Dishwashers, Clothes Washers, and Behavioral Impacts: Savings Opportunity by Increased and Better Use

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ABSTRACT

In 2024, The U.S. DOE is expected to finalize energy and water conservation standards for residential dishwashers and clothes washers that will save 0.43 quads of site energy and 2.13 trillion gallons of water. While these impacts are substantial, the potential energy and water savings related to consumer social, emotional, and cultural behavioral shifts are even greater. Twenty percent of U.S. dishwasher owners report not using their dishwasher, opting instead to handwash, which can consume 650 percent more water and 190 percent more energy than a dishwasher. The reasons for handwashing when a dishwasher is available vary, but cultural differences, distrust in technology, and personal preference are often cited. If these dishwasher owners opted to use their dishwasher instead of handwashing, it could save an estimated 0.35 quads of site energy and 2.63 trillion gallons of water. Clothes washers offer a similar magnitude of savings when transitioning from top-loaders to front-loaders. Top-loaders require 35 percent more water to wash the same amount of clothing than a front-loader, nevertheless, top-loaders make up more than 70 percent of U.S. residential clothes washer sales. Consumers often cite concerns of mold, mildew, and odor of front-loaders for their purchasing decisions. If all U.S. consumers purchased a front-load clothes washer to replace their top-loader, we could save an estimated 1.02 quads of site energy and 2.56 trillion gallons of water. This paper will explore the significant impact that U.S. consumer behavior has on energy and water conservation in the context of dishwashers and clothes washers.

Introduction

The National Appliance Energy Conservation Act of 1987 amended the Energy Policy and Conservation Act (EPCA) of 1975 by, among other things, establishing the first minimum efficiency standards for clothes washers and dishwashers (DOE n.d.). These first standards were prescriptive and relatively simple, mandating that all U.S. consumer dishwashers sold after January 1st, 1988, had to be equipped with an option to dry without heat, and that all consumer clothes washers sold after January 1st, 1988, must include an unheated water option for all rinse cycles. The U.S. Department of Energy (DOE), along with other constitutional amendments, continued amending the energy — and eventually water — conservation standards multiple times over the next few decades. The goal of the conservation standard amendments can be described by EPCA's criteria for prescribing new or amended standards: any conservation standard shall be designed to achieve the maximum improvement in energy efficiency that is technologically feasible and economically justified; one factor in considering economic justification is the need for national water conservation (*42 U.S.C. § 6295)*.

Each EPCA covered product (e.g., clothes washers and dishwashers) may contain multiple product classes. Product classes are different types of the overarching product defined by consuming a different kind of energy, having a different capacity, or some other unique performance-related feature (*42 U.S.C. § 6295)*. Consumer dishwashers currently have two such

product classes, a standard size and compact size, which are defined by the number of place settings and serving pieces the dishwasher can wash in one cycle. Consumer clothes washers are separated into five product classes: three top-loading varieties, separated into standard size, compact size, and those with semi-automatic operation; and two front-loading varieties, separated into a standard and compact size. Each product class may have their own energy and water conservation efficiency standard.

Since their inception in 1988, the consumer dishwasher conservation standards have been amended three times, with a fourth amendment expected in 2024, while the consumer clothes washer conservation standards have been amended nine times, with a tenth amendment expected in 2024. Since 1994, the consumer dishwasher standards are expected to save an estimated 1.03 quads of site energy and 0.38 trillion gallons of water through 2057, and the consumer clothes washer standards are expected to save an estimated 5.36 quads of site energy and 16.7 trillion gallons of water through 2058. This is more than 1.5 times the water usage and 1.25 times the energy usage of Los Angeles over the same time period (LADWP n.d.; CDC n.d.). While this is a significant improvement in energy and water efficiency, it occurred over decades with considerable time and action by legislators, DOE, states, utilities, manufacturers, and energy efficiency advocates. Energy and water savings of the same magnitude are achievable by working with consumers to make the best use of already installed dishwashers and replacing top-loading clothes washers with front-loading clothes washers when making future purchases.

Dishwashers

Energy and Water Savings

The most recent U.S. Energy Information Administration Residential Energy Consumption Survey (RECS) from 2020 identifies dishwashers as the major home appliance with the lowest penetration rate, as seen in Figure 1, with only 73 percent of homes identified as having a consumer dishwasher (EIA 2022). Dishwashers also have the highest representation of consumers who choose to not regularly use the appliance even though they have one in their residence, at 19 percent, equivalent to 17.11 million U.S. households. This disparity in dishwasher ownership versus regular usage represents a significant opportunity for cost-effective energy and water savings as there is no need for a new appliance purchase.

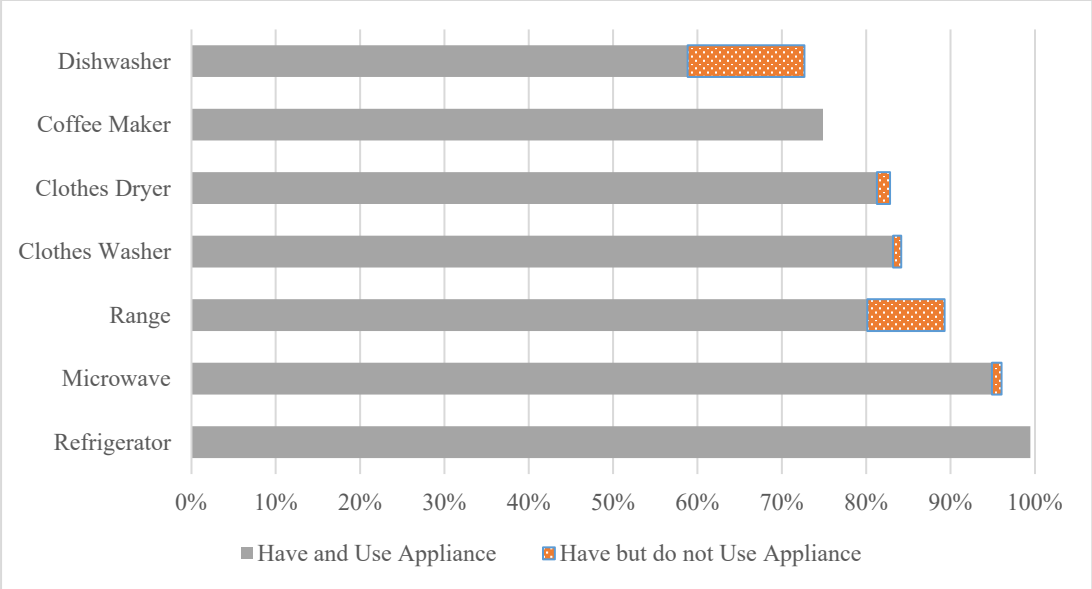

Figure 1: Ownership and regular use rate (more than once per week) of major home appliances in the U.S. *Source*: EIA 2020.

RECS also shows that there are a significant number of very old dishwashers, those 15 years or older. DOE energy and water conversation standards have increased stringency over time, so it's reasonable to assume that older dishwasher models will typically be less efficient than today's products. In Table1, we associate those older products, as delineated by RECS, with the DOE energy and water conservation standards that would have been most applicable at the time.

Table 1: Count of dishwashers by age and associated efficiency standard

Dishwasher age	Millions of households	Maximum allowed kWh per year[A]	Maximum allowed gallons of water per year	Applicable standard compliance year
Less than 2 years old	13.86	281	985	2013
2 to 4 years old	21.09	281	985	2013
5 to 9 years old	28.29	303	1,133	2010 & 2013
10 to 14 years old	15.19	318	1,281[B]	1994
15 to 19 years old	6.51	318	1,281[B]	1994
20 or more years old	4.84	318	1,281[B]	1994

A – All kWh per year values are aligned with DOE's current expectations of 197 cycles per year.

B – The 1994 DOE conservation standards did not include water efficiency. The Energy Independence and Security Act (EISA) of 2007 established the first water conservation standards that were later required for compliance in 2010. In the absence of such standards, the 2010 water efficiency standard was used to represent water consumption for dishwashers of this age.

It stands to reason that households that do not use their dishwasher are more likely to have an older model, as replacing the unit with an updated unit would not be a priority. In these conditions, the 17.11 million households that have a dishwasher but reported using it zero times per week comprise all dishwashers older than 15 years and 32 percent of the dishwashers

between 10 and 14 years old. If all of these dishwashers are minimally compliant with the efficiency standards of their time, they would represent 5.4 TWhs of energy and 21.9 trillion gallons of water consumed each year. While that is a significant amount of energy and water, it pales in comparison to the consumption of the dishwasher alternative, handwashing.

The lack of dishwasher usage does not mean dirty dishes are not produced, rather, they are cleaned by hand. In a 2023 analysis, the DOE noted that handwashing consumes 140 percent more energy and 200 percent more water than a dishwashing machine (DOE 2023b). In response, the California investor-owned utilities (IOUs) compiled a more extensive summary of handwashing studies and concluded that handwashing uses 190 percent more energy and 650 percent more water than a dishwashing machine (CA IOUs 2023a). As ENERGY STAR® publicly states "if you still wash your dishes by hand, you're wasting more than just time" (EPA n.d.). In an updated 2024 analysis, DOE maintained the assumption that handwashing uses 200 percent more water but reduced its estimate down to parity for energy usage between handwashing and dishwasher usage (DOE 2024). DOE's source of information for such assumptions remained consistent from 2023 to 2024 and was not updated to account for the more expansive data set provided by the California IOUs. As such, the 2024 DOE analysis appear to be more conservative than many studies (as cited by the California IOUs) and the U.S. Environmental Protection Agency (EPA) suggest (EPA n.d.). The aforementioned estimates do not however account for additional water and energy consumed when consumers pre-rinse dishes before loading them into a dishwasher, which the EPA has estimated to represent 20 gallons of additional water consumed (EPA 2003). An LBNL survey found that 55% of respondents continue to pre-rinse their dishes before putting them in the dishwasher, contrary to the behest of dishwasher and detergent manufacturers, DOE, EPA, and energy and water efficiency organizations who do not recommend this practices for best dishwasher efficiency and performance (EPA n.d.; Stratton et al. 2021; DOE 2022; AHAM 2022). Best dishwasher practices include scraping large bits of food off the dishware without water and then placing them directly in the dishwasher, which will be the savings use-case considered in this report (Schencking 2022). Table 2, which compiles the potential energy and water savings over a 30-year period, shows that a potential shift in dishwasher usage represents the highest energy and water savings opportunity since the first performance-based conservation standards were implemented in 1994.

Table 2: Energy and water 30-year savings[A]

Consideration	Site savings of energy (quads)	Water savings (trillion gallons)
17.11 million consumers use dishwashers regularly	0.35	2.63
DOE efficiency standard, 1994 compliance	0.59	-
DOE efficiency standard, 2010 compliance	0.34	Not reported
DOE efficiency standard, 2013 compliance	0.07	0.14
DOE efficiency standard, joint recommended 2027 compliance	0.17	0.24

A – DOE commonly reports energy and water savings over a 30-year period as part of their energy conservation rulemakings. The 2010 compliance conservation standards were enacted by the Energy Independence and Conservation Act of 2007 and did not include a water savings analysis.

Household Characteristics

The 2020 RECS shows that the households that reported using their dishwasher zero times per week have a similar number of people living in their household, have slightly lower household incomes, are more likely to rent their residence, and are slightly more likely for that residence to be an apartment than households that use their dishwasher more regularly. The distribution among all RECS weekly usage respondents is shown in Table 3.

Table 3: 2020 RECS household characteristics by dishwasher usage per week

	Used zero times per week	Used one time per week	Used two to three times per week	Used four to six times per week	Used seven or more times per week
Average number of people in home	2.3	1.9	2.3	2.7	3.3
Average household income	$50,053	$58,211	$58,474	$61,805	$58,194
Own residence	61%	73%	77%	80%	80%
Apartment residence	32%	28%	20%	16%	15%
Located in Southeast and Southwest[A]	41%	33%	28%	27%	27%

A – RECS classifies locations by climate type. Mixed-dry/hot-dry and hot-humid climates are the areas of concern and are primarily located in the Southwest (mixed-dry/hot-dry) and Southeast (hot-humid).

The number of people in a household is the most telling figure in terms of an energy and water savings opportunity. Outside of the "zero times per week" respondents, there is a clear trend where the more people in a home, the more dishwasher cycles are run. This intuitively makes sense as the more people are in a household, the more dirty dishes the household will produce. There is an equal number of household members in the zero times per week respondents category and the two to three times per week respondents category, signaling that the zero times per week households likely have plenty of people in a household making dirty dishes to make effective use of a dishwasher. While property ownership and household income are major drivers in being able to purchase a *new* dishwasher, they are not hinderances to using a dishwasher already installed on the premise, particularly if you are a renter where the responsibility for maintenance and replacement of a major household appliance lies with the property owner. Though this imbalance of power can sometimes leave renters hesitant to reach out to landlords to fix problematic appliances (Dillahunt, Mankoff, and Paulos 2010). The households using their dishwasher zero times per week are also more likely to live in the southern parts of the U.S. than more frequent dishwasher users.

The California Residential Appliance Saturation Survey (RASS) is specific to California and part of the southern U.S. that has a higher penetration of consumers with a dishwasher who report using it zero times per week (CEC 2021). As expected for the location, California has more consumers who report using their dishwasher zero times per week at 22 percent than the

U.S. as a whole at 19 percent. RASS also provides additional demographic information that RECS does not. This data shows that those who reported using their dishwasher zero times per week have a strong tendency to speak Spanish or an Asian language as their primary language; identify as Asian Pacific Islander, Black African American, or Hispanic Latino; and have completed less school, as seen in Figures 2 through 4. RASS does not include the ages or number of residents in a home, but does ask if a household includes seniors or children. Households that had children tended to have higher dishwasher usage per week than childless households, likely to due an increase in occupants. No correlation was found between senior occupied housing and dishwasher usage.

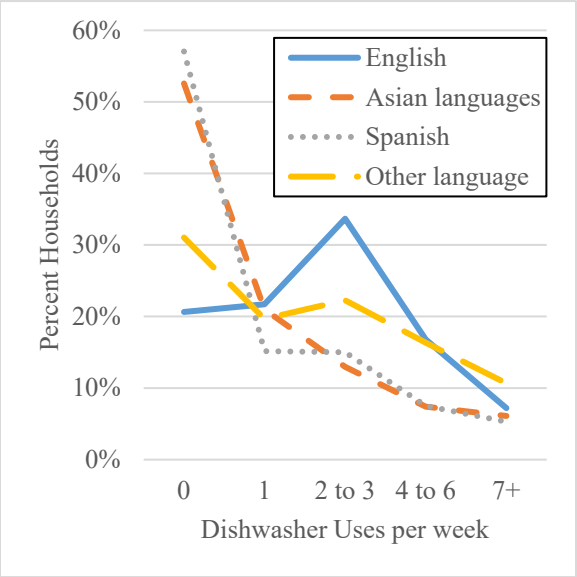

Figure 2: Dishwasher weekly usage by primary language. *Source*: CEC 2021.

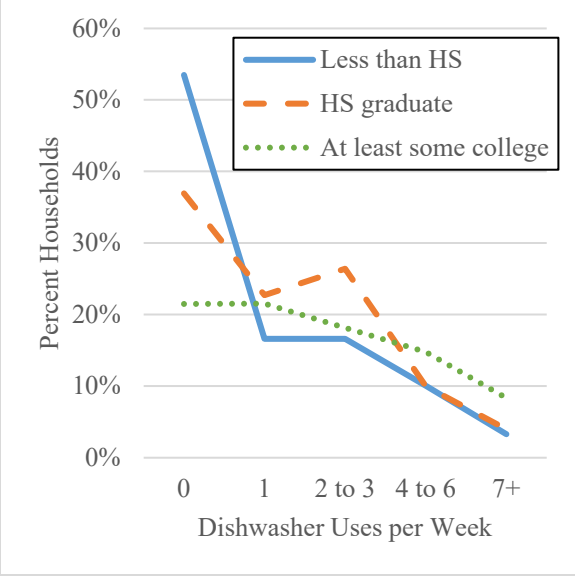

Figure 3: Dishwasher weekly usage by education. *Source*: CEC 2021.

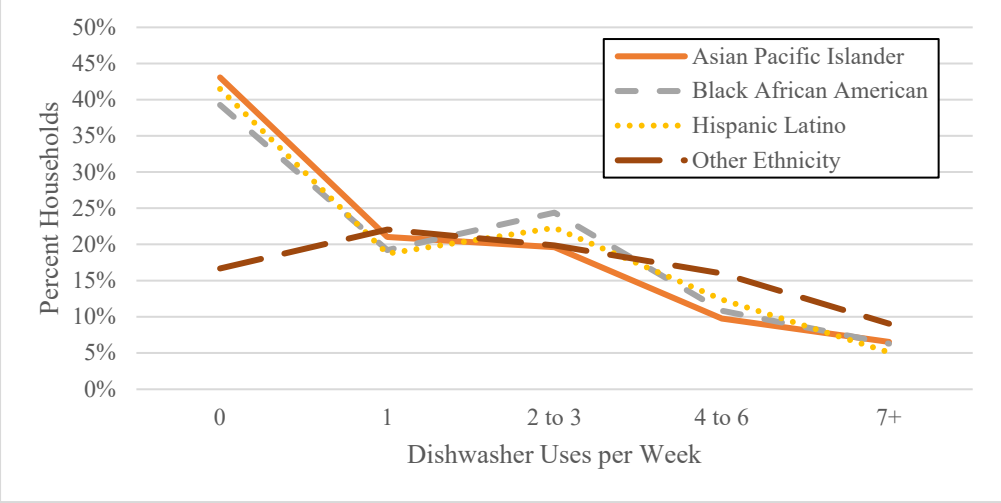

Figure 4: Dishwasher weekly usage by ethnicity. *Source:* CEC 2021.

Based on this data, it is apparent that lower income, less educated, apartment renting, often marginalized communities that do not speak English as a primary language are the

dominant categories of households that handwash instead of using the dishwasher installed in their home.

Barriers and Opportunities for Increased Usage

Studies have consistently shown that consumers have misconceptions about the cleanliness, energy consumption, and water consumption of a dishwasher compared to handwashing (Berkholz et al. 2010; Berkholtz et al. 2013). Those who own a dishwasher have a more favorable view of their performance, yet only 43 percent of dishwasher owners believed that their dishwasher cleaned dishes better and **only 54 percent believed it used less energy and water than handwashing** (Berkholz et al. 2013). A 2024 survey by Proctor and Gamble found that 79% dishwasher owners rated the information that dishwasher use less energy than hand washing as important or very important (CA IOUs 2024a). Indicating that there is some discrepancy between consumer perception and dishwasher efficiency or poor implementation of dishwasher best practices (e.g., pre-scraping large food residue off dishware, do not pre-rinse, putting heavily soiled dishes on the lower rack, and do not block water jet access to all dishes).

This common misconception is something the dishwasher industry tried to debunk in a large marketing campaign led by the detergent brand Cascade in 2020 (Business Wire 2020). Studies have shown that the success of green marketing campaigns rely on trust with the institution providing the message (Sun et al. 2021). Eco-labels and eco-claims certified by third parties, or by a public authority, are generally seen as more reliable than ones coming directly from the organization that would financially profit from the marketing campaign (Sun et al. 2021. This can be challenging for businesses promoting a message that will benefit their bottom line, but promoting through validation through a trusted third party, e.g., a government agency or consumer reviews, can help alleviate those concerns. A Lawrence Berkeley National Laboratory (LBNL) study reported that 78 percent of consumers look at consumer reviews and product ratings before buying an appliance and that 57 percent of consumers reported that ENERGY STAR and EnergyGuide labels played a significant role in their purchasing decisions (Stratton et al. 2021). While ENERGY STAR includes information on the benefits of using a dishwasher compared to handwashing, it is located deep within their website — on the dishwasher page under a *savings tips* dropdown — and not on the ENERGY STAR label itself. This is also true for EnergyGuide labels, which include information on annual energy consumption, but no information on water usage or information contextualizing water usage from running a dishwasher against handwashing. Being able to point to trusted sources of information that display clear water and energy cost savings for using a dishwasher compared to handwashing may help persuade skeptical consumers.

Many U.S. immigrants who may not speak English as a first language come from cultures where they did not use dishwashers growing up (Solomon 2019). Instead, a dishwasher may have been treated as a drying rack for already clean dishes (Ly 2005). This trait is so pervasive that it made its way into pop culture on an episode of the TV show *Fresh Off the Boat*.[1] The desire to wash dishes by hand after a meal could stem from a general distrust of technology, bad past experiences, a simple *we've always done it this way* point of view, a desire to complete the task of washing dishes immediately, or a malfunctioning dishwasher and a reluctance to ask a landlord to provide maintenance. In these cases, highlighting the non-energy and water related benefits of using a dishwasher — for example, the time to load and unload dishes from a

[1] Season 3, episode 5. https://www.youtube.com/watch?v=BvfcRR3PZYE.

dishwasher can be five times faster than doing dishes by hand, that time can be better spent elsewhere, or that dishwashers can get dishes cleaner and provide substantially more hygienic results than handwashing — may be prudent (Berkholz et al. 2010; Schencking and Stamminger 2023).

One common dishwasher best practice is to run full loads whenever possible (EPA n.d.; Schencking and Stamminger 2023). While focusing on best practices is helpful, it is also beneficial to indicate where the tipping point is in terms of dishwasher energy and water savings compared to handwashing. The EPA says that the standard flow of a faucet is 2.2 gallons per minute (EPA 2023). All standard-sized dishwashers sold since January 1st, 2010, may not use more than 6.5 gallons of water per cycle. If your dishwasher is no more than 14 years old and the number of dishes you plan to hand wash would take you more than three minutes, you'll likely be using more water handwashing than using the dishwasher. Similarly, providing easy to understand guidance on what types of dishwash and cookware are acceptable to run through a dishwasher may help to fill an otherwise half-full dishwasher load. Dishwasher cycle speed may also be a hindrance for daily use to some, as the default cycle for a dishwasher often exceeds 2 hours. Drawing consumers attention to the short or fast cycle of a dishwasher – available on 87 percent of recent annual dishwasher shipments – may provide additional benefits, as such fast loads can sufficiently wash and dry a dishwasher load in just over an hour while still typically being more energy and water efficient than handwashing (CA IOUs 2024). Guidance such as this would prove useful to smaller households, those that do not cook as frequently, or those that need to reuse the same dishes or cookware daily and may have trouble completely filling a standard-sized (eight place settings plus six serving pieces) dishwasher and are thus uncertain as to which dish cleaning method is most efficient. An energy-related equivalent can also be derived depending on the household's water heater.

Clothes Washers

Energy and Water Savings

While consumer clothes washers have the aforementioned five product classes, the product category is dominated by two classes, with standard-sized front-loaders (horizontal axis) and top-loaders (vertical axis) representing 96 percent of the U.S. market (DOE 2023a). These two product classes had the same DOE energy and water efficiency standards until the 2015 compliance standards, at which point new conservation standards made minimally compliant front-loaders 79 percent more energy and 43 percent more water efficient than their top-loader counterparts. While the relative difference for minimally compliant products has generally been shrinking, as seen in Figure 5, front-loaders are still required to be far more energy and water efficient than top-loaders.

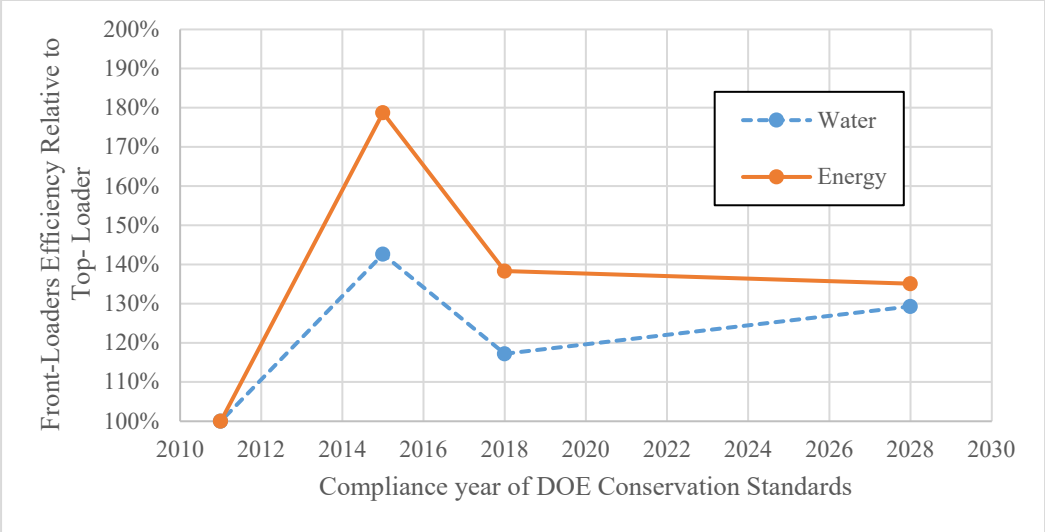

Figure 5: Standard size front-load clothes washer energy and water conservation standards relative to standard size top-loaders. E.g., in 2015, front-loader energy conservation standards were 180% more stringent than top-loader energy conservation standards.

Top-loaders were the first clothes washer models developed and have since dominated the U.S. market. Front-loaders gained market share until late 2009, peaking at 37 percent of annual shipments, but have since seen their relative growth decline to a low of 24 percent, as shown in Figure 6 (AHAM 2022a). Without some changes to the market offerings or other intervention strategy, there isn't any reason to expect this market share distribution to change.

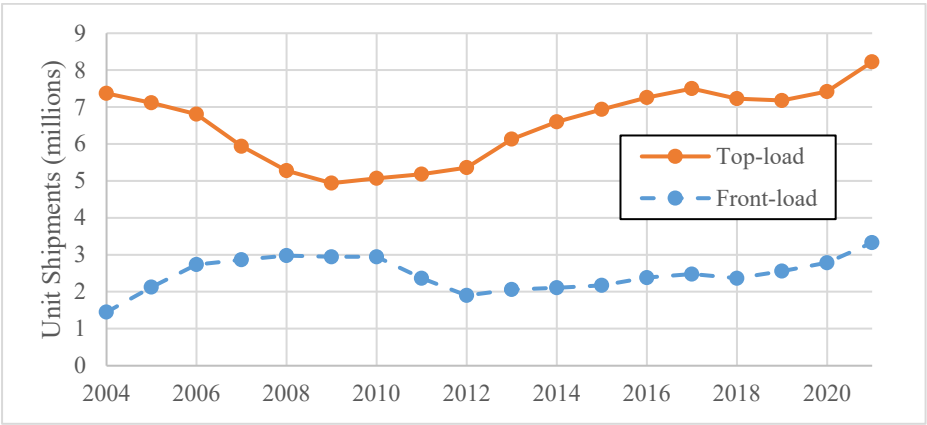

Figure 6: Front- versus top-loader clothes washer annual shipments. *Source:* AHAM 2022a.

DOE estimates that by 2027 the total stock of standard-sized top-loading clothes washers will be 82.7 million (DOE 2023). If all consumers who own a standard- sized top-loading clothes washers were to replace them with a minimally compliant front-loader instead of a minimally compliant top-loader, that would represent an estimated 1.02 quads of site energy and 2.56 trillion gallons of water saved over a 30-year period. This is calculated using the standard levels recommended to DOE by a group of stakeholders, where minimally compliant standard-sized front-loaders are 29 percent more energy and 35 percent more water efficient (Joint Recommendation 2023). This is on par with some recent DOE conservation standards, as shown

in Table 4, though it requires no new conservation standards, simply consumers choosing a front-loader instead of a top-loader as their next clothes washer purchase.

Table 4: Clothes washer site energy and water 30-year savings

Consideration	Site savings of energy (quads)	Water savings (trillion gallons)
82.7 million front-loaders instead of top-loaders	1.02	2.56
DOE efficiency standard, 2004 and 2007 compliance	3.72	12.88
DOE efficiency standard, 2015 and 2018 compliance	1.41	3.03
DOE efficiency standard, joint recommended 2028 compliance	0.31	2.08

Household Characteristics

Households that have a top-loading clothes washer are more likely to be renters with a single low-income household member (EIA 2022). The California RASS shows similar trends as RECS while offering additional demographic information. Spanish speakers, American Indians, Black African Americans, Hispanic Latinos, and senior households had noticeably higher penetrations of top-loading clothes washers than other demographics. Above all demographic criteria, household income had the greatest spread of clothes washer type ownership, as seen in Figure 7, with the highest household earners tipping into having more front-loaders than top-loaders — the only reported demographic category that showed such a flip in clothes washer orientation penetration.

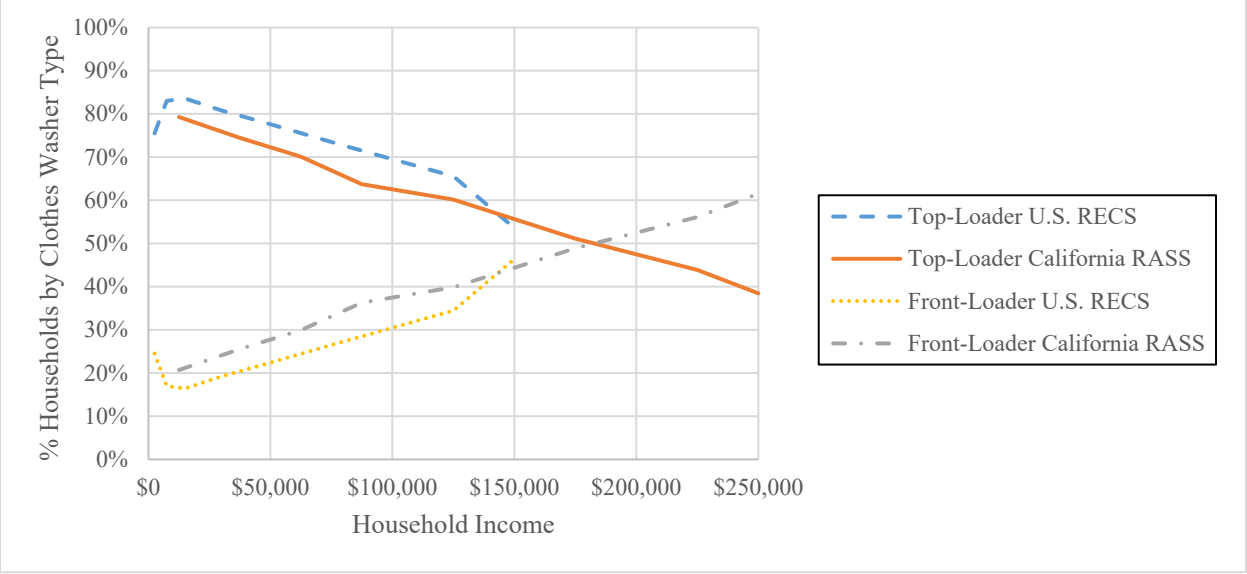

Figure 7: Distribution of households with a top-loader compared to front-loader by household income. *Source:* EIA 2020 and CEC 2021

Barriers and Opportunities for Increased Usage

A Consumer Reports survey of 100,000 Consumer Reports members noted that mold, mildew, and odor are common concerns for front-loaders (Flamer 2022); 14 percent of the front-

loader owners reported mold or mildew issues compared to only four percent of the top-loader owners (Flamer 2023). A 2024 smaller-scale in-store survey of 31 consumers actively looking to purchase a clothes washer indicated that only a slight minority – 45 percent – would choose a front-loader if it were the same price as a top-loader (Shift Consortium 2024). The primary reasons provided for not choosing the front-loader were concerns with cleaning and mold, along with concerns over water leaking and door access. (Shift Consortium 2024). According to a survey commissioned by GE, half of all front-loader owners move back to top-loaders because of the mold/mildew issue (Janeway 2020); this shift in equipment preference due to mold, mildew, and odor is not as prominent in other large surveys, but nonetheless, this concern needs to be managed. Manufacturers have attempted to address the mold, mildew, and odor issues by including specific drum cleaning cycles and built-in methods for leaving the clothes washer door ajar between wash cycles. However, past efforts to mitigate these issues have not resulted in significant changes in consumer concern (Janeway 2020). Consumer education on how to handle this issue is an option, but consumers have shown a low desire to conduct home appliance maintenance. For example, a 2010 Consumer Product Safety Commission report noted that only 68 percent of consumers clean their clothes dryer lint filter after every drying cycle, a ubiquitous, and generally easily accessible and quick maintenance task (CPSC 2010). An additional task a consumer must undertake to maintain their appliance in good working order will likely remain undone until the problem is too pervasive for preventative maintenance to make an impact. It will be critical for manufacturers to continue innovating ways to stimy the development of mold, mildew, and odor in methods that require little to no intervention by consumers.

A 2012 study of 319 U.S. consumers identified purchase price as a primary driver for a consumer's selection of top-loaders compared to front-loaders (Hustvedt, Ahn, and Emmel 2013). Respondents did not express any unique concerns with front-loaders in terms of challenges with loading and unloading or care and maintenance. About half of the top-loader owners surveyed expressed interest in purchasing a front-loader when their current clothes washer needs to be replaced, citing energy and water savings as their primary motivation.

An analysis of over 100,000 online customer reviews indicated that lower-income households may have different purchase motivations and product satisfaction than middle- or high-income households (Wang, Lu, and Tan 2018). For cheaper products, consumer satisfaction decreased the more expensive the product became, while the inverse was true for moderately priced or more expensive products, indicating that for households shopping for cheaper products, price is the strongest influencing factor by a wide margin. According to DOE, entry-level front-loading clothes washers are, on average, double the price of an equivalent top-loader (DOE 2023a).

Consumers looking for cheaper products are more likely to be people of color and under financial strain, both of which align with the RECS and RASS identified characteristics of households with the strongest propensity for top-loaders (Frank et al. 2020). Providing these consumers with entry-level front-load options that are closer in price to top-loaders – perhaps through utility rebates – will be critical for increasing front-load adoption among these households where product cost is a significant barrier. Incentivizing manufacturers to develop lost-cost entry-level products by maintaining only the most critical and influential energy and water saving features may be key (Frank et al. 2022).

Lack of information was also identified as a major driver in a consumer's selection of top-loaders (Hustvedt, Ahn, and Emmel 2013). Owners of top-loaders vastly underestimated the amount of water that their clothes washers used. 33 percent believed that front-loaders consumed

more energy than top-loaders. Respondents of both clothes' washer configurations were unlikely to identify reduced clothes dryer energy usage and reduced clothes dryer cycle time as a benefit of front-loaders' ability to typically remove more moisture than top-loaders. On average, today's top-loaders leave 28 percent more moisture in clothing than front-loaders (DOE 2022a).

Consumers must also trust that the information provided highlighting a product's energy and water savings is accurate (Wang and Tian 2023). This trust is particularly important when the more efficient product is typically more expensive, as a household will rely on the annual savings to pay back the difference in upfront cost, but often has little visibility into the ongoing cost savings.

ENERGY STAR recently put forth a discussion guide for their residential clothes dryer specification. One aspect considered is how to properly rate washers and dryers that are intended to work with one another as recommended by the manufacturer or by design (e.g., a single drum combination washer-dryer). Currently, DOE and ENERGY STAR test and rate clothes washers and dryers separately, disallowing for the benefits (e.g., energy costs and cycle time) to be shown if the same clothes dryer was paired with a front-loader that produces a lower remaining moisture content compared to a top-loader. The California IOUs and clothes washer and dryer manufacturer Electrolux highlighted the impact of this lack of information and suggested improvements to a recent Federal Trade Commission rulemaking concerning EnergyGuide labels (CA IOUs 2023; Electrolux Home Products, Inc. 2023). Incorporating these suggestions to better show the energy, water, and time savings benefits of rating matched pair washer and dryers together and making them prominently featured on appliance sellers' websites where consumers most commonly research appliances before making purchases may help bridge the information gap (AHAM 2023).

Interviews with households in Brazil and India showed that emotional and societal factors also influence the decision of which clothes washer to purchase (Spencer, Lilley, and Porter 2015). Front-loaders are commonly seen as more efficient and an aspirational purchase, but those interviewed for the study often longed to achieve the same feeling of clean clothes from their youth when their parents did their laundry, leading them to purchase the clothes washer configuration they had in their youth. This response has more to do with feelings of nostalgia when an elder would do laundry for you, rather than a practical measurement of clothing cleanliness. Emotional ties with appliances must be handled with care and not summarily dismissed. Anecdotal evidence by U.S. consumers tend to focus on the additional mental load associated with the maintenance of a front-load clothes washers. When asked if they would consider a front-loader at the same price of a top-loader, one consumer who would still not purchase the front-loader responded that they were "not willing to maintain it" and "would not clean [the] seal [or] leave [the] door open properly" (Shift Consortium 2024). Consumers are busy and often make purchasing decisions based on what they are most familiar with, either from their own past or the actions of their peers, as to avoid having to manage or learn something new when they don't feel it offers a prominent and substantial benefit. Providing more complete savings information in readily available sources, closing the initial cost gap for entry-level front- and top-loading clothes washers, and providing means to validate the benefits of a front-loader may aid in overcoming these barriers.

Conclusion and Next Steps

The DOE Appliance and Equipment Standards Program has been wildly successful in producing energy and water savings, but the efficiency standard process is limited in its

influence above requiring that all products meet a minimum performance. Outside of the DOE process, it behooves us to ensure that products are used effectively. There is substantial potential for increased energy and water savings — on par with a DOE conservation standard regulations — by encouraging consumers with dishwashers in their households to use them and to make their next clothes washer purchase a front-loader. Some approaches have already been taken to encourage such action, but they do not appear to be sufficient, based on existing data. Addressing the economic, social, emotional, and cultural behaviors that influence consumer decisions will be paramount to achieving the cost-effective savings opportunities that are readily available with consumer dishwashers and clothes washers.

First, the exact barriers for the specific subgroups identified in this paper should be studied through consumer surveys. Such surveys should evaluate different messaging and intervention strategies with the primary tradeoffs of the handwashing vs dishwasher and front- vs top-loading clothes washers: financial, temporal, and cleanliness. This can help to identify consumer trade off preferences and what messages will be most impactful for different subgroups. Second, field studies should be completed to develop case studies showing the potential energy, time, and cleanliness impacts for real consumers. This could be done by installing a water sensor on the kitchen faucet and energy monitor on a dishwasher to evaluate households with little dishwasher usage before and after incentivizing them to shift away from handwashing to using their dishwasher. Third, the best medium to present this information will be key. A consumer survey evaluating different presentation styles, data, and medium should be conducted to identify the most effective method for communication. The messaging must come from a source consumers believe is impartial, reputable, reliable, and easily accessible. This information should be front and center when a consumer is researching what appliance to purchase or searching for associated products (e.g., dishes, flatware, or clothing retailers). One potential option is to offer a more expansive Energy Guide label – as suggested by the California IOUs – that features the energy and water savings discussed in this report that is prominently featured as the second image on a retailer's website (CA IOUs, 2024a). Fourth, low-income incentive targeting methods, such as those being discussed in the advancement plans for the California Market Transformation Administrator (CalMTA 2024), may help overcome the pervasive first cost barrier to purchasing energy and water efficient models. Lastly, product manufacturers must be engaged and incentivized to further develop and refine products to overcome product specific barrier, such as consumer concerns with mold and mildew for front-load clothes washers.

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