Cold or hot wash: How technological choices would lead to cultural change and potential increase in clothes washing energy use in China

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Abstract

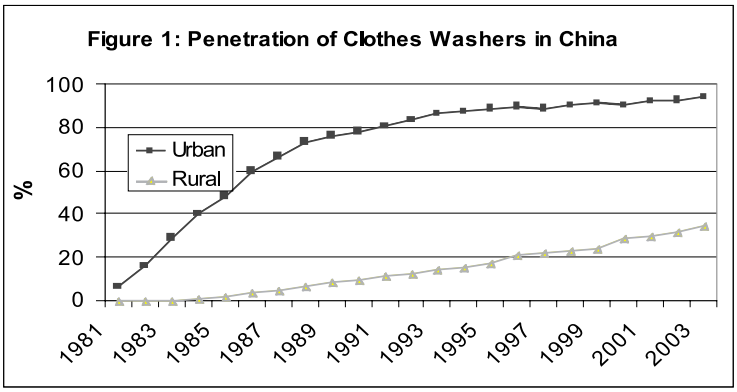
Usage pattern of clothes washing (and clothes washers) are strongly related to local cultural practices. Such practices have led to the development of distinctive clothes washing technologies in US, Europe, and Japan. In the emerging markets such as China, several types of technologies often co-exist. Some use less energy but more water (the impeller type), and some use more energy but less water (the horizontal axis type, often with built-in water heaters). The competition between different technologies is thought to lead to better consumer choices. However, it could also lead to changes in clothes washing habits – from cold to hot wash, and therefore to much higher energy use. This paper examines the standards development process in China, the largest appliance producer and market in the world, to illustrate that adoption of foreign technologies and technical standards, if not carefully calibrated to the local cultural practices, could have unintended consequences for energy use and environment.

Introduction

Clothes washing is one of the earliest domestic activities in human society. The way people wash their clothes remained unchanged until the emergence of mechanical clothes washers for domestic use in the last century. Clothes washers, now mundane in our life, were once considered one of the greatest human inventions that rescued "women" from their daily drudgery of chores. The earliest washing machine was the scrub board invented in 1797. James King, an American, patented the first washing machine to use a drum in 1851. The drum made King's machine resemble a "modern" machine, however it was still manually powered. The Thor was the first electric-powered washing machine, which was introduced in 1908 by the Hurley Machine Company of Chicago, Illinois. Since the introduction of these prototypes, clothes washers have come a long way both in their performance as well as convenience. While convenience comes with its own costs, in the current context, greater energy and water use, such costs are considered negligible or acceptable, since for people in the industrialized societies as well as in many parts of the developing world, the norm of clothes washing has changed from manual to mechanical.

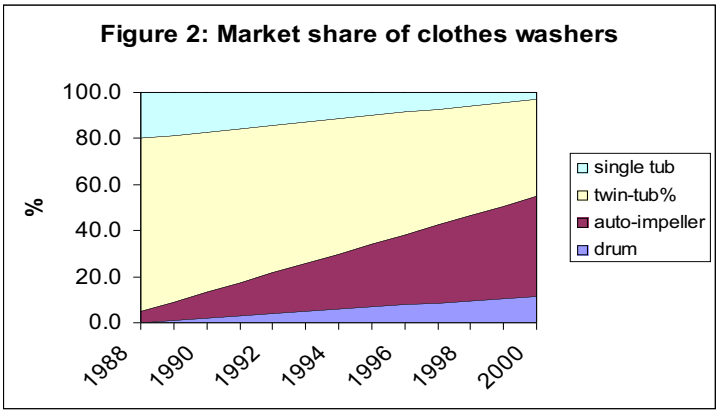
In China, such changes occurred in a much shorter time, given the nascent nature of the Chinese household appliance market. It is only since the 1980's that clothes washers became available to average households in China. The dramatic uptake of clothes washers in China seems to validate the belief that a shift from manual to mechanical washing is a desired choice by average consumers; and that people are comfortable with the consequences of higher utility bills.

With increasing competition in the clothes washers' market in China, more and more features are pitched to consumers as newer and better in performance. However, whether "newer" is "better" is debatable beyond a certain "cleanliness" threshold, the primary utility of clothes washers. Nevertheless, the choice of certain features and technologies could lead consumers to drastically different paths in terms of energy and water use for clothes washing in China. This is especially true between the impeller type washing



Source: China Statistical Yearbook 2003

Figure 1.



Source: China Association of Light Industries (cited in CNIS report)

Figure 2.

machines introduced from Japan and the drum type introduced from Europe. Drum (also known as horizontal axis) washers typically use half the water but up to ten times as much electricity as the impeller washers do. The higher energy use is mostly due to the fact that drum machines are tested under hot wash conditions and many drum washers in China have built-in heating elements as domestic hot water is not available in most of the houses in China at present. China's new national standard for clothes washers sets separate energy and water performance levels for impeller and drum washers, according to different test procedures originally developed in Japan and Europe. Thus many consumers who buy or switch to drum washers would be unwittingly stuck with hot wash cycles, a choice often not clearly understood by consumers.

This paper examines the market development of clothes washers and standards development process in China and attempts to assess the impact of technological choices on China's clothes washing energy use.

Development of Clothes Washer Industry in China

While China is the largest market for clothes washers today, it was not until 1980's clothes washers were introduced to the ordinary Chinese consumers. As China's economy took off in 1980s, demand for consumer appliances also skyrocketed. Annual shipment of clothes washers rose from 1.28 million in 1981 to 19.4 million in 2003. While very few families had their own clothes washers in 1980, about 95% of urban families and over 40% of rural families in China now have their own clothes washers (Figure 1).

While in the 1980's foreign makers dominated the clothes washer market, several large Chinese appliance manufacturers have since captured the majority of the market today, with Haier and Little Swan holding roughly 40% of the domestic market. As the clothes washer market grew, product range diversified as well. In the 1980's, most washers are of the single- and twin-tub type. The former only has the washing and rinsing cycles – one has to manually wring the water out of the clothes; the latter provides a separate spin tub, but the user has to manually transfer the clothes at the end of washing cycle from the first tub to the second tub.

Today the increasingly affluent Chinese urban households have chosen the convenience of the automatic clothes washers, while rural households tend to purchase the twin-tub washers because of the lower prices. Of the automatic washers, the traditional impeller washers (vertical axis), first introduced from Japan, are still the dominant type, but the drum type (horizontal axis) washers, introduced more recently by the European manufacturers, are gaining popularity, due to its water saving features, longer lifetime, and "superior quality" as advertised by its manufacturers. The type of clothes washers found in US is rarely seen in China. For the purpose of this paper, the discussion is centered on the automatic impeller and drum washers, since twin-tub washers do not offer the same level of convenience and functionality.

Technology interacts with humans /cultural preference

We have seen historically that technology never acts alone in the process of economic and social development. The role that a technique or a technology plays in a society depends in large part on the manner in which it is introduced, made familiar to and understood by the users. It is thus useful to acknowledge that technology and society are dependent upon each other; shaping and shaped by the other as a technology matures into a mass-produced entity with a strong self-momentum and other interests driving it. This leads us to the concept of co-evolution of science, technology and society, which is not new and has been part of the discourse for a while in evolutionary economics, sociology, and in science & technology studies. In the current context of clothes washers and cleaning practices, it is important to pay attention to the dynamics of consumption and cultural practices. For instance, how do personal preferences transcend the realm of choice into becoming the "norm" or a "practice"? As we will discuss later in this section, there are relevant social and material differences in how convenience and cleanliness are perceived, specified and achieved. This has some non-trivial effects in the normalization of standards and practices. The discussions involve how systems of goods or practices either stabilize or disappear in time. At the level of

individual household, this process can be described as the formation of a particular type of lifestyle. How does lifestyle move from the individual level to the neighborhood to community level? Elizabeth Shove, in her book on Comfort, Cleanliness, and Convenience (Shove 2003), introduces the concept of conventions of comfort or of cleanliness being soaked with moral, social, and symbolic meaning. This is somewhat established in the examples that we provide later on cross-cultural practices of cleaning. Though conventions may be steeped in cultural preferences, it is the co-evolution of these preferences through the interaction of different socio-technical systems (the technical with the social, in this case) that determines energy or resource content of a particular end-use.

It is easy to understand the evolution of washing technology from manual to mechanical, and from single- and twin-tub to automatic washers, because each step forward offers clear benefits for consumers in terms of convenience, which is assumed to outweigh associated energy and water costs. The case for European type (drum) washers, at least in the Chinese market, however, is not so straightforward. In comparison to the Japanese type (impeller), the drum washers have both advantages and disadvantages.

The drum washers are publicized as water saving, better cleaning, "high-tech", and having superior quality. Drum washers typically use about half as much water as impeller washers. Their "better cleaning" performance is considered related to hot wash and longer washing cycle. Whether this perception is justified will be discussed later in this paper. Clothes washers introduced in recent years have a variety of features to allow more choice and control for end-users. Whether drum washers have better technologies over impeller ones is debatable: for example, does the number of control buttons on clothes washers signify the content of technologies? Drum washers do tend to have longer lifetime, mostly due to more robust materials used (stainless steel versus plastic tubs), but cost considerably more than impeller ones, which in itself can be perceived as a sign of "superior" quality.

In addition to higher prices, drum washers, due to the use of hot water, use dramatically more energy – as much as ten times more than the impeller type. This fact, however, is not currently conveyed to consumers. Drum washers also take more space (important due to the space constraint in Chinese homes) and heavier. The washing cycle is longer, causing delays if multiple loads need to be finished within limited time frame. Most drum washers are front-loading, which is less convenient, to load and un-load clothes. Of these disadvantages, the hot wash cycle is of greatest concern here, since consumers could be unwittingly stuck with higher energy use, without having made the conscious choice (default cycle). While it is possible to disable the water heating function in drum washers and choose cold wash cycle instead, it is equally or more likely that consumers would choose the default hot wash cycle rather than going through the user's manual to understand the steps that are required to disable the heating function. It is also perceivable that the availability of hot wash cycle in itself would encourage a change in the washing habit among Chinese consumers – from cold to hot wash, since these "newer and better" features are often thought to provide "cleaner" wash.

PERCEPTION OF CLEANNESS – CULTURAL NORM VERSUS TECHNOLOGICAL OUTCOME

Cleanness of washing is a function of many factors such as water temperature, length of washing cycle, detergents, washer designs, and water quality. However, anecdotal evidence suggests that when asked, consumers often cite water temperature of the key determinant[1]. Length of time is mentioned sometimes as well. Anecdotal evidence indicates that hotter is better (cleaner) for Europeans. Americans seem to use "warm wash" most often (49% of washes are done in warm cycle, and only 14% in hot cycle). Japanese predominantly use cold wash -- most Japanese clothes washers don't even have a temperature selector. When asked, the Japanese seem to be puzzled by the concern that cold wash may not be clean enough, since they have been practicing cold washing forever[2]. In this context, it is important to mention that the Japanese market already uses detergent that is rich in enzymes able to tackle protein as well as fat based dirt removal even in cold temperatures. Thus in the Japanese case, the temperature factor as a determinant of cleanliness loses its importance in a relative sense. But washing practices and technologies supporting those practices in a different cultural and geographic setting perform differently without the technological accoutrements that encompass the system of washing.

Recently, Procter and Gamble (P&G) has launched a ColdWater Challenge with the Alliance to Save Energy to educate American consumers the financial and environmental benefits of cold wash. P&G claims that its Tide ColdWater detergent delivers great cleaning in cold wash, while saving energy and money, and keeping colors fresh.

There is a reasonable amount researched and written about cleaning habits across different cultures and the human response to climatic conditions, resource availability and socio-technical trajectories. A cross-cultural study of Japan and Norway (Wilhite et al, 1996) revealed strikingly different attitudes towards the relationship between hot water and cleanliness. In comparing the washing habits of the urban Japanese and Norwegians, the study concluded that they washed their clothes in cold and hot water respectively. The contrast was particularly striking given their personal preference for cleanliness. In contrast to the Norwegians, the Japanese had less resource intensive clothes washing practices. The authors observed, "the Japanese do not share Westerner's obsessive link between hot water and hygiene". In the same context, when it comes to bathing, the picture is quite the reverse. The Japanese use significantly greater amounts of water, energy and time in the bath, while the

1. For cross-culture perspective, the authors have interviewed a group of 9 Americans, Germans, and Japanese who live in the Bay Area, US.
2. Most Japanese households use cold water to wash their clothes. There are instances that water from the bath (still warm) is used for clothes washing, but mostly for water-saving/recycling purposes.

Norwegians take showers and thus consume much less water and energy.

The foregoing examples highlight that cleaning practices have deep cultural roots and that although what it means to be dirty and the rituals and expectations surrounding cleanliness vary widely, cleanliness or the methods for accomplishing it is an issue that is firmly anchored in convention. Added to this, there are temporal differences in approach, i.e. cleaning practices can evolve or change over time. These can be aided by standards, which are modified by the introduction of new technologies such as showers, washing machines, and dish washers.

SOCIO-TECHNICAL SYSTEMS AND THEIR TRANSFORMATION OF A CONSUMER

As discussed earlier, social construction of technologies is what shapes a consumer. Contrary to the popular belief in the energy community, technology is not a set of independent, value-free machine nor is society composed of pliable, individually selected, behaviors driven by morals, which can be established by advocacy or public education. In fact, technology transforms and is transformed by humans as well as the context within which they are operated.

Research focusing on bringing convergence in consumer value and perceptions, and technology, has attempted to modify consumer and his or her decisions by providing what can be considered "useful" energy information (Goldman *et al* 1996, Iyer et al 1998). Efforts are also directed towards changing technology so that it better possesses attributes that correspond to what consumers will likely value. Achieving a successful convergence for the case of energy efficiency is undoubtedly difficult, given that our understanding of what consumers want and how they perceive information is nascent. This also begs the question as to how consumers match their values to their choices, given that product attributes can only be partially known at the time of the purchase? How well can technologies or their scripting and branding be modified to match the information that will allow consumers to make informed decisions, while retaining their energy efficient character, and through what mechanisms can the market achieve such transformations?

Besides the issue of information, an important and often ignored concern is that of what happens to a technology post-purchase. Policy focus is often on the purchase decision, and the mere purchase of an energy-efficient product is considered a success. But, at the time of purchase, the decision is made on the basis of consumer expectations. How well the product meets expectations and how it gets used determines whether the purchase decision will lead to realizable savings.

What is conveyed through branding?

The field of energy efficiency is replete with examples that emphasize the role and importance of information that is conveyed through labels. Kempton (Kempton 1995) and Egan (Egan et al 1996) provide a significant discussion in the American context of the value customers place on accurate and easy to understand energy information. Research has also shown a correlation between consumer action and information.

The labeling of energy or water consumption values without reference to other performance attributes has the potential to seriously mislead consumers. The Chinese clothes washer market presently characterizes drum washers as a "water-saver". This provides no information to the consumer about other attributes of the machine, such as the high energy use of drum washers. Some performance attributes are straightforward and easy to specify in parallel with energy or water consumption information. In the case of clothes dryers, standard test procedures will typically specify initial and final moisture content for a load and this makes up a definition of "wet and dry clothes" for the purposes of comparative energy consumption and efficiency. However, for clothes washers, the issue of what constitutes clean clothes is complicated and subjective. However, in the absence of information on default temperature settings and incomplete information on resource use the effective performance of the appliance is called into question.

Another issue that may be of possible concern is that of branding leading to increased consumption not simply because of hidden technical details, but because of changing habits and shifts in cleaning practices. Shove (Shove 2003) discusses the "moral landscaping" of actions. For example, branding of washers and detergents has the potential to create and sustain conventions that are difficult to circumvent. These conventions in turn lend an "environmental morality" to these practices that allow and justify expansion of these practices.

Energy and Water Use Differences

While there may be differences in technical measurement of cleanness, both Europeans and Japanese are quite content with the cleaning performance of their own washing technologies. Interviews with Europeans and Japanese living in America, who have the experience of using different types of washers, indicate strong cultural affinity in which type of washing machines they prefer[3], but little concern over cleaning performance of various clothes washers.

Energy and water use differ significantly between the Japanese and European style washers. The water saving is part of drum washer's design feature, clothes do not have to be totally immersed in water. But new design features have narrowed the gap in water use between drum and impeller washers.

The difference in energy use, on the other hand, is largely due to the different measurement protocols used to test the performance of clothes washers. Drum washers are tested according ISO 60456 using 60°C water, while impeller washers are tested according to JIS 9606 using 30°C water. Each test protocol was developed to benchmark native technologies and cultural habit of clothes washing. However, the difference in test protocols makes it difficult to compare these two types of washers on equal footing. In the development of China's energy efficiency standard for clothes washers,

3. However, the super-size of the American washing machines is gaining favors among families.

Table 1. China's 2003 Energy Efficiency Standard for Clothes Washers.

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

Table 2. China's Endorsement Label Criteria for Clothes Washes.*

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

**The voluntary labeling program is administered by CECP*

Table 3. Annual Household Electricity and Water Use for Clothes Washing.

Clothes washers	***AEC (kWh*)***	***AWC (liters)***	***Annual Operating** Cost (RMB)***
Impeller	42	46 800	136
Drum	455	26 000	270

* Typical load is 5 kg, and wash per week is 5, which is based on data obtained from CNIS as well as from a five-city household energy use survey conducted by LBNL (Brockett, et al, 2000).
** Electric tariff of 0.45 yuan.kWh and water tariff of 0.0025/liter are obtained by CNIS.

Table 4. Annual National Electricity and Water Use for Clothes Washing.

Clothes washers	*AEC (GWh)*	*AWC (million liters)*	*Cost (million RMB)*	*Carbon Emissions (1 000 ton)*
Impeller	1 716	1 930 500	5 598	628
Drum	18 769	1 072 500	11 127	6 869

clothes washers were divided into two categories: drum and impeller – each is measured differently using either ISO or JIS measurement standard. The resulting standard sets separate requirement for each category as listed below.

It is clear from the table above that maximum energy limit per cycle for drum washers is ten times greater than that for impeller washers, while the water limit is 45% lower. Other things being equal, introduction of drum washers in China would certainly lead to much higher energy use (and lower water use) for clothes washing.

The requirement for China's endorsement label for clothes washers contains similar contradictions: even the most energy-efficient drum washers won't meet the energy limits for impeller washers.

Obviously, a new unified test protocol for both types of clothes washers is needed. Such a test protocol should incorporate the clothes-washing pattern observed in China – cold wash. Otherwise, not only is the information provided in the label misleading for consumers, it could also lead to Chinese consumers who have chosen the drum washers stuck with hot wash cycle and higher energy costs. Worse still, the misinformation and the perception it creates could help to influence the washing norm in China to shift from cold to hot wash, with great environmental and economic consequences.

ON THE HOUSEHOLD LEVEL

The increased energy use for drum washers operating under hot wash is significant for average Chinese families. Using the maximum limits in China's 2003 standard, the annual energy, water, and operating cost of clothes washers are calculated.

Urban Chinese homes use on average about 1 600 kWh of electricity per year, therefore this increased electricity use represents roughly 25% increase in household electricity use (Brockett et al 2002).

ON THE NATIONAL LEVEL

As drum washers are expected to gain market share in the future, this trend could lead to huge impact on China's energy use and associated emissions of pollutants. Table 4 summarizes the energy and environmental impact if one third of China's washers in the near future (roughly 125 millions in 2010) is drum type.

The adoption of drum washing machines with hot wash cycle could lead to about 17 TWh additional electricity use in China, equivalent to 12 large base-load power plants at 300 MW each and over 6 Million tons of carbon emissions. In addition, Chinese consumers are expected to pay an additional 5.5 Billion RMB (roughly 500 Million Euro) annually in operating cost!

Conclusions

In most of the developed world, three distinctive types of clothes washers (the Japanese impeller, the European drum type, and the American agitator) have emerged, each with its own testing and measurement protocol. Each continues to dominate its home market.[4] However, when such competing technologies are introduced in emerging markets such as China, they bring additional complexity for local policymakers and consumers in comparing these competing technologies in their own cultural context.

Reasonable comparison requires appropriate testing and measurement protocols. Developing an appropriate test protocol reflecting local cultural practices as well as supporting infrastructure[5] is a time-consuming and technically challenging process. Oftentimes, international protocols are adopted in its entirety without modification. Such practices can lead to unforeseen negative consequences.

In the new standards and labeling requirements for clothes washers in China, separate performance requirements were set for drum and impeller washers. This can also lead to misleading information in the energy label – the energy efficient drum washers are in fact energy hogs in comparison to impeller washers. Chinese consumers, without complete information on clothes washers' energy and water use, may continue the current trend of choosing drum washers over the impeller type and thus unwittingly commit themselves to changing the cultural practice of clothes washing in China. This could have serious economic and environmental consequences.

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4. The rise of drum washers in the US deserves separate discussion.
5. Especially relevant when all of the hot water for a hot wash requirement are met within the clothes washer, thus using a relatively inefficient method to heat water.