calculated specific energy consumption between the two labs was slightly larger with an average percentage difference of 1.6% but this was considered to be acceptable.

The differences in both unit water consumption and specific water consumption were considered to be unacceptably high and variable with average percentage differences of 6.6% and 6.7% respectively. The water consumption results for Code A in particular had very large percentage differences of 12.2% for unit water consumption and 11.3% in specific water consumption.

Possible explanations for the large differences in measured water consumption between the two labs are as follows:

- At CNIS, the base loads were prepared in soft water and rinsed between test runs, so may have different water up-take characteristics compared to Intertek base loads which are always washed in hard water and only rinsed at the end of a test series.
- The CNIS water meter was brand new. It was supplied with a factory calibration which had not been checked. The calibration was for a higher flow range than that which is applicable for most washing machines. Intertek water meters are all calibrated in situ at typical washing machine fill rates.

From the results of Step 1 it can be concluded that if CNIS had tested washing machines D, E and F at 230 volts and not 220 volts they would have obtained similar results to Intertek for energy consumption. However, no prediction can be made about the result that would have been obtained for water consumption.

The analysis of Step 2 is shown in Figure 12 below.

Figure 12: Analysis of CNIS GB 220v and CNIS EN 220v (Codes D, E and F)

		Percentage difference between the two standards tested by CNIS			
Code	washing machine	Unit water consumption/L	Unit Energy Consumption (UEC): kWh/cycle	Specific water consumption/L	Specific energy consumption (SEC): kWh/cycle/kg
D	XQG80-HBD1626	2.1%	-14.1%	8.2%	-12.9%
E	XG70-10266A	-3.3%	-20.6%	12.4%	-8.7%
F	XQG60-1079	-9.9%	-18.8%	-8.4%	-20.4%
Average percentage difference		-3.7%	-17.8%	4.1%	-14.0%

The results of Step 2, displayed in the chart above i.e. comparing the CNIS results for the GB method with the CNIS results for the EN method using 220 volts (washing machines D, E & F), show that even when testing is carried out at the same voltage and in the same lab, the differences between the two standards result in large and variable differences in water consumption and energy consumption.

Step 3 of the approach described above was to calculate a set of factors to convert energy and water consumption data measured by the GB method at 220 volts to the equivalent of what CNIS would have been obtained using the EN method had they tested at 230 volts. However, as there was no close agreement between the water consumption results in Step 1, only energy consumption was considered at this stage. Figure 13 provides an illustrative set of conversion factors based on this dataset.

Figure 13: Conversion factors for energy consumption based on this dataset

		To convert Chinese to EU, multiply by		Estimated EN results (converted from CNIS GB)		Percent Error in Conversion	
Code	washing machine	Unit Energy Consumption conversion factor	Specific energy consumption conversion factor	Unit Energy Consumption (UEC): kWh/cycle	Specific energy consumption (SEC): kWh/cycle/kg	Unit Energy Consumption	Specific energy consumption
D	XQG80-HBD1626	0.88	0.89	1.08	0.211	-3.1%	-0.8%
E	XG70-10266A	0.83	0.92	0.99	0.220	2.4%	-4.5%
F	XQG60-1079	0.84	0.83	0.79	0.213	0.9%	5.8%
	Average	**0.85**	**0.88**	**0.95**	**0.214**	**0.1%**	**0.2%**

One further analysis was undertaken to provide another indicative benchmark. This was established by applying the results to the levels required for energy labeling in each of these markets. Figure 14 provides the results of this direct comparison.

Figure 14: Labeling comparison between the Chinese and EU markets

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)

These appear to show, and this is supported up by the calculated conversion factors given in Figure 13, that there is a fairly close correlation between the standards being applied in both the Chinese and EU markets for the energy efficiency of front-loading washers.

Conclusions

For the very first time, front-loading washers were benchmarked 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.

The comparison of labelling levels in both the Chinese and EU markets for the same samples tested shows that there are notable correlations between the standards being applied in both markets for front-loading washers. The differences in energy consumption values generated by the two test methods seems to be fairly consistent and a conversion factor could be potentially be used to convert data generated by one method for comparison with data generated by the other.

The differences in water consumption values generated by the two test methods did not appear to be consistent. Until the reliability of the water measurements undertaken at CNIS can be checked further, it is necessary to conclude that there is currently no evidence from the test data that a conversion factor could be reliably used to convert water consumption measurements from one method to the other.

This was a useful exercise to indicate the potential to calculate robust conversion factors. However, the small number of samples tested and the fact that they were all produced by the same manufacturer means that further testing with washing machines produced by other manufacturers would be needed to prove a reliable conversion factor. If testing was extended to a larger and more representative sample then it is expected that the results of further testing would be regarded as robust. Serious consideration could then be given to using conversion factors for aligning data from GB 12021.4-20xx with that of EN 60456: 2011

Further results could be expected give CNIS confidence that adoption of test methods based on EN 60456 and performance standards similar to those used in the EU, would be likely to be acceptable to most stakeholders.

The Chinese standard currently being used for measuring the energy consumption of front-loader washers has fairly similar test conditions to those required by the international (IEC) and EU (EN) test standards. It would be a straight forward task for test laboratories in China to work to methods based on the IEC standard if the authorities adopted a version of that standard in the future.

For the purpose of providing technical training in testing techniques to CNIS laboratory staff, this program achieved all its objectives since CNIS test laboratory is now able to fully test washers to EN 60456:2011.

Recommendations

The recommendations given below vary according to the intent of any future program.

1. If a robust mathematical correction factor is required to be established that would enable energy consumption determined under the conditions of one test standard to be converted into those that would have been determined under a different test standard then 15 different models would need to be tested to both test standards. These models would need to be from brands that represent at least 50% of the market share to ensure all design variations had been factored into the results.

2. Results intended for use in establishing correction factors should be subjected to expert statistical analysis. This, and any other expert analysis, should take place concurrently with testing to ensure any additional checks can be made and/or tests repeated whilst the samples and facilities were still available.

3. Testing to establish correction factors should take place in a single expert laboratory in order to minimize inconsistences in the application of testing procedures. Minor deviations result in increasing the uncertainty of measurement and so contribute to increasing the size of statistically calculated confidence intervals.

4. If the recipient body only requires familiarization training to enable it to undertake testing to another method in its own, already well equipped test laboratory, then a suitable expert can provide all the essential training on a single visit lasting 5-10 days.

5. 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, but not essential, for familiarization training and is likely to more than double the cost of the training program.