Awash in Energy Efficiency: Overcoming Barriers to Market Penetration of Horizontal Axis Clothes Washing Machines

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Horizontal axis clothes washing machines are significantly more energy efficient than vertical-axis washers. They also offer consumers lower life cycle costs than vertical axis washers and use less water. Yet, horizontal axis washers account for only a minuscule share of the home clothes washing machine market in the United States, which is dominated by vertical axis designs. Thus, the potential savings associated with horizontal axis washers remains untapped by both consumers and electric and water utilities.

This paper identifies barriers constraining market penetration of horizontal axis clothes washers, and evaluates the cost-effectiveness of using utility rebates to overcome these barriers and increase consumer purchase of these appliances. Barriers identified include a lack of scale economies and competition in horizontal axis washer manufacturing and distribution, the high initial purchase price of horizontal axis washers, and a lack of marketing of horizontal axis washers by the appliance industry. Other barriers may stem from consumer perceptions that horizontal axis washers wash fewer clothes per load and consumer antipathy to the front-loading design of horizontal axis washer available in the United States. Analysis shows it to be cost-effective for electrical utilities to operate rebate programs to overcome these barriers, suggesting that they should operate rebate programs to boost consumer acceptance of horizontal axis washer as a means of acquiring demand-side resources.

Introduction

In the United States, the market for home clothes washing machines is dominated by the top loading vertical axis design (V-axis). Top loading refers to the location of the door through which clothing is loaded into the wash tub. Vertical-axis refers to the upright orientation of the axis upon which the wash tub is mounted and about which the wash tub spins (Figure 1). V-axis washers also have mounted upon their axes an agitator device, the purpose of which is to circulate clothing in the wash water.

Horizontal-axis washers (H-axis) are also sold in the United States. In H-axis washers, the wash tub sits on its side and turns around a horizontal axis. Unlike V-axis washers, most H-axis washers are front loading. Also, unlike V-axis washers, H-axis washers have no agitator. In H-axis washers, clothing is distributed through wash water by the tumbling motion of the wash tub as it rotates around its axis.

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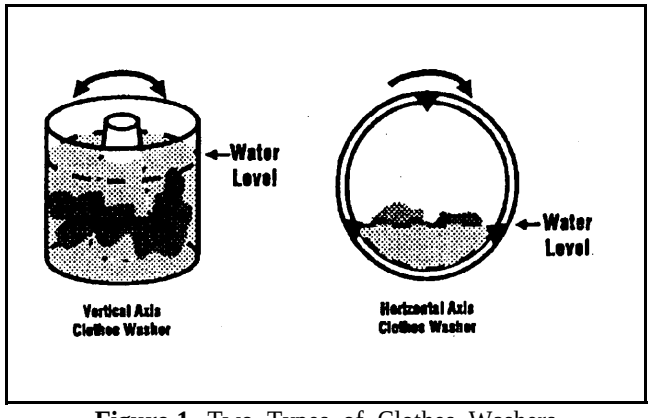

Figure 1. Two Types of Clothes Washers

Although once popular with U.S. consumers, H-axis washers are estimated at the current time to account for only two or three percent of home clothes washer sales in the United States. V-axis washers make up the balance of the market (Pope and Slavin 1992). Thus, the savings to be derived from H-axis washers remains untapped by both consumers and utilities.

This paper identifies barriers constraining market penetration of horizontal axis clothes washers, and shows that it is cost-effective for electric utilities to use rebates to overcome these barriers and increase consumer acceptance of these appliances. The paper also discusses why H-axis washers are more energy efficient than V-axis washers, estimates the technical potential for acquiring energy and water conservation by expanding the market for H-axis washers, and shows H-axis washers to offer consumers lower life cycle costs than V-axis washers.

The paper focuses upon how expanding the market for H-axis washers can help conserve electricity. Also addressed is how expanded use of H-axis washers can contribute to water conservation. Although an expanded H-axis washer market can also serve as a source of natural gas conservation, this is not the central concern of this paper.

The Source of H-Axis Washer Efficiency

May, 1994 saw the introduction of a new federal energy efficiency standard for home clothes washing machines. Home clothes washers manufactured subsequent to May 1994 must have a minimum Energy Factor of 1.18 cubic feet of wash tub capacity per kWh if they are to be offered for sale in the United States. A typical washer complying with the new standard will consume an average of 675 kWh annually (DOE 1990).

The 1994 standard was based upon what was viewed as the maximal feasible efficiency level attainable with conventional V-axis washer technology. H-axis washers exceed this standard. H-axis washers produced for sale in the United States in 1994 will require approximately 300 kWh annually to operate, a figure equivalent to 45 percent of what will be consumed by V-axis washers meeting the new federal standard.

H-axis washers are more energy-efficient than V-axis washers because of the economical way they use hot water during the wash cycle. Although water heating actually takes place in a hot water tank, it is an intrinsic part of washer operation, accounting for between 80 and 90 percent of the energy needed to operate the average clothes washer. Washing machines that use much less hot water require less energy to operate.

V-axis washers require that clothing be fully immersed in wash water, so that the machine's central agitator can properly circulate and agitate clothing. In H-axis washers, clothing is agitated in wash water by the tumbling action of the washer tub. This eliminates the need to fully immerse clothing in wash water. As a result, operation of H-axis washers requires, on average, one-third less total water, and, importantly, two-thirds less hot water, than comparably-featured V-axis washers that comply with new 1994 standards (DOE 1990).

A second efficiency advantage of H-axis washers stems from their ability to minimize the remaining moisture content (RMC) left in clothing at the conclusion of the wash cycle through the installation of high-speed spin water extraction technology. In the United States, home clothes washers are typically operated in tandem with clothes dryers, which use heated air to evaporate moisture. The amount of energy consumed by clothes dryers is largely a function of RMC. To the degree that RMC can be reduced, the amount of energy needed for dryer operation will be proportionately reduced.

High-speed spin produces energy savings because it is approximately 70 times more energy efficient to remove moisture by spinning than by heating (Lovett 1981). Estimates are that installing high-speed spin in a H-axis washer can reduce dryer energy use on the order of 25 percent, while requiring only a marginal increase in washer motor energy.

At this time, high-speed spin technology is unavailable on domestically produced H-axis washers. However, high-speed spin should become a standard feature of domestically produced H-axis washers by 1995. This is in contrast to the case with V-axis washers. At the time of this writing, appliance manufacturers do not appear to have plans to introduce high-speed spin to V-axis washers.[1]

Technical Energy Savings Potential

Table 1 estimates of the technical potential for conserving electricity from increasing the share of the nation's home clothes washer stock accounted for by efficient H-axis washers. To illustrate the conservation potential that might be derived from H-axis washers with high-speed spin, the Table 1 energy savings estimates reflect paired washer-dryer systems. Savings estimates reflect the difference between how much energy would be consumed by the nation's stock of home clothes washers and dryers in 2010 if the nation's washer stock remained characterized by the prevailing breakdown between H- and V-axis designs, and if the share of H-axis washers with high-speed spin in use during this period were to increase. Selection of 2010 as the benchmark for these estimates reflects the fourteen year average operating life of the nation's stock of clothes washers. By 2010, the majority of the existing washer stock will be replaced. Table 1 estimates savings at three different levels of H-axis washer penetration, to shed light on the order of magnitude to which expanded H-axis use can help save energy.[2]

Table 1. Technical Energy Savings Potential from H-Axis Washers in 2010

Percent Market Share- H-Axis Washers	20% H-axis	50% H-axis	100% H-axis
Annual Energy Savings (MWh)	9,153,000	24,408,000	49,833,000
Annual Water Savings (millions of gallons)	54,821	146,189	298,470

Table 1 shows expansion of the H-axis washer market to comprise a potential source of significant electricity savings. For example, increasing the share of the nation's home clothes washer stock accounted for by H-axis washers with high-speed spin to 20 percent would yield an estimated 9 million megawatt hours in electricity conservation nation wide in 2010. Should H-axis washers come to account for the entire stock of washers in use in 2010, an admittedly unlikely potentiality, national electricity savings could approach 50 million MWh.

Table 1 also points to expanded H-axis washers use as a potentially valuable source of water conservation, Expanding market penetration of H-axis washers to 20 percent of the nation's total washer clothes washer stock would reduce annual water consumption nationwide in 2010 by over 50 billion gallons. One-hundred percent saturation of the clothes washer market by H-axis washers would lead to an annual water savings of almost 300 billion gallons.

Consumer Life Cycle Analysis

H-axis washers offer consumers lower life cycle costs than do V-axis washers, despite the fact that H-axis washers are more expensive to purchase than V-axis washers. With an expected purchase price of approximately $775, new domestically produced H-axis washers with high-speed spin offered for sale in 1995 should retail for an average of $300 more than V-axis washers containing comparable features. Imported H-axis washers offered for sale in the United States are even more costly, being priced in excess of $1,000.

Table 2 compares estimated life cycle costs of H-axis and V-axis washers.[3] Life cycle costs are calculated in constant 1993 dollars at alternative consumer real discount rates of 3 and 10 percent. Costs are estimated based on an electricity price of 8 cents per kWh, a figure illustrative of the national average retail price of home electricity. With either discount rate, it is clear that the life cycle cost of H-axis washers is lower than that of V-axis washers. The simple payback on an H-axis washer is three years.

The lower life cycle cost of H-axis washers derives from three factors. One is the need to heat less water for the wash cycle, which lowers the energy bills of H-axis users below those of users of comparably-featured V-axis machines. A second source of savings stems from the reduced requirement for laundry detergent by H-axis washers. Estimates are that H-axis washers use on average between 35 to 40 percent of the amount of detergent necessary to operate a comparable V-axis washers (Kadulski 1992; Lebot, Turiel, and Rosenquist 1990). This is a direct consequence of the lower water requirements of H-axis washers and means that consumers operating H-axis washers are likely to spend less on laundry detergent than those operating V-axis washers. Last, because H-axis washers need less water to operate than V-axis washers, consumers save on their water and sewer bills.

Market Barriers

The market for H-axis washers appears to be constrained by several factors. These can be divided into those that stem from industry practices, and those that arise from consumer perceptions.

Industry Practices

A key barrier to consumer purchase of H-axis washers is the high purchase price of these appliances. One factor that appears to account for their high purchase price is the absence in the production and distribution of H-axis washers of the cost saving scale economies that characterize high volume V-axis washers. Another factor is the high degree of concentration that characterizes domestic H-axis production, which probably drives up prices beyond those that would prevail in a more competitive market. At the time of this writing, there was but a single domestic manufacturer of H-axis washers. This is in contrast to V-axis washers. domestic production of which is diversified amongst at least five firms (DOE 1990).

Additional barriers to expanded consumer purchase of H-axis washers stem from their limited availability in the

Table 2. Consumer Washer Life Cycle Cost Comparison

	Three Percent Discount Rate[a]			Ten Percent Discount Rate		
	V-Axis	H-Axis	Savings	V-Axis	H-Axis	Savings
Washer Purchase Price	$475	$775	$(300)	$475	$775	$(300)
PV[b] Energy Cost	$1,362	$852	$510	$889	$556	$333
PV Detergent, Water, Sewer Costs	$1,791	$1,161	$630	$1,168	$758	$410
PV Total Savings			$840			$443

(a) Costs are discounted in real constant dollar terms.
(b) PV = Present Value

retail marketplace, and a lack of industry marketing. Most appliance stores do not stock H-axis washers. This probably reflects the monopolization of domestic H-axis washer production, since retailers not contracted to carry the single manufactured line are thereby denied their display. Also, there is virtually no marketing of H-axis washers, industry marketing activities being almost exclusively focused upon V-axis washers. The lack of marketing of H-axis washers deprives consumers information on their relative benefits, and uninformed consumers make unlikely purchasers (Pope and Slavin 1992).

Consumer Perceptions

Consumers may be deterred from purchasing H-axis washers by the fact that H-axis washers have wash tubs traditionally only half to three-quarters the size of tubs found in the V-axis washers featured in U.S. appliance showrooms. As a practical matter, the horizontal orientation of H-axis washers allows them to wash more laundry per-volume of tub space than V-axis washers (International Electrotechnical Commission 1987). Still, many American consumers may equate "bigger" with better," and this may translate into a preference for V-axis washers.

The front-loading orientation of H-axis washers may present another barrier to consumer purchase of these appliances, a conclusion suggested by a study of Canadian appliance consumers, who demonstrated a preference for top-loading washers (Lebot 1990). Consumers may believe that it is easier to load and unload laundry from top loading washers than from front loading designs. However, H-axis washers can be designed to provide wash tub access from the top instead of the front. Top-loading H-axis washers are common in Europe, and are likely to be manufactured in the United States in the future. Furthermore, front-loading washers are space savers, because they can be stacked and placed under counter tops. This could be an asset to people living in apartments and condominiums.

The front-loading design of domestically produced H-axis washers may also deter consumers who fear flooding should the washer door become ajar during the wash cycle. In practice, this is improbable, as H-axis washers contain a door-locking feature activated during wash cycles.

Transforming the H-Axis Washer Market

Federal energy efficiency standards comprise a traditional approach to promoting market transformations to more efficient home appliances. New home clothes washer energy efficiency standards took effect May 1994. However, manufacturers are likely to bring V-axis washers into compliance with the new standard by simply eliminating the warm water rinse option from these appliances (DOE 1990). Thus, at least for the present, federal standards alone are unlikely to provide impetus to wider demand for H-axis washers.

Rebates can help overcome barriers constraining market penetration of energy efficient appliances (Kreitler 1991, Kreitler and Tobin 1991; Gorzelnik 1984). Rebates could help boost the H-axis washer market by closing the purchase price differential between H- and V-axis washers, encouraging purchase of H-axis washers by consumers otherwise deterred by their purchase price. The marketing efforts that accompany rebate programs could help publicize the economic and efficiency benefits of

H-axis washers to consumers and address misconceptions surrounding the smaller size of H-axis washer wash tubs.

The long-run aim of rebate programs would be to propel more far reaching changes in the home clothes washer market. To the degree that rebates stimulate consumer demand, they could help increase the scale economies of H-axis washer production and distribution and encourage entry into the H-axis washer market by new domestic producers. Taken to its logical conclusion, the result could be downward pressure on H-axis washer prices, a further stimulus to consumer demand.

The Cost-Effectiveness of Utility Rebates

Figure 2 shows that it is cost-effective for utilities to offer substantial rebates to promote market penetration of H-axis washers in homes with electric water heating and electric drying. The chart illustrates how much of a rebate electrical utility could cost-effectively pay to consumers as a function of utility levelized costs for conservation resource acquisition. The numbers along the chart's side reflect utility real levelized costs. The numbers across the chart's bottom reflect the corresponding rebate amount. Estimates are provided for alternative utility discount rates of 3 percent and 6 percent.[4]

Figure 2 shows that electrical utilities with a conservation measure cost threshold of 44 mills could find it cost effective to incur per-unit rebate costs approaching $250 to operate H-axis washer rebate programs.[5] At this level, a utility would rebate a sum equivalent to over 80 percent of the incremental price differential between H- and V-axis washers. A utility with a lower levelized cost, of say 30 mills, which should meet the conservation cost threshold of most utilities, would find it cost effective to rebate $205, enough to offset almost 70 percent the incremental price difference between H- and V-axis washers.

Recommendations

This paper shows that it is cost-effective for utilities to offer substantial incentives to promote market penetration of H-axis washers in homes with electric water heating. Electric utilities should move to evaluate the cost-effectiveness of operating H-axis washer rebate programs in their own service areas. The water savings potential of H-axis washers suggests that they should consider doing so in conjunction with water utilities seeking strategies to conserve water.

This message appears to be gaining acceptance. One sign is the collaborative effort mounted by the Consortium for Energy Efficiency (CEE), composed of energy and water utilities, environmental groups, and state agencies from across the nation. In 1993, CEE adopted voluntary energy and water efficiency criteria for efficient clothes washer programs which are only attainable with H-axis washer

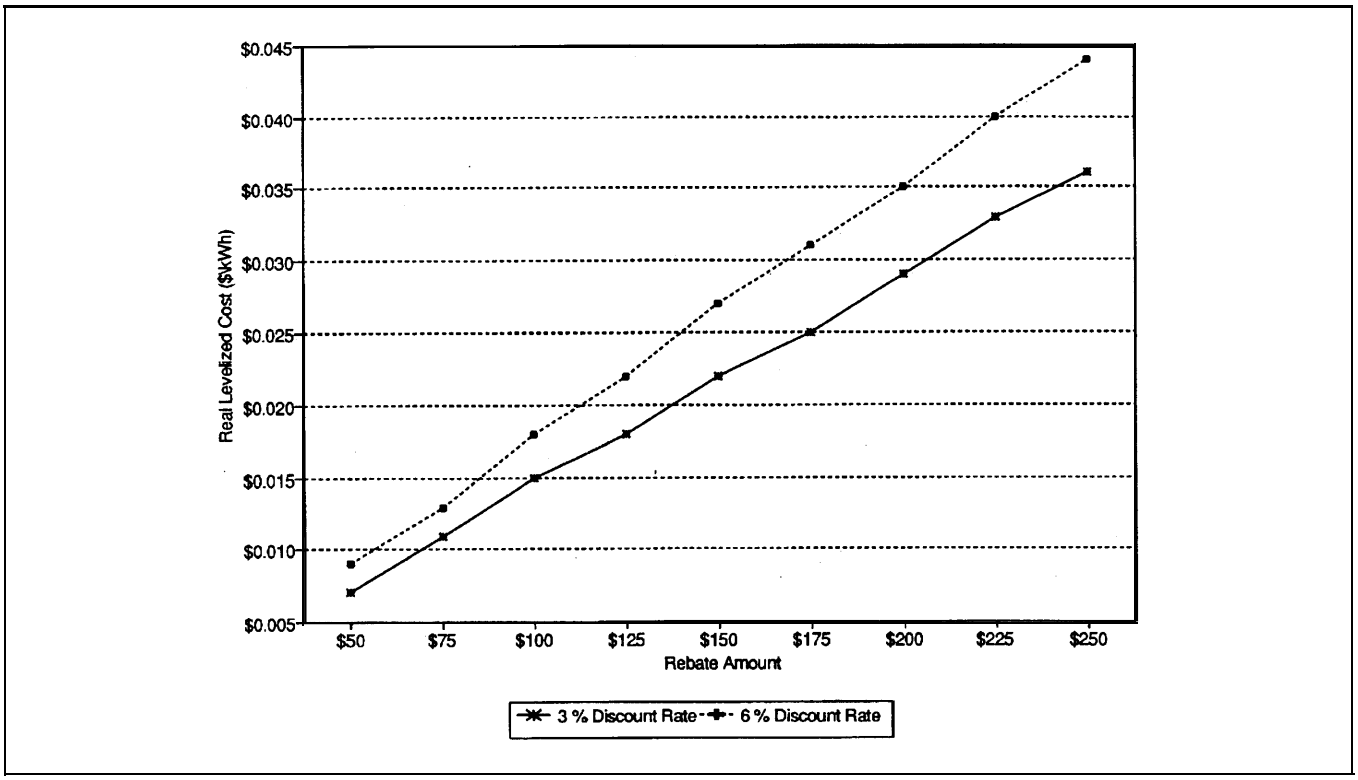

Figure 2. Rebate Cost-Effectiveness

technology. CEE is now engaged in discussions with utilities interested in adopting these criteria as the basis for their own H-axis incentive programs. Another sign is The High Efficiency Laundry Metering & Marketing Analysis project (THELMA), funded by the Electric Power Research Institute (EPRI) and a consortium of twenty-six electric, gas, water, and sewer utilities, and related organizations. The objectives of THELMA are to further assess consumer acceptance of H-axis washers and further quantify potential energy and water savings to be derived from expanding the H-axis washer market, and to identify program design strategies for utilities seeking to implement incentive programs to expand H-axis washer use. These efforts suggest growing awareness that the time to expand the H-axis market has come.

Acknowledgments

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Endnotes

1. References made in this paper to industry plans for the future manufacturing and marketing H-axis clothes washers are drawn from personal conversations between Ted Pope and appliance industry representatives.

2. Estimates of technical potential assume that washers and dryers are installed in 90 million households in 2010, and that annual paired washer-dryer energy consumption will be 943 kWh for paired H-axis washers and 1,508 for paired V-axis washers. Annual water consumption for H-axis and V-axis washers is assumed to be 10,868 and 14,252 gallons. For simplicity, the energy savings are calculated as if all water heaters and clothes dryers are electrically heated, which probably understates actual potential energy savings.

3. Life cycle cost estimate assumptions are as stated in text and end notes with following additions. Electricity is assumed to cost $0.08 per kWh, and water and sewer rates of $0.0018 and $0.0045 per gallon are assumed. Annual detergent costs for H-axis and V-axis washers are assumed at $34.40 and $68.80, respectively.

4. Assumptions are as previously stated in text and end notes.

5. Per-unit program administrative costs would need to be added to values along the chart's bottom in order to identify total program costs.

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