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THELMA: ASSESSING THE MARKET TRANSFORMATION POTENTIAL FOR EFFICIENT CLOTHES WASHERS IN THE RESIDENTIAL SECTOR

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Horizontal axis (h-axis) clothes washers with high speed spin cycles promise substantial energy and water savings through more efficient use of wash cycle water and improved moisture removal. A consortium of energy and water utilities and related organizations is participating in an effort to further quantify the estimated savings from these efficient clothes washers and to determine the potential for successful market intervention programs. The amount of information necessary to properly quantify savings and estimate market acceptance is immense. An integrated research plan was designed to address these informational needs. The research plan includes an international survey of efficient clothes washers, laboratory testing, a market assessment, a distribution analysis, and an impact assessment. The syntheses of the THELMA research should quantify the potential resource savings and identify the optimal market intervention strategies for leveraging a lasting market transformation to high efficiency clothes washers in the residential sector.

Background

In 1992, a coalition of Pacific Northwest utilities, government agencies and environmental groups interested in promoting appliance efficiency identified the h-axis clothes washer as a promising technology. Limited testing and anecdotal information suggested that the h-axis configuration could provide substantial energy and water savings as well as other performance benefits. H-axis washers, however, represented less than two percent of annual U.S. washer sales.

According to information supplied by the Association of Home Appliance Manufacturers (AHAM, 1993) and the U.S. Department of Energy (DOE, 1990), the average US household with a washer purchased in 1992 used an average of 39 gallons of water and 2.7 kWh per cycle (assuming 100% efficient water heat) for a total of 16,200 gallons and 1,120 kWh annually. In addition, the average dryer energy use was 2.4 kWh per cycle or 1,000 kWh annually. The 1994 federal standards, however, now require that new washers use fifteen percent less energy than the 1992 models. Furthermore, most observers believe that the above figures overstate actual consumption because they are based on 1975 consumer laundering patterns which have grown less energy intensive since that time (Lebot *et. al.*, 1990).

Unlike the typical vertical axis washer which has a central agitator post and must have its wash tub filled with water for proper cleaning, the h-axis washer tub need be only partially filled with water for proper cleaning action. Clothing is tumbled through the wash solution approximately once a second by the rotating drum. Under typical usage, 80-90 percent of the energy consumption attributed to clothes washers is used to heat water (DOE, 1990). The partial filling of the h-axis washer's tub, therefore, results in significant reductions in total water, hot water and water heating energy. Furthermore, recent models of h-axis washers have typically included high speed spin cycles that extract more moisture than is common in typical vertical axis washers. A lower remaining moisture content allows shorter dryer cycles. Shorter dryer cycles result in proportionate dryer energy reductions (Arthur D. Little, 1995).

On behalf of the coalition of Northwest utilities, the Washington State Energy Office completed a technology assessment and cost effectiveness evaluation of h-axis clothes washers in mid-1992 (Pope and Slavin, 1992). In general, the results showed h-axis clothes washers with high spin speeds could use one-third less water, two thirds less energy, substantially less detergent, and reduce dryer time by one-third. The assessment suggested that certain cleaning and fabric care advantages might be associated with the tumble action of the h-axis design.

In view of the estimated savings and minimal market share, the coalition members perceived h-axis market intervention to be an ideal opportunity for collaboration amount water, electric, gas. and sewer utilities. While the technology showed promise, the coalition utilities did not have all the quantitative and qualitative data needed to assess program cost-effectiveness. The number and complexity of the variables driving energy and water use

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estimates suggested that more data appropriate to the region was needed on energy, water and detergent consumption, consumer laundering behavior, and machine performance.

THELMA Colaborative Formation

Seattle Water and Seattle City Light began discussing the opportunity for collaboration on clothes washer research in late 1992 with other utilities. With a strong interest in pursuing the h-axis washer resource, they developed The High Efficiency Laundry Metering & Marketing Analysis (THELMA) to provide the information necessary to develop programs. In search of additional resources, the utilities approached the Electric Power Research Institute (EPRI) to discuss a larger research project with a broader scope. Due to the interest from several resource sectors, the project was structured as an EPRI Tailored Collaborative so that non-energy organizations could participate. The collaboration continued to expand in late 1993 and early 1994 with the inclusion of additional Northwest utilities and organizations from California, Florida and Ontario, Canada. Ultimately, 19 organizations joined the collaborative effort. The THELMA participants represent electric, natural gas, water and waste water utilities and related government agencies. These organizations are listed in Table 1.

THELMA Research Design

In order to determine whether to promote efficient clothes washers as a demand-side conservation measure, THELMA participants needed to learn more about the washer technology, potential resource savings, and potential market acceptance. To address these issues, the THELMA research included the following objectives:

Characterize the current status of the h-axis technology world-wide.

Confirm engineering estimates of savings & assess customer laundering habits in US markets.

Identify potential barriers to market penetration of efficient clothes washers.

Identify critical issues and suggest strategies for utility market intervention programs.

Figure A presents an overview of the major THELMA research activities, which include a global efficient washer survey, laboratory testing, market assessment, distribution system analysis, and an impact analysis. The figure also illustrates the linkages between each of these major research tasks. The Global Washer Survey and Laboratory Tests were initiated early in the project development phase. later, a consulting team was hired to design and implement a comprehensive research plan covering the remainder of the research tasks (HBRS *et. al.*, 1995).

Global Washer Survey

In recent years, most h-axis technology advancements have occurred outside of North America. In order to assess the current state of the art in efficient clothes washers, a consultant was hired to gather and compile technical, performance, and market data about the world's most efficient clothes washers. A detailed survey form was developed and mailed to over 100 manufacturers and distributors of residential clothes washers world-wide. The analysis of the survey results showed that there were many h-axis products that dramatically exceeded typical vertical axis efficiencies for water and energy use (Seattle Water, 1994). The survey also identified several issues that required further evaluation in the THELMA research.

Laboratory Testing

Little information was provided by manufacturers in the global survey that could be used to accurately compare the performance of the different products. However, the results from the survey were used to select the washer models to be tested in an independent laboratory setting. The laboratory tests addressed the following topics:

- Water consumption
- Energy Consumption
- Water extraction effectiveness
- Effect of moisture content on dryer energy
- Soil removal effectiveness
- Rinsing effectiveness
- Gentleness of action

The laboratory tested six h-axis washers and one vertical axis washer selected to represent typical washers on the U.S. market. The THELMA steering committee selected the units in part for their diversity of features -- front-loading, top-loading, internal heating, domestic, imported, automatic level selecting, and other automatic features. It should be noted that this laboratory study emphasized existing products (not all available in the U.S.) and was not intended to characterize the performance of products expected to be released in the US market in 1995 and 1996. The testing confirmed expectations regarding energy and water use. Average, normalized energy use of the h-axis models was about half that of the vertical axis washer. Average normalized water consumption was about 20% lower. The highest Energy Factor exceeded 3.0 cubic fee/kWh (versus the current federal standard of 1.18) and the most water efficient washer used 50 percent less water (normalized) than the vertical axis washer (Arthur D. Little, 1995). There appeared to be no relationship between Energy Factor and normalized water consumption.

Cleaning effectiveness was measured using an industry standard soil removal test procedure (ANSI/AHAM HLW-1-1987). All h-axis models substantially out-performed the vertical axis washer in this test. The AHAM soil removal test is just a partial test of total cleaning performance, but the results provide confidence that h-axis washers are likely to at least meet consumer expectation for cleaning ability. Based on calculations performed by the laboratory, it is clear that the h-axis washers generally exceeded the vertical axis washer in rinsing effectiveness.

Market Assessment

The market assessment is designed to address three primary objectives: 1) assess the potential market barriers and customer acceptance of efficient washers; 2) validate key findings in the impact assessment and assist in extrapolating those results to other service areas that were not represented in the metering study; and 3) identify issues and strategies that will help utilities develop incentive programs to leverage a lasting market transformation toward efficient washers.

The key research activities for the market assessment include: 1) a series of focus group discussions with consumers to explore issues related to their laundry behavior and the desirable characteristics of washers; 2) a large-scale market research survey, using a combination of telephone and mail/diary procedures; 3) a laundry demonstration site where participants can wash a load of clothes with an efficient washer; and 4) in-home interviews with the households that participate in the impact (i.e., metering) portion of this study.

Focus Group Discussions. Four focus groups were completed to qualitatively explore current washing attitudes and behaviors, to gather reactions to h-axis washing machines, and to assess various components of the research design. The findings will guide development of the phone/mail survey, the in-home monitoring, and the laundry demonstration center activities and will flag educational needs of consumers.

Market Research Survey. A key objective of the market research survey will be to collect quantitative data on many of the same topics included in the focus group and demonstration center tasks from a sample of households that represent the service areas of participating organizations. The survey will also collect household demographic and socioeconomic data, as well as data on current laundry practices.

The market research survey will be conducted using a combination of telephone and mail survey procedures. The plan is to complete telephone interviews with 3,000 households in participating utility service areas and 1,000 households from across the continental United States. Both groups will receive a mail questionnaire and laundry diary. The 4,000 interviews will collect basic demographic information on the household, information about the age of the washing machine, attitudes toward washer characteristics, and general attitudes toward new technologies.

The mail questionnaire/diary portion of the survey will also be used to validate the laundry behavior data collected in the impact analysis. Households selected for the impact assessment monitoring sample will be asked to keep a similar diary to describe their laundry behavior while their washing machine is being monitored. The diary data from the market research survey can then be linked to the other household and demographic information collected in the initial telephone interview. These linkages will allow for the extrapolation of the findings from the impact analysis to the service areas of the participating organizations.

THELMA Laundry Demonstration Center. The research design also includes a THELMA Laundry Demonstration Center where customers can be interviewed in depth about h-axis washing machines in an actual laundry setting.

The THELMA Center will allow consumers to see and actually do laundry using an h-axis machine, to compare an h-axis machine to a v-axis machine, and to consider purchasing an h-axis machine once they are more familiar with it. Thus, consumer perceptions about the advantages and disadvantages of the new washers and the issues affecting purchase decisions about these washers are more reliable.

In-Home Interviews with the Field Monitoring Participants. Tracking the experience of 92 households participating in the field monitoring is a key element of the market assessment. This approach allows the in-home monitoring to do double duty as a conveyor of both impact and market insights. The researchers will be a consistent point of contact for providing feedback about participant experiences with the washers and concerns about or problems with the monitoring (thus increasing quality assurance), as well as other aspects of the data collection.

Distribution System Analysis

The distribution system analysis will consist of interviews with key manufacturers, distributors, and retailers of laundry equipment. it will assess manufacturer, distributor, and retailer attitudes toward and perceptions of h-axis washers, as well as the infrastructure, capital resources, and other factors that may impact the ability to produce h-axis washers. This research should lend to a greater understanding of the distribution system for both v-axis and h-axis washers and help identify the techniques (e.g., rebates, distribution channel incentives, etc.) needed to increase the influence of utility programs on these systems.

Impact Analysis

The primary objective of the impact assessment/analysis is to estimate the potential impact on energy consumption, water use, and detergent use that could be achieved with a successful market transformation to the h-axis washing machine technology. The impact analysis will rely upon information collected from three principal sources: available laboratory test results, filed monitoring of 92 households, and market data collected under the market assessment task.

Although laboratory testing results (previously discussed) are certainly important in quantifying the differences in energy and water consumption between the two technologies (v-axis versus h-axis), they may not fully represent actual in-home results. The objective of the field monitoring is to assess how these data may vary in actual home use situations and develop correction factors that can be applied to the laboratory findings. Data on energy, water, and laundry chemical factors will first be monitored for a period of six weeks with the v-axis washer currently in the home and then for eight weeks with an h-axis machine, which will be installed in the home. The primary information to be obtained is the change in total water use, total hot water use, and total energy use (washer and dryer) between the two periods. In addition, the monitored households will keep a laundry diary during the monitoring period. Data from the diary will identify and quantify the behavioral changes in consumers' use of the h-axis washer compared to their use of the v-axis washer.

Each of the metering sites will have certain characteristics that have been identified as parameters potentially important to overall energy and water savings. Examples of these characteristics are predominately cold, warm, or hot water wash users; homes that do primarily large/full wash loads versus homes that do small loads, and homes that do several loads of wash per week versus homes that do only a few. This same information will be collected in the mail survey and used to extrapolate the monitored data to other utility service territories.

Linkages Between Research Activities

Figure A illustrates the linkages between the research activities. Focus group results will be used to modify the telephone survey, in-home interviews, and laundry demonstration site procedures. Metering study participants will be segmented by demographic and household laundry characteristics. These same variables will be measured in the market survey, so that projections of the number of households fitting each segment profile (and their estimated laundry energy and water usage) can be calculated for the service areas that are represented by survey respondents. To facilitate the process of interpreting and integrating the data, the distribution system surveys will be designed in coordination with the customer-based surveys. Critical program design issues can then be addressed by reviewing both the distribution system analysis and the customer-based market research effort. For example, projected penetration rates based solely upon customer research results could over- or understate the actual penetration rate that can be achieved through a coordinated utility effort. Knowledge of the distribution system's likely response can be compared to customer-based research results to provide more realistic estimates of market penetration.

Both the customer-based market research effort and the distribution system analysis will be integrated with the impact analysis so that projections can be made about the amount of water and energy savings that are achievable through the increased market penetration of efficient washers. Close coordination between the customer-based surveys and diaries, and the diaries and data collection instrument used in the impact analysis, will be the key to successful integration.

Conclusion

THELMA research will provide estimates for energy and water savings resulting from the use of h-axis washers and will suggest strategies for market intervention programs. The project is unique in its complexity, timeliness, and appropriateness for collaborative implementation. An immense amount of information is needed to understand the range of qualitative and quantitative issues. In response to the informational demands and limited funding, the research design was tightly "nested" and inter-linked, so that the use of each data point is maximized. Additionally, by defining residential laundering in terms of demographic and geographic variables, it is hoped that the final results will find wide application in other service territories and regions not included in the study.

The THELMA project is timely in two respects. First, several of the major US appliance manufacturers are expected to introduce h-axis clothes washers in the next eighteen months. THELMA results will enable utilities to work more closely with appliance manufacturers and trade allies during the early stages of product introduction. Second, the U.S. DOE has just begun the revision process for federal clothes washers efficiency standards. Knowledge gained through THELMA may be helpful in the selection of the most appropriate efficiency standards.

It is unlikely that any single organization would have undertaken this research effort alone. It is fortuitous that such a large number and variety of organizations chose to participate in THELMA. The collaboration from these diverse organizations lays the groundwork for integrated, regionally coordinated market intervention programs. The increasing reality of declining utility DSM budgets, coupled with the emphasis upon market transformation as a program goal, necessitates this type of collaborative effort. Collaboration also demonstrates to the appliance manufacturers and trade allies that a large customer base can be influenced by utility programs. This enhanced

"market clout" encourages manufacturers to partner with utilities. Industry-utility partnerships can accelerate consumer demand for high quality, more efficient products.

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