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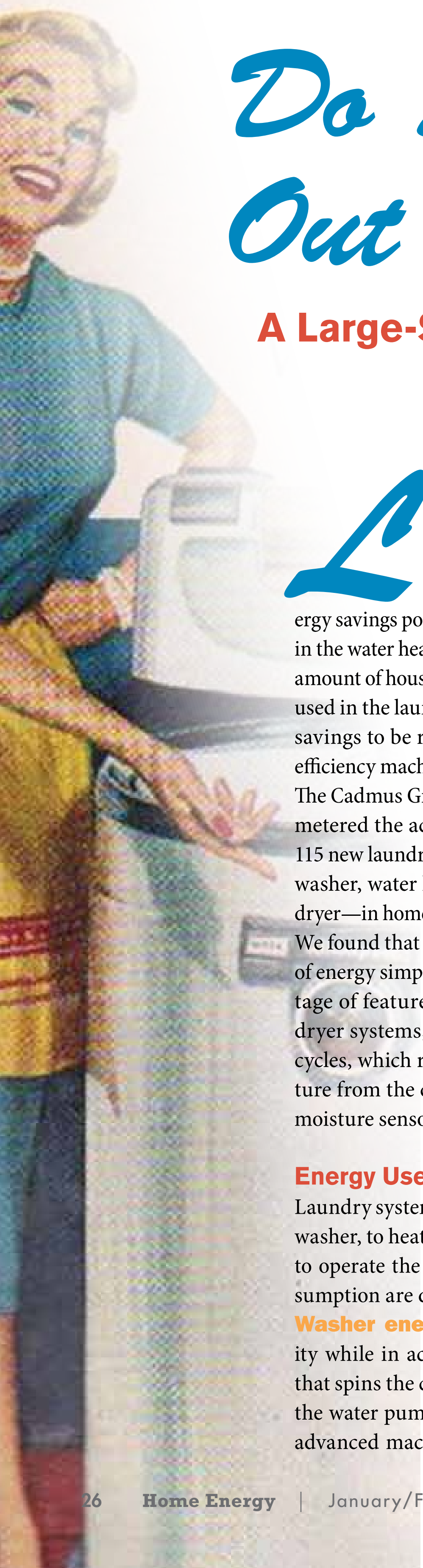

Do Savings Come Out in the Wash?

A Large-Scale Study of Residential Laundry Systems

by David Korn and Lauren Mattison

Laundry systems are a hot spot for energy use in the home. Efficient laundry systems—and clothes washers in particular—are unusual in that most of the energy savings potential is not in the clothes washer itself, but in the water heater and the clothes dryer. To determine the amount of household energy that is used in the laundry room, and the savings to be realized with high-efficiency machines, our company, The Cadmus Group, Incorporated, metered the actual energy use of 115 new laundry systems—clothes washer, water heater, and clothes dryer—in homes across California. We found that users can save a lot of energy simply by taking advantage of features on new washer/dryer systems, such as high spin cycles, which remove more moisture from the clothes, and automated dryer cycles with moisture sensors.

Energy Use by Laundry Systems

Laundry systems consume energy to operate the clothes washer, to heat water used for hot and warm cycles, and to operate the clothes dryer. These three types of consumption are discussed below.

Washer energy use. Clothes washers use electricity while in active mode to drive two motors: the one that spins the clothes tumbler and the one that operates the water pump that drains the clothes tumbler; many advanced machines use universal and three-phase AC motors capable of spinning in both directions to operate advanced cycles. One washer load might consume 0.2 kWh of electricity. Many advanced clothes washers consume standby energy to keep various controls active. Standby power draw is typically on the order of 2 watts, or about 0.34 kWh per week.

Table 1. Clothes Washer Efficiency Standards, 2009 and 2011

	2009		2011	
	Minimum MEF	Maximum Water Factor	Minimum MEF	Maximum Water Factor
Federal Standard	1.26	N/A	1.26	9.5
EPA Energy Star*	1.72	8.0	2.0	6.0
CEE Tier 1	1.8	7.5	2.0	6.0
CEE Tier 2	2.0	6.0	2.2	4.5
CEE Tier 3	2.2	4.5	2.4	4.0

** In July 2009, the Energy Star requirement was raised to MEF 1.8 and WF 7.5.*

Hot water. Clothes washers have three temperature settings: cold, warm, and hot. Even a hot wash cycle, however, is typically coupled with a cold or warm rinse cycle. Warm cycles combine hot and cold water. Therefore, even households that run mostly hot or warm wash cycles use hot water for only a fraction of their total laundry water volume. Nationally, according to the Energy Information Agency, 58% of residential domestic water heaters use gas and 42% use electricity.

Dryer energy use. Moisture remaining in clothing after it has gone through the wash and spin cycles is removed in the clothes dryer. An electric-resistance heater or a gas-fired heat exchanger is used

EXPECTED SAVINGS WITH THREE CLOTHES WASHER EFFICIENCY STANDARDS

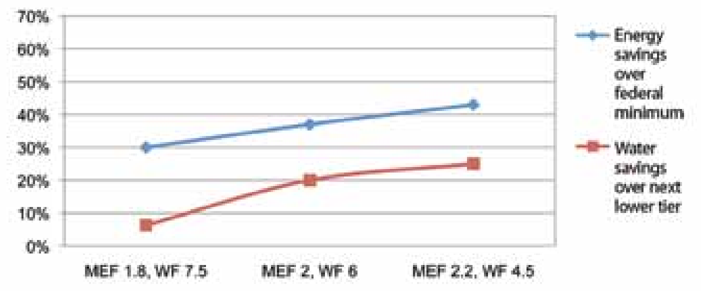

Figure 1. Theoretical energy savings of high efficiency washers over the Federal standard can be as much as 40%.

to heat air that is blown through tumbled clothing. The higher moisture-carrying capacity of the warmer air carries the moisture from the clothes to the drier vent. Nationally, 22% of residential dryers use gas and 78% use electricity.

How Are Laundry Systems Rated?

Clothes washers are rated according to their modified energy factor (MEF). The MEF is the quotient of the capacity of the washer divided by the total amount of energy that it consumes per cycle. The MEF is expressed in cubic feet per kilowatt-hour per cycle (ft^3/kWh/cycle). The higher the MEF value, the more efficient the clothes washer is.

The water factor (WF) is expressed as gallons per cubic foot per cycle (gallons/ft^3/cycle). The WF is the quotient of total weighted per-cycle water consumption divided by the capacity of the clothes washer. The lower the WF value the more efficient the clothes washer.

MEF and WF are used to determine the federal standard for minimum allowable clothes washer efficiency, as well as the voluntary energy efficiency standards set by Energy Star and by the Consortium for Energy Efficiency (CEE), a membership group of utilities. Table 1 shows the voluntary standards and minimum federal standards that were in force in 2011, and in 2009, when the Cadmus Group study was conducted. In recent years, the efficiency ratings of available washers have increased substantially. The minimum MEF for Energy Star qualification was raised three times between 2006 and 2011, going from 1.42 to 2.

The expected savings for three efficiency levels (expressed in three pairs of MEF and WF values) are shown in Figure 1.

There are no efficiency standards for clothes dryers, because dryer efficiency varies little if at all. However, dryers account for the majority of the energy used for laundry, so dryers are often included in studies of this kind.

How Do Laundry Systems Save Energy?

Unlike other energy-efficient appliances, efficient clothes washers use about the same amount of energy as standard models. They save energy by using less water to wash clothes, and by removing more water at the end of the wash cycle, thereby allowing for shorter dryer cycles.

By using less water. Efficient clothes washers use less water to wash and rinse clothes. This is accomplished in most machines by tumbling clothes through water in a horizontal-axis tumbler, as opposed to soaking them under water in a vertical-axis machine; there are however several Energy Star-qualified, vertical-axis machines that are efficient users of water. One strategy vertical-axis machines use to save water is using a high-pressure spray rinse instead of filling the tub with water.

By removing more water. Efficient clothes washers spin at a faster rate than standard models, exerting a high g-force on the clothes and removing more water. Modern machines can exert 100 to 500 g's on the clothes. The more water removed, in general, the shorter the drying cycle; however, this depends on the clothes dryer and on user behavior. To achieve savings, the user must select the automatic drying cycle, if the dryer is equipped with a moisture sensor and automatic shutoff; or if not, must run the dryer for less time than would be needed for wetter clothing.

If moisture sensors or user behavior do not eliminate excessive drying, the dryer may run longer than necessary. This will waste energy. If the dryer runs on a timed cycle, it is likely that some overdrying will occur. Consider, for example, a load of laundry that is dried for 15 minutes longer than necessary. During those 15 minutes, a 4,800W dryer will waste 1.2 kWh of energy. The average dryer in the Cadmus study used 2.6 kWh per cycle. It follows that even a short period overdrying can substantially increase a dryer's energy use.

Researching Laundry Rooms

We recruited households from the territories of Pacific Gas and Electric Company and San Diego Gas and Electric Company during spring and early summer 2009. Our sample included both customers who had received a utility incentive for purchasing an efficient clothes washer (participants) and customers who had not received an incentive, but who might also have purchased a high-efficiency washer (nonparticipants). The sample included only homes with 240V electric dryers. Homes with gas dryers were excluded from the study because of the difficulty of directly metering gas used by dryers.

In all, we studied 24 non-Energy Star clothes washers and 91 Energy Star-qualified clothes washers, including 74 incentive program participants and 41 nonparticipants. Most machines had an MEF of at least 2.2, meeting the 2009 CEE Tier 3 and the 2011 CEE Tier 2 minimum.

METERED WATER USE

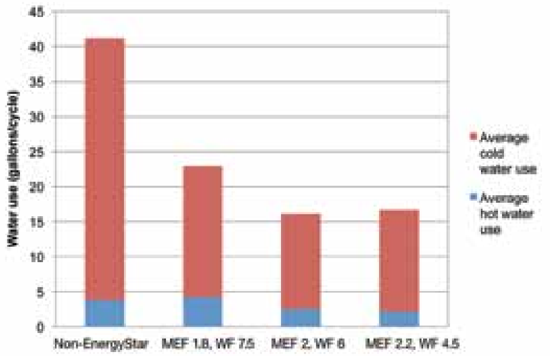

Figure 2. High-efficiency washers used half the water of the baseline machines.

EXPECTED VS. ACTUAL WATER SAVINGS

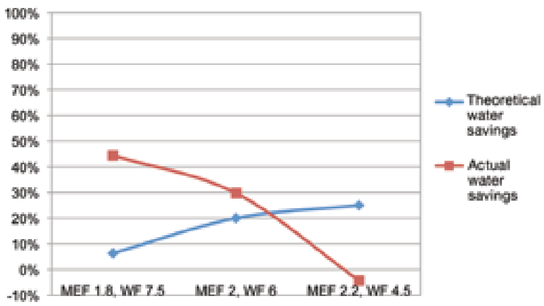

Figure 3. Actual water savings from one level to the next varied from the theoretical savings.

METERED WATER-HEATING ENERGY USE

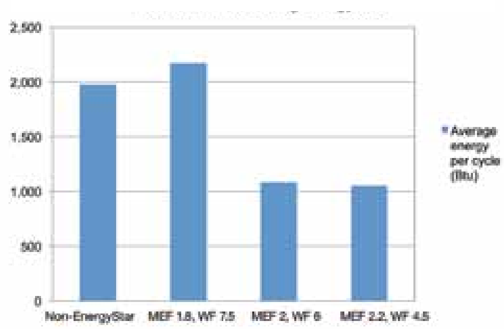

Figure 4. High-efficiency washers reduced water heating energy, but this savings is a small portion of total energy savings.

We collected data by metering the following values in situ for three weeks:

- volumetric flow through the hot-water hose serving the clothes washer;
- volumetric flow through the cold- water hose serving the clothes washer;
- temperature of the hot water entering the clothes washer;
- temperature of the cold water entering the clothes washer;
- electricity consumed by the clothes washer; and
- electricity consumed by the 240V electric dryer.

The electricity consumed by the clothes washer and dryer was metered directly and was expressed in kWh. The heat energy of the hot water used was expressed in Btu and was calculated as follows:

Heat energy (Btu) = Flow (gallons) x (Hot temperature–entering cold temperature) x 8.3 (lb/gallon) x 1 Btu/°F*lb).

What the Laundry Rooms Reveal

The number of dryer loads (4.7) was slightly lower than the number of washer loads (4.8), but neither this nor differences between user groups (participants versus nonparticipants, those who purchased Energy Star versus non-Energy Star machines) were found to be statistically significant.

Washer electricity use. The average electricity use of the 24 baseline machines—those that met the federal standard but were not Energy Star qualified—was 0.21 kWh per cycle. The average electricity use of all 115 machines was 0.2 kWh per cycle. This small difference is not statistically significant and could easily arise from differences in user behavior.

Many advanced clothes washers consume standby energy to keep various controls active. While standby power draw is typically low, on the order of 2 watts, or 0.34 kWh per week, it still adds something to the 0.2 kWh consumed in the course of running a load. This means that for frequently used machines, the standby losses are small, but for lightly used machines, the standby losses may be substantial, relative to the electricity directly consumed by the clothes washer.

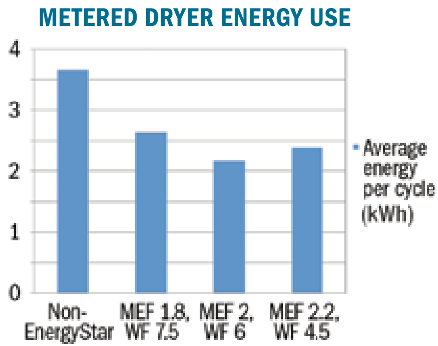

Figure 5. Dryers used with Energy Star washers saved an average of 35% per cycle.

Washer water use. Figure 2 shows average metered water use per load. Most of the water used is cold; only about 13% of it is heated. Energy Star-qualified machines use substantially less water than baseline machines.

The average Energy Star machine used 55% less water than the average non-Energy Star machine. We found an unexpected, but slight, increase in water use by the machines with the highest efficiency ratings (a 4% increase over the previous tier). This may be because the sample contained only six lower-tier machines, and because the highest-efficiency machines were also the largest. The most efficient machines were, on average, 6% larger than the other Energy Star-qualified machines, but the study did not examine the effect of size on water use.

Figure 3 shows the actual water savings versus savings expected from improvements in WF. Savings are expressed in percent savings over the previous tier with the first tier compared to the federal standard.

Washer hot water use. Hot-water use varies from user to user and does not appear to correspond with the efficiency of the machine, because the choice of wash cycles is variable and user driven. Hot water is heated about 50°F above incoming water temperature. Small differences in hot-water temperature had little effect on the analysis, because hot water accounts for only about 13% of the energy used in laundry systems.

Typically, there is a run of piping from the water heater to the clothes washer valve. The length of the run ranges from about 12 feet, for pipes run across the ceiling, to 20 feet or more if the hot-water tank and the clothes washer are in different rooms. This water sits in the piping between washes, and its temperature gradually becomes equal to the ambient temperature. This

can create a "dead-leg" loss of 1 gallon or more of hot water. Initial hot-water flow in this study was 70–75°F. After approximately 30 seconds, hot-water flow rose to near the hot-water set point, minus a small steady-state loss between the water heater and the clothes washer.

Very little energy is used to heat water, even for non-Energy Star machines, because clothes washers use very little hot water. As shown in Figure 4, the most efficient machines save about 900 Btu, or a little more than 0.25 kWh per cycle, compared to the non-Energy Star machines.

Dryer electricity use. We also normalized dryer energy to average energy used per load for each site. See Figure 5. Average electricity use per drying cycle was substantially lower for Energy Star machines than for baseline machines, with an average of 35% energy savings per cycle for dryers used with Energy Star washers. There was a slight increase, however, in dryer energy use with the most efficient washers. As explained above, these washers were on average 6% larger than the other Energy Star-rated machines. This could make for larger loads and the use of more energy to dry them.

Furthermore, high-efficiency washers achieve savings through higher spin rates. Some may have three or four different spin settings. Users who choose less than the maximum spin rate may decrease the operating efficiency of their machine. The higher the spin setting, the less moisture remains in the clothing, and the moisture can be decreased further by running the very high spin twice. We calculated the effective MEF at each spin setting. With the spin setting on medium, the effective MEF drops from 2.4 to 1.76, below the current Energy Star level.

Overall energy use. As shown in Figure 6, roughly 81% of the energy used by the laundry systems we studied was used by the clothes dryer. Water heating (13%) and operating the clothes washer (6%) were relatively minor contributors to overall energy use.

It is generally assumed that 90% of the energy used for washing clothes in a conventional top-loading washer is used for heating the water. For new washing machines, most of which are front-loading, we found that the figure was closer to 72%; but when we looked at total system energy, including the energy used for drying, we found that the energy used for heating water was only 13% of the total. Clearly, the savings delivered by an efficient clothes washer depend a great deal on how dryers are used.

ELECTRICITY USE IN LAUNDRY SYSTEMS BY END USE

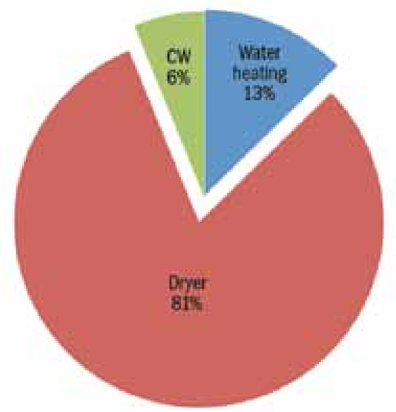

Figure 6. Dryers used 81% of the energy in laundry systems.

TOTAL ENERGY SAVINGS

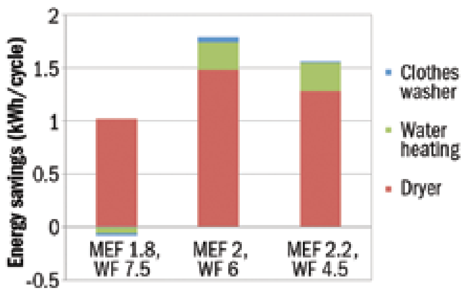

Figure 7. Energy savings varied with efficiency level, with most of the savings in the dryer.

Total electricity use by efficiency level. Figure 7 shows total per cycle energy savings for three levels of efficient machines, compared to non-Energy Star machines. Total savings ranged from 1 kWh per cycle for machines that just met the Energy Star specification to 1.8 kWh per cycle for some higher-efficiency machines. The machines with the highest efficiency ratings did not perform the best, for reasons that we explained above.

Figure 8 compares the total actual and expected energy savings of each efficiency level compared to non-Energy Star machines. Overall, the actual savings were slightly lower than the expected savings.

Look for the Energy Star and Wash Efficiently

Efficient clothes washers are unique in that the amount of energy they save depends on how they are used with other devices—namely water heaters and clothes dryers. This study of 115 laundry systems showed that most of the energy consumed, and most of the potential savings, depend on reduced operation of the clothes dryer.

- Households studied ran about five loads of laundry per week. Little hot water was used in the system, in part because of cold washing and cold water rinsing. Only 13% of the water used in the laundry system was heated. Of the hot water used, a portion of the heat was lost from water standing in the piping between the washer and dryer.

- Efficient clothes washers use as little as 12 gallons of water per load. Hot water represents only a small part of this amount even for hot cycles. In some installations, 2 gallons or more of hot water can be wasted standing in the piping, reducing the amount of hot water that actually reaches the clothes washer.
- Lower spin settings remove less water than the highest spin setting and therefore require more drying time. A laundry system with a machine that just meets the Energy Star specification could actually use less energy than a system with a much more efficient washer, if a medium spin setting were used on the more efficient machine. Users should be educated in the use of spin cycles.

Given that most of the savings delivered by clothes washers are from shorter drying cycles, it is important that dryers be equipped with functioning moisture sensors, and that users understand that energy savings depend on the use of automated drying cycles.

To ensure that your laundry system is as efficient as possible, look for the Energy Star label, which can be found on a wide range of brands, and use features such as high spin on the washer and automated moisture-sensing cycles on the dryer.

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EXPECTED VS. ACTUAL ENERGY SAVINGS

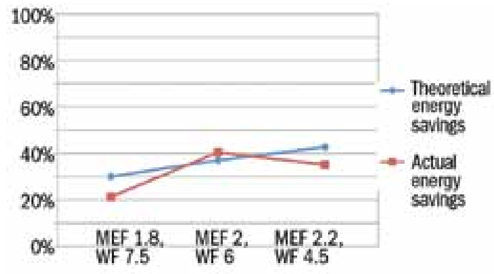

Figure 8. Overall, actual savings compared to the federal standard were slightly lower than theoretical savings.

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