Clothes Washer Standards in China – the Problem of Water and Energy Trade-offs in Establishing Efficiency Standards

Peter J. Biermayer and Jiang Lin, Lawrence Berkeley National Laboratory (LBNL)

ABSTRACT

Currently the sales of clothes washers in China consist of several general varieties. Some use more energy (with or without including hot water energy use) and some use more water. Both energy and water are in short supply in China. This poses the question - how do you trade off water versus energy in establishing efficiency standards? This paper discusses how China dealt with this situation and how it established minimum efficiency standards for clothes washers.

Introduction

In 1989, China's State Bureau of Quality and Technical Supervision (SBQTS) established standards for eight residential products. The first China mandatory efficiency standard for clothes washer was promulgated in 1990 (CLASP 2004). In the past, in China, as well as other countries, clothes washer minimum efficiency levels and labeling was based on energy consumption, and water consumption was not taken into consideration.[1] In China, a national standard containing the efficiency levels for the minimum efficiency standard and labeling schemes, references another document with the test procedure or method of test. While this report refers primarily to a minimum efficiency standard, the same analysis applies to the information and endorsement labeling schemes.

Background

In September 2001, Energy Analysis Department of the Environmental Energy Technologies Division at LBNL began a collaborative project with China National Institute of Standardization (CNIS), the agency in China given the responsibility to establish minimum efficiency performance standards (MEPS) for appliances. LBNL helped CNIS to perform analyses with the goal of setting minimum efficiency standards on clothes washers in China. This entailed showing them how the analysis is performed in the U.S. for the Department of Energy. In December 2001, training was provided in market assessment, test procedures,

[1] In the U.S. the costs of water for clothes washing was included in the economic justification for energy efficiency standards, but no standard was set for water efficiency.

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engineering analysis, consumer impacts, and national energy & water saving impacts. Because of our awareness of water shortage issues in both the U.S. and China, it was decided early on to analyze water consumption as well as energy consumption for the Chinese clothes washer standards. By including the analysis of water consumption as well as energy consumption in this minimum standard setting process, we hope to avoid an increase energy efficiency resulting in higher water consumption.

After data collection and analysis by CNIS, as well as their dialog with the Chinese industry on the proper level of the MEPS, CNIS set a minimum efficiency standard for clothes washers in 2003. The efficiency standard included both energy and water consumption.

In addition to MEPS, China also has an information label and an endorsement label for clothes washers. These include information on energy, water and the cleaning performance of the clothes washer.

Overview of the Chinese Clothes Washer Market

Types of Washers China has several different types of clothes washers. These can be classified into three basic types listed in Table 1 below.

Table 1. Types and Market Share of Clothes Washers in China

Type	Regions of Greatest Popularity	Percentage of Sales
Impeller (pulsator)	Asia	90%
Horizontal axis (drum type)	European	10%
Agitator (vertical axis)	North America	Very few

Source: Cheng et al., 2003

In an impeller washing machine the textiles are substantially immersed in the washing water and the mechanical action is produced by a device rotating about its axis continuously or which reverses after a number of revolutions (an impeller). The uppermost point of this device is substantially below the minimum water level (IEC 1998). These are also known as vortex, jet type or pulsator type. See Figure 1.

In a horizontal drum washing machine textiles are placed in a horizontal or inclined drum and partially immersed in the washing water, the mechanical action being produced by rotation of the drum about its axis, the movement being either continuous or periodically reversed (IEC 1998). See Figure 2.

In an agitator washing machine the textiles are substantially immersed in the washing water and the mechanical action is produced by a device moving about or along its vertical axis with a reciprocating motion (an agitator). This device usually extends above the maximum water level (IEC 1998).

Within these categories, there are several subcategories. For impeller types, there are single cylinder and double cylinder, which can be semi-automatic or automatic. For the horizontal drum type, most come with an internal electric water heater, although some do not have an integral heater.

China clothes washers are dominated by the impeller models, which are also popular in Japan, while the drum type (also known as horizontal axis, tumbler or front loader type) clothes washer is gaining in popularity. The American style clothes washers (top loaded vertical axis models with an agitator) are not commonly available in China today.

The type of clothes washer as well as the penetration or market saturation varies greatly between urban and rural areas. In the year 2000, 90.5% of urban consumers had a clothes washer, as compared to only 26% in rural areas (Cheng et al. 2003). The drum type of washer is much more prevalent in urban areas than in rural areas.

Figure 1. Impeller Type Washer

Figure 2. Drum Type Washer

Effect of Washer Type on Energy and Water Consumption

Due to the rise of water rates, consumers are paying more attention to the water consumption of washing machines. This is influencing the popularity of drum type washers over impeller washers. Drum machines are also gaining in popularity as they are perceived to not damage clothes; however, they have a high price, are difficult to move and have a long wash time (Cheng et al. 2003). Table 2 below summarizes the basic differences between impeller and drum washers. Using less water also reduces electricity consumption, due to a reduction in required pumping energy and energy for wastewater treatment.

Table 2. Washer designs can be a trade-off between water and energy savings

Impeller Washer	Uses more water Uses less energy
Drum Washer	Uses less water Uses more energy Greater cleaning ability?

Table 3 shows that the power consumption of drum type washers appears to be ten times greater than an impeller type washer, based on the Hong Kong voluntary efficiency standard. However, what may not be commonly realized is that the energy consumption is measured with two very different test procedures, making it difficult to compare the energy consumptions of the two types of washing machines.

Table 3. Voluntary Energy Efficiency Standard for Washing Machines in Hong Kong

Type	Power Consumption	Standard Specification
Automatic/ semi-automatic drum type washing machines	0.26kWh/kg (hot water)	IEC 456:1994 (drum type washers)
Automatic / semiautomatic impeller or milling washing machines	0.0264 kWh/kg (cold water)	JIS C 9606:1997 (impeller or agitator washers)

Source: (Cheng et al. 2003)

As drum type washers become more popular, there could be a large increase in energy consumption for washing clothes, especially if a change is made to washing with hot water. Drum type washers use approximately ten times more energy, while using less water than the traditional impeller washers. To a large extent, this is caused by the fact that the energy consumption of drum washers is rated under the hot wash cycle, while that for the traditional impeller washer is rated under the cold wash cycle. Currently only a small minority of urban households use hot water to wash clothes. Even accounting for the difference due to hot water the drum washers would probably still consume twice as much energy as the impeller type washers (Lin 2002).

Differences in Washing Clothes

Unlike in the U.S. and Europe, most residential wash in China is performed in cold water. If such a pattern persists, the power consumption (if based on hot water use) of drum clothes washers would be grossly overestimated. As a consequence, drum models would be unfairly penalized in the market place, given their water saving advantage. However, if the availability of drum models with internal heating features leads to a switch in washing behavior from cold to hot wash, the future energy used to wash clothes in China would increase substantially (Lin 2003c). Moreover, this switch could be happening without consumers' consent, since many washers may be shipped with default settings using hot wash cycle. Consumers have to reprogram their washers to specify cold wash cycle[2].

[2] An recent conservation with an energy conservation official in Shanghai confirms this suspicion. She was not aware that she has been washing clothes with 40 degree C water for sometime, until it was pointed out to her by another member of her household.

Cultural Implications for Clothes Washing Energy and Water Use

Clothes washer energy consumption is more dependent on consumer usage patterns than other appliances such as refrigerators. Little is certain about how cultural/behavioral changes are influenced by technological changes. Would Chinese consumers abandon clothes lines and embrace clothes dryers? Will they adopt hot wash cycle, with its higher cost as well as (probably) better washing performance? The availability of detergents that clean effectively in cold water may have some influence on this. Some anecdotal evidence suggests drum washers clean better than impeller washers. But how clean is clean enough? Such cultural dimensions of appliance usage need to be explored in the future to enhance our understanding of their impact on energy consumption (Lin 2002).

The default settings on a washer may also have an influence on whether or not hot water is used. If the default setting is a hot water wash, rather than a cold water wash, it may increase the likelihood of laundry being washed in hot water. This is especially true if the consumer is not aware of the energy use implications of this decision.

Other Considerations

Some suspect the drum washers do not clean as well under cold wash cycle. It is not clear why this should be, since cleaning performance is related to washing duration, temperature, the type of detergents used, other things being equal. It would be worthwhile to conduct experiments to assess energy use and cleaning performance of drum machines under the cold wash cycle.

Other questions worthy of research might include:

- Should cleaning performance of the washers be measured?
- Do machines clean equally well?
- How clean is clean enough?
- Is a lower efficiency standard for Chinese drum washers justified because they may not have detergents as effective as those sold in Europe?

The European perspective is that the washers must clean and not just save energy. In the U.S., the Department of Energy (DOE) position is that it sets the minimum efficiency and the market decides whether the washers do an adequate job of cleaning.

Test Procedures

Before a minimum efficiency level can be set, a common procedure is needed to measure the energy and water usage of a clothes washer.

First Chinese Clothes Washer Standard

When China published its first clothes washer standard in 1989, almost all clothes washers in China were the impeller type. Thus, the JIS test procedure was adopted to measure the energy performance. Table 4 below shows the product classes and allowed energy use in the 1989 standard.

Table 4. First Chinese Standard on Clothes Washers (1989)

Type	Sort	The maximum allowed energy consumption per kilogram of wash (Wh/kg)
Pulsator (impeller) type	Single-tub washer	24
	Twin-tub washer	28
	Half-auto single-tub washer	29
	Half-auto twin tub washer	32
	Auto washer	38
Roller (drum type)	Auto-washer without heating water	None
	Auto-washer with heating water	None

Source: (AQSIQ 1989)

Selecting a Test Procedure

There are several factors that influence the choice of test procedures. Harmonizing with international standards would increase trade and exports by reducing technical barriers to trade, especially now that China is a member of the WTO. A test procedure should be representative of how an appliance is actually used, in the country where it is sold. Unlike some appliances the energy use of a clothes washer is very dependent on how it is used by the consumer. In addition, a balance must be met on the complexity of a test procedure and how well it replicates actual use.

International Test Procedures

In developing a new set of efficiency levels, revising the test procedure was a consideration. The first step taken was to review other test procedures around the world. In general, clothes washer testing procedures around the world were developed based on regional washing habits. In Europe, the clothes washer test specifies that hot water be used. In the U.S. test procedure, assumptions are made as to the percentage of clothes that are washed in hot, warm and cold water, as well as the temperature of the rinse water. In addition, in the U.S. the moisture content of the test clothes are measured after a wash in order to determine how much energy is needed to dry the clothes in an electric or gas dryer. Japan's test procedure does not specify a test for energy consumption but the washing performance test is based on common washing habits in Japan, including the use of 30°C water. Japanese washers use only cold water but can be set up to use bath water for the wash cycle. Since in Japan the wash water has been previously used for taking a soaking bath, the energy needed to heat the water is not counted as energy use by the washer. However, the 30°C water is used for purposes of determining the cleaning performance. If in another country soaking baths are not taken, should the energy to heat the water be counted toward the clothes washer energy use?

Approach Taken for the 2003 Clothes Washer Standard

The 2003 Chinese clothes washer standard uses a combination of Japanese and European testing procedures. The impeller or "Japanese" style will be tested using the JIS Japanese test procedure, whereas, the drum type will be based on the European test procedure (Lin 2003a). This approach is the same as the voluntary label approach taken by Hong Kong. The Hong Kong labeling scheme purpose is to be able to compare impeller washers to other impeller washers and drum type washers to other drum type washers. It was not meant to be used to compare an impeller type to a drum type washer.

Test Procedure and Calculated Energy Savings

Adopting or adapting international standards and test procedures is in general a good practice. However, in the case of clothes washers, the difference in test procedures introduces arbitrary biases in the energy performance of washers, which have significant negative impacts on standard and labeling requirement. Impeller washers are tested with 30°C water, while drum washers are tested with 15°C water that are internally heated to 60°C (140°F). Thus, drum washer energy rating includes energy for heating water, while the impeller rating does not. Therefore, the information label would offer unfair comparisons between drum and impeller machines under the current testing conditions. Class A drum washers would be rated as using ten times more energy than class A impeller washers. This contradiction would not only weaken the value of the label, but would also lead to a bias against drum washers which save water, another important resource in China. In fact, if Chinese consumers continue to use cold wash cycle, the drum washers would use perhaps twice the amount of energy as the impeller types, but would provide an important water saving feature.

Recommendations for a Revised Test Procedure

Based on these observations, it was recommended that CNIS initiate the work on revising the test procedure so that both impeller and drum washers are tested with 30°C (86°F) water without internal heating.

Revising the test procedure would also have large long-term impact on clothes washing energy use. If adequate cleaning performance can be achieved under the current cold wash usage pattern, it would be a mistake to encourage the proliferation of washers with internal heating units, which is likely to lead to much higher energy use for clothes washing in the future. The best test procedure should attempt to simulate the usage conditions in real life, which in China today is almost entirely cold wash cycle.

If tested under the cold wash cycle, the rated energy use performance of impeller and drum washers can be compared on equal footing. More importantly, the MEPS and labeling requirement based on these ratings would discourage the inclusion of internal heater in clothes washers, which could significantly influence the future energy use of clothes washers. This assumes that China will not start connecting their drum washers to an external hot water supply.

Setting A Minimum Energy Efficiency Standard

One method of setting a minimum efficiency level would be to minimize the total cost of water and electricity. A problem with that is approach is that electricity and water prices to the consumer may be subsidized and not be representative of their true cost. External factors such as the water table becoming depleted may also not be reflected in the current price of water.

Similarly, the cost of air pollution from electricity generation, may be difficult to quantify for an economic analysis.

An analysis using actual water and energy prices to the consumer was performed, but was used as a comparison method only within a clothes washer product class and not used to evaluate the desirability of a drum type washer to an impeller washer.

Deciding on a Minimum Efficiency Level

CNIS places high importance on the opinions of the clothes washer manufacturers in China, in part to ensure good compliance, given that monitoring and enforcement of standards in a vast market more than often is beyond the limited resource of the relevant agencies. At the 2003 efficiency levels, it is likely that all currently built drum models will meet the new energy efficiency and water use limits of the new standard.

According to Lin, the maximum allowance for drum washers at 350 Wh/kg/cycle is too lax, as manufacturers and test laboratories report that the energy use of drum machines are in the range of 200 – 250Wh/kg (Lin 2003a). In addition, the lowest life-cycle cost for drum washers in the engineering analysis was at 223 Wh/kg (Lin 2003a). In comparison, the European Union labeling scheme requirement for category E drum machines is 350 Wh/kg.[3] On December 31, 1999 the European Union had effectively phased out clothes washer categories below the C level. Only 2% are in the category D level. The average use of drum washers in the European Union was 213 Wh/kg in 2001.

Information Label

Energy efficiency information labels as well as minimum efficiency standards are also affected by the test procedure. Given the ambiguity in the Chinese washer testing procedure, it is fairly easy for manufacturers to manipulate the energy use of their washers by dropping the washing temperature (Lin 2003a). One manufacturer suggested that 90% of Chinese drum washers could qualify for a "A class" (at 190 Wh/kg/cycle). If most washers in a category receive the highest efficiency rating, the value of the label for differentiating products is negated. (Lin 2003a)

Current MEPS, Information Label Criteria and Endorsement Label Criteria

Shown in Table 5 below are the 2003 limits on clothes washer energy and water use.

Table 5. New Limits on Electricity and Water Use (MEPS)

Clothes Washer Type	Unit Electricity Limit (kWh/ cycle /kg)	Unit Water Limit (L/ cycle /kg)
Impeller, automatic	0.032	36
Drum	0.350	20

Source: (AQSIQ 2003) GB 12021.4 –2003

[3] In Europe appliances are assigned a letter grade, with "A" being the more efficient.

CNIS decided to use two different test procedures with different assumptions for setting minimum values for clothes washer energy use; however, it is useful that they included both water as well as energy consumption.

Other approaches that could have been taken include adopting the same assumptions for both drum and impeller type washers, so that they could be directly compared. Additional reported information could have been hot water energy, cold water use and motor energy. This would also assist with a comparison for those washing in cold water.

Table 6 shows the levels used to assign washer rating levels for the information label. These can assist consumers in identifying washers with higher efficiencies than required. Note that it includes information on cleaning performance.

Table 6. Energy Efficiency Label Rating (Informational label)

Washer Rating	Impeller			Drum		
	Electricity KWh/cycle/kg	Water L/cycle/kg	Clean ratio	Electricity KWh/cycle/kg	Water L/cycle/kg	Clean ratio
1	≤0.012	≤20	≥0.90	≤0.19	≤12	≥1.03
2	≤0.017	≤24	≥0.80	≤0.23	≤14	≥0.94
3	≤0.022	≤28		≤0.27	≤16	
4	≤0.027	≤32	≥0.70	≤0.31	≤18	≥0.70
5	≤0.032	≤36		≤0.35	≤20	

Source: (AQSIQ 2003) GB 12021.4 –2003

Table 7 below shows another set of clothes washer levels used for an endorsement label administered by the China Center for the Certification of Energy Conservation Products (CECP).

Table 7. Endorsement Label Criteria[4]

Washer type	Electricity KWh/cycle/kg	Water L/cycle/kg	Clean ratio
Impeller	≤0.017 (30°C water)	≤24	≥0.80
drum	≤0.230 (60° C water)	≤14	≥0.94

Source: (AQSIQ 2003) GB 12021.4 –2003

It is interesting to note that under the 2003 standard, the drum type washers use almost ten times as much electricity as the impeller ones, but consume only half as much water. The difference in energy use is largely due to the difference in test procedures: impeller models are tested with water temperature of 30°C (as prescribed in the Japanese test procedure), while drum models are tested with input water of 15°C but heated to 60°C internally (as prescribed in IEC test procedure followed in Europe). This difference certainly biases against the drum clothes washers, other things being equal (Lin 2003c).

[4] Administered by CECP

Design Options

Options for improving energy efficiency fall into two main categories:

1. reduce the amount of hot water and the need to heat it
2. reduce the electricity consumption by using more efficient motors, pumps and transmission systems.

Forecasting Energy and Water Savings

Because of the large differences in energy and water consumption between impeller and drum type washers, the minimum level of efficiency the washer must meet does not just influence the efficiency within that category but may also have an effect on which type of washer the consumer chooses. For example, in addition to other factors the consumer uses to select which washer to purchase consumer may choose to save more water or more energy based on information on the label. Analysis of national energy savings is made more difficult due to the possibility of one type of washer being replaced by another.

Conclusions

When promulgating energy efficiency standards the effects on other parameters such as water use also need to be examined. If only energy consumption were analyzed, a minimum efficiency performance standard (MEPS) may have the unintentional effect of increasing water use, particularly if it causes consumers to switch from one type of clothes washer to another. The 2003 Chinese standard includes measures both for electricity and water usages. This is a major step toward the right direction.

The selection of a test procedure can have an effect on energy and water savings. If the test procedure does not compare different types of washers in an equitable way or if the test procedure differs significantly from how clothes washers are actually used, the resulting standard or labeling scheme may give consumers false impressions on the energy efficiency of clothes washing products.

In order to avoid a decision that would either favor energy or water savings, CNIS treated two different types of washers, as different products to be tested under different test conditions. This solves the problem of having to make a judgment on whether to eliminate a product type in order to give priority to either water or energy savings. However, it makes it difficult to compare two different types of washers. The best approach is to use a single test procedure based on how a product will be actually used but to have some of the basic assumptions consistent so as not to bias unfairly the choice of washers. This may necessitate modifying international standards to take into account of the Chinese clothes washing habits.

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