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# 2023 Residential Laundry Field Study

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## Key Terms and Acronyms

| Term/Acronym | Definition |
|---|---|
| AHAM | Association of Home Appliance Manufacturers |
| Automatic Termination | A dryer program that uses sensors and programming to adjust the cycle length to the textile load's dryness. |
| Bone-dry Load Weight | The bone-dry weight of the load, as defined by the DOE-developed test procedure for dryers in Appendix D2 (CFR 2025a) |
| CEF | The combined energy factor, i.e., the energy performance metric for clothes dryers. It compares the energy efficiency of gas and electric dryers in pounds per kWh. The higher the CEF, the more efficient the dryer is. |
| Clean Dry-load Weight | The weight of the laundry load after removal from the clothes dryer. |
| cu ft | cubic foot or cubic feet |
| Cycle | For this report, a cycle refers to the complete process of washing or drying a load of textiles. |
| Confidence interval | The range of values—determined by adding and subtracting the margin of error from the sample mean—in which the true mean is likely to belong. |
| Confidence level | The likelihood that a confidence interval contains the true value of a population parameter. The higher the confidence level, the greater the certainty that the true value is within the confidence interval. |
| Dirty Dry-load Weight | The weight of the laundry load before it goes into the washer. |
| DOE | U.S. Department of Energy |
| EER | Energy efficiency ratio: the clothes washer energy efficiency metric defined by Appendix J (CFR 2025b). |
| ENERGY STAR® | The government-backed symbol for energy efficiency for laundry and other equipment. At the date of this publication, the EPA administers the ENERGY STAR program. |
| EPA | U.S. Environmental Protection Agency |
| ESME | ENERGY STAR Most Efficient |
| EULR | End-Use Load Research: a NEEA project that collects continuous energy consumption in more than 350 homes for some laundry equipment and other major energy end uses.[1] |
| Evergreen | Evergreen Economics |
| Fabric thickness | Refers to the level of fabric weight: Heavy, Medium, or Light. |
| Front load | A clothes washer with a horizontal axis. |
| IMEF | Integrated Modified Energy Factor: the clothes washer energy efficiency metric defined by Appendix J2 (CFR 2025c). |
| IWF | Integrated Water Factor: the clothes washer water efficiency metric defined by Appendix J2 (CFR 2025c). |
| lb | pound or pounds |

[1] For more information, see https://neea.org/resources/the-northwest-end-use-load-research-eulr-project.

| Term/Acronym | Definition |
|---|---|
| LEC | Laundry equipment characteristics dataset, a subset of OBEC, gathered by Evergreen Economics. |
| Load | For this report, a load refers to the textiles in a washing or drying cycle. |
| Load size | Weight of fabrics grouped into three bins: Small (0-6.29 lb), Medium (6.3-10.59 lb), and Large (10.6+ lb) |
| Margin of error | The amount of uncertainty both above and below the average, indicating the extent to which results may differ from the true value. Calculating the margin of error requires knowledge of the sample size, distribution of the data for a particular metric, and the confidence level chosen. |
| Metered Data | The dataset from the field monitoring equipment. |
| NEEA | Northwest Energy Efficiency Alliance |
| Non-qualified | A washer or dryer that does not have the ENERGY STAR label. |
| QPL | Qualified Product List maintained by ENERGY STAR. |
| OBEC | Occupant behavior and equipment characteristics: the primary detailed dataset leveraged in this report, collected by Evergreen Economics. |
| Occupant Journal | The tool used by project participants to record laundry equipment usage characteristics (e.g., load weights and settings) for the research study. |
| Program | The name of a washer or dryer cycle setting; each is capitalized in this report for clarity (e.g., Normal, Delicate, Quick Wash). |
| RBSA | Residential Building Stock Assessment |
| RMC | remaining moisture content (in washer textiles at cycle completion) |
| RTF | Regional Technical Forum |
| Timed Dry | A clothes dryer program that allows a consumer to set a specific drying length for a load (in minutes). |
| Top load | A clothes washer with a vertical axis (agitator or impeller). |
| UES | unit energy savings |
| VOJM | Validated Occupant Journals with Metered Data; a dataset that includes only the self-reported data from participants that correspond accurately to data from energy monitoring equipment. |
| Weighted average | An average value that is weighted by another population parameter to better represent the population. |
| WER | Water efficiency ratio: the clothes washer water efficiency metric defined by Appendix J (CFR 2025b). |
| Wet-load Weight | The weight of the wet load coming out of the washer before it goes into the dryer. |

*Notes:* For clarity, common nouns with specific definitions in this report are intentionally capitalized (e.g., Clean Dry-load Weight, Normal program setting, Metered Data).

# EXECUTIVE SUMMARY

The 2023 Laundry Field Study supplements NEEA's 2022 Residential Building Stock Assessment (RBSA). It focuses on two areas of research: 1) occupant behavior and equipment characteristics (OBEC) for laundry equipment and 2) annual number of laundry cycles and energy use estimates, which leverages End-Use Load Research (EULR) data.

The OBEC metering and Occupant Journal data were collected in 63 homes in 2023. Key findings for clothes washers and dryers include:

- Normal is the most common clothes washer program consumers use (66% of cycles).
- Clothes dryer Automatic Termination programs are more common than timed dry (67% of cycles).
- Normal is the most common automatic termination program for clothes dryers (40% of all cycles).
- For all ENERGY STAR© dryers with an Eco Mode cycle modifier available, Eco Mode is turned off 35% of the time.
- Almost half of washer and dryer loads are between 6.3 and 10.6 lb (about 45% of cycles).
- Consumers often wash mixed loads of cotton and synthetic fabrics (67% of cycles), and most washer loads are a mix of fabric thicknesses and weights (55% of cycles).
- The remaining moisture content (RMC) averages of the clothes washer load varied by program, spin speed, textile type, and washer axis type (front and top load). The overall field average RMC for all washer loads was about 51%.[2]
- Most loads are transferred from the washer to the dryer within one hour of the end of the washer cycle (69% of cycles).

The annual number of dryer cycles and the annual energy use of dryers were determined using EULR data. The EULR data include continuous power metering of dryers in hundreds of Northwest homes. Results reveal that the average household in the US runs a dryer cycle of 20 minutes or longer 307 times per year. Additionally, consumers run 60 partial cycles (between 5 and 15 minutes in length) annually. On average, electric dryers in the Northwest and US use just over 690 kWh per year, while gas dryers use approximately 24 Therms and 71 kWh per year.

NEEA anticipates using these findings to refine regional energy use and savings estimates, support Market Transformation efforts, and inform comments on future U.S. Department of Energy (DOE) regulations and voluntary specifications, such as the ENERGY STAR program. Future research opportunities include further characterization of OBEC data for both washers and dryers that have not yet been analyzed in this report, and EULR investigation of seasonal laundry differences.

[2] Lab tested RMCs would be slightly higher because Bone-dry Load Weights measured in the lab are lighter than the Clean Dry-load Weights used for this study.

# 1 INTRODUCTION

The Northwest Energy Efficiency Alliance (NEEA) is an alliance of more than 140 utilities and energy efficiency organizations working on behalf of more than 13 million energy consumers to increase the adoption of energy-efficient products, services, and practices. To do this, the alliance identifies and removes market barriers to energy efficiency to drive permanent change throughout the supply chain. NEEA pools resources and shares risks to transform the market for energy-efficient products and services to benefit all consumers in the Northwest.

NEEA is pleased to present the 2023 Laundry Field Study as a supplement to the 2022 Residential Building Stock Assessment (RBSA) (NEEA 2024), which provides building characteristics and energy usage data on residential buildings in the Northwest. This report details the field study effort to document typical home laundry equipment characteristics, record consumers' laundry processing behaviors, and collect real-time clothes washer and dryer energy data. It also describes the analysis of consumer laundry processing patterns. Furthermore, it leverages the End-Use Load Research (EULR) project's continuous metering data from more than 350 Northwest homes to estimate the region's annual washer and dryer usage patterns. Together, the findings will help NEEA identify opportunities for promoting new, more efficient types of laundry processing equipment in its Market Transformation efforts.

The 2023 Residential Laundry Field Study is organized as follows: **Section 2** provides an overview of the project, its rationale, and the objectives that NEEA aims to achieve. **Section 3** describes the field research methodology to document occupant behavior and equipment characteristics (OBEC), while **Section 4** provides the OBEC results. **Section 5** describes the methods for utilizing EULR data to develop annual residential dryer cycles and energy use estimates, and **Section 6** presents the corresponding results. **Section 7** summarizes key takeaways, including recommended areas for additional research and analysis. **Section 8** concludes the report with project references and relevant NEEA publications. **Appendix A** provides supplemental project information.

Two primary contractors supported NEEA on this project. As the primary contractor, Evergreen Economics (Evergreen) developed the OBEC methodology and conducted the analysis (Sections 3 and 0). Kannah Consulting provided laundry equipment expertise to help refine Evergreen's analysis of OBEC data on dryer settings and load weights (Sections 4.8.1 and 4.8.2), estimated annual gas dryer energy use based on electric dryer energy use (Section 5.3), and collaborated with NEEA staff to develop EULR results (Sections 5.2 and 6.3).

# 2 Project Rationale and Objectives

## 2.1 Historical Overview

NEEA's long history of supporting improvements in consumer laundry efficiency began with clothes washers nearly 25 years ago. Regional incentive programs for manufacturers and retailers were early successes, and by 2006, the market share for efficient front load clothes washers had reached 50% (NEEA 2020d). Using this as leverage, NEEA worked with its partners to influence new federal standards for clothes washer efficiency and even higher ENERGY STAR© specifications. However, consumer dissatisfaction with certain aspects of front load washers (e.g., moldy gaskets) (Flamer 2024) has led to a decline where they now represent approximately 30% of sales (NEEA 2023b). Since standards and ENERGY STAR specifications improved the efficiency of top load washers as well, NEEA has considered efficiency opportunities for both top and front load washers to ensure consumer choice and support market competition.

For clothes dryer efficiency, NEEA began research and market-based efforts over a decade ago, championing residential heat pump clothes dryers through seminal technical, lab, and field research; policy efforts for standards and voluntary programs; and market-based support of utility incentive programs. The opportunity to address dryer energy use was detailed in the 2012 Laundry Field Study (Hannas and Gilman 2014), which also leveraged the broader RBSA from that era.

Together, NEEA's notable accomplishments for residential clothes washers and dryers include:

- Developing multiple technical research reports investigating laundry equipment (NEEA 2024a; NEEA 2023a; Foster Porter et al. 2022; NEEA 2022b; Foster Porter et al. 2020; Dymond 2018; Dymond 2017).
- Crafting numerous comment letters to the U.S. Department of Energy (DOE) on energy use and efficiency test procedures and conservation standards for laundry equipment (AHAM et al. 2024; NEEA et al. 2023a; Ameren Illinois et al. 2022; and NEEA 2022a, 2021, 2020a, 2020b, 2020c, 2019a, and 2019b).
- Serving as a co-signatory of the Joint Energy Efficiency Agreement (EEA) for residential clothes washers and dryers standards, part of a broader set of recommendations by a wide range of stakeholders (AHAM et al. 2023). The standards set efficiency levels in terms of energy efficiency ratio (EER) and water efficiency ratio (WER). DOE adopted them as a direct final rule (DOE 2024a and 2024b).[3]
- Developing a test procedure for the Qualified Product List (QPL) to enable utilities to offer incentive programs for efficient residential dryers (NEEA 2023a and 2022b).
- Demonstrating the opportunity and advocating for voluntary washer and dryer ENERGY STAR specifications, including the continuation of a Most Efficient (ESME) specification for both washers and dryers (NEEA 2020d, 2024b, and 2024c).
- Pioneering research into commercial heat pump dryer use in hotels and other commercial applications (Foster Porter et al. 2025).

[3] DOE later withdrew the water efficiency portion of the requirement for standard-sized washers (2025b) and all efficiency requirements for compact washers (2025a) as part of a broader deregulatory effort (The White House 2025). These rollbacks are expected to face legal challenges.

A follow-up field study was appropriate for several reasons, which are discussed next.

## 2.2 Rationale

### *2.2.1 Impacts of Market-Based Efforts and New Technologies = New Opportunities*

The current and upcoming test procedures for measuring the energy efficiency of clothes washers consider the energy used by the washer during the cycle and while on standby, the energy used to heat the water, and the energy used to run the dryer (CFR 2025b and 2025c). For both procedures, most of the energy consumed in the home laundry process is used for drying. For this reason, past efficiency efforts primarily focused on reducing the remaining moisture content (RMC) in washers to decrease drying energy demands, with little attention paid to the dryer's efficiency.

With the efforts and successes described in Section 2.1, improvements in clothes washer efficiency and the increased availability of heat pump dryers have steadily shifted NEEA's laundry efficiency focus to dryers. More recently, all-in-one washer-dryer combo units with heat pump drying have entered the market, and data from NEEA's ENERGY STAR Retail Products Program show strong initial consumer interest. This suggests that opportunities may exist for other market-based efforts to support their adoption, and data from this project will support that endeavor. Understanding modern consumer laundry patterns will also help NEEA identify other opportunities to increase the adoption of more efficient clothes washers and heat pump dryers, benefiting Northwest consumers.

### *2.2.2 Regional Energy Use and Savings Estimates*

The data collected will also assist the Regional Technical Forum (RTF) in updating its estimates for residential laundry equipment in the Northwest. The RTF is a technical advisory committee to the Northwest Power and Conservation Council that develops standards to verify and evaluate energy efficiency savings. NEEA supports RTF by supplying data for creating and/or modifying unit energy savings (UES) measures.[4] With the last residential laundry field study conducted in 2012 and the introduction of new laundry equipment technologies, the data are timely for the RTF.

## 2.3 Goals and Objectives

Two primary goals serve this project. NEEA's first aim is to document laundry equipment installed in the Northwest, consumer usage patterns, and real-time washer and dryer energy consumption. The second goal is to develop a snapshot of current Northwest consumer laundry behaviors and correlate any notable demographic attributes. Anticipated applications of these findings include:

- Refined RTF energy use and savings estimates for residential laundry equipment in the Northwest
- Approaches for supporting Market Transformation efforts for more efficient laundry equipment
- Representative consumer data to support NEEA's comments on future DOE laundry equipment regulations and voluntary specifications like the ENERGY STAR program

[4] See https://rtf.nwcouncil.org/measures for more information.

Research project objectives are divided into two categories: 1) Occupant behavior and equipment characteristics (OBEC) and 2) annual number of washer and dryer cycles and annual energy use (EULR).

Evergreen Economics, with support from Driftless Energy, led the field data collection effort for the first set of research objectives. The OBEC data provide visibility into specific consumer behavior and equipment characteristics that are unavailable in studies with a larger number of households. The second set of research objectives leveraged NEEA staff analysis of the EULR continuous metered data of more than 350 homes in the Northwest. The EULR data provided continuous energy use information over all four seasons of the year and a larger sample size, enabling higher confidence in annual dryer cycle counts and energy use.

Objectives for each category are outlined in Tables 1 and 2.

**Table 1. Occupant behavior and equipment characteristics (OBEC)**

| Objective | Outcomes |
|---|---|
| **Document homeowner and laundry equipment attributes** | For the household, itemize various demographic attributes. For laundry equipment, identify the make, model, manufacturer, and other relevant details about the appliances and their location. |
| **Gather and categorize self-reported consumer setting/cycle choices (Occupant Journal*)** | Record and categorize consumer choices for the wash and dry cycle programs, as well as other settings. |
| **Gather and categorize self-reported laundry load textile types (Occupant Journal*)** | Characterize the variation in laundry load textile types. |
| **Gather and categorize self-reported laundry load weights (Occupant Journal*)** | Document laundry load weights: 1) before washing, 2) coming out of the wash, and 3) coming out of the dryer to calculate the remaining moisture content (RMC) of each washer load. Develop a matrix of load types to identify patterns and the distribution of load weights to determine the most common load weights and any other salient factors. |
| **Meter washer and dryer energy use (Metered Data)** | Install energy meters to log the electricity usage of real-time laundry equipment for each household in the sample over a one-month period. |
| **Combine Metered Data with Occupant Journal data for additional analyses** | Combine Metered Data to align with self-reported data for analysis of 1) Cycle time and energy use of washers and dryers, and 2) the duration between the completion of a wash load and the initiation of its drying cycle. Also, showcase different power signatures by comparing various settings, load sizes, textiles, and technologies. |

*The Occupant Journal is the survey tool used by study participants to record their self-reported data; it is described further in Section 3.5.

**Table 2. Annual number of dryer cycles and annual energy use (EULR)**

| Objective | Outcomes |
|---|---|
| **Estimate the number of annual dryer cycles** | Provide a methodology and estimate the number of residential annual dryer cycles. |
| **Estimate the annual energy use of dryers (electric)** | Assess the annual average residential dryer electricity use. |
| **Estimate the annual energy use of dryers (gas)** | Assess the annual average residential dryer gas energy use. |

Sections 3 and 0 detail the methodologies for achieving these objectives. Section 0 discusses OBEC results and Section 0 discusses EULR results.

# 3 Occupant Behavior and Equipment Characteristics (OBEC) Methodologies

## 3.1 Overview

Evergreen led the OBEC data collection and analysis team with field engineer support from Driftwood Energy. The team collected primary data on laundry equipment at 63 participating homes from February to September 2023. Datasets include field-documented laundry equipment characteristics (LEC), installed energy and water monitoring equipment (Metered Data), self-reported laundry usage data logged by participants (Occupant Journal), and Validated Occupant Journals with Metered Data (VOJM).

## 3.2 Sample Selection

The primary sample of OBEC homes was recruited from participants in the 2022 Residential Building Stock Assessment (RBSA) (NEEA 2024). Since few heat pump dryers were observed during this study, sample recruitment was augmented with Avista utility data for customers who had received an efficiency program rebate for a heat pump dryer in 2022 or Q1 2023. This approach ensured the study collected representative field data for heat pump dryers.

Evergreen targeted data collection in four locations that included homes located in the surrounding areas:

- Portland, Oregon
- Eugene, Oregon
- Bend, Oregon
- Spokane, Washington

These four areas also represent three different climate zones.

Demographic data were available for RBSA respondents but not for Avista customers. Demographic data captured included:

- Household size (1, 2, 3, 4+)
- Presence/absence of seniors
- Children (0, 1-2, 3+)
- Income ($49,999 or less, $50,000 to $99,999, $100,000 to $199,999, $200,000+)
- Highest level of education attained in the household (high school graduate, some college, associate's degree, bachelor's degree, advanced degree)
- Location (eastern Washington, eastern and western Oregon)
- Rural or urban setting

## 3.3 Laundry Equipment Characteristic (LEC) Data Collection

Driftless Energy field engineers were responsible for collecting LEC data. Table 3 and Table 4 provide the checklists for documenting key equipment characteristics while on-site for washers and dryers, respectively.

**Table 3. Field engineer laundry equipment characteristic (LEC) data checklist for washers**

| Data Collected |
|---|
| **Washers** |
| Manufacturer |
| Model |
| Capacity |
| Front load or top load (including axis type) |
| Year of purchase/manufacture |
| Non-qualified/ENERGY STAR |
| Cycle choices available |
| Distance from the water heater to the washer |
| Water heater temperature setting |
| Location (conditioned living space, conditioned/unconditioned garage, conditioned/unconditioned basement) |
| Networked/smartphone application |

**Table 4. Field engineer laundry equipment characteristic (LEC) data checklist for dryers**

| Data Collected |
|---|
| **Dryers** |
| Manufacturer |
| Model |
| Capacity |
| Year of purchase/manufacture |
| Non-qualified/ENERGY STAR |
| Cycle choices available |
| Venting style |
| General condition and length of duct if vented |
| Location (conditioned living space, conditioned/unconditioned garage, conditioned/unconditioned basement) |
| Networked/smartphone application |

## 3.4 Metered Energy Monitoring

Driftless Energy field engineers installed energy monitoring equipment (detailed in Appendix A: OBEC Field Equipment Installation and Data Collection Methodology) to collect energy use data once per minute for both washers and dryers. For washers, the monitoring equipment also captured hot- and cold-water usage using flow meters. For dryers, the monitoring equipment captured the airflow. Data collection ran for approximately one month at each site.

## 3.5 Self-reported Occupant Journal Data

Participants were instructed to keep a detailed accounting of their laundry usage during the study period using the Occupant Journal form, detailed in Table 5 and Table 6 (for washers and dryers, respectively).

**Table 5. Participant laundry usage data collection (Occupant Journal) for washers**

| Data Collected |
|---|
| **Washers** |
| Cycle date |
| Cycle start time |
| Any delayed start details (duration and reason) |
| Program setting name (including self-clean) |
| Water temperature |
| Spin speed |
| Fill setting/option |
| Textile type |
| Textile thickness |
| Dirty Dry-load Weight (lb) going into washer* |

**Table 6. Participant laundry usage data collection (Occupant Journal) for dryers**

| Data Collected |
|---|
| **Dryers** |
| Cycle date |
| Cycle start time |
| Any delayed start details (duration and reason) |
| Program setting name |
| Mode (Normal or Eco) setting |
| Dryness level setting |
| Temperature setting |
| Washer Wet-load Weight (lb) going into dryer* |
| Clean Dry-load Weight (lb) coming out of dryer* |
| Notation of any wash loads not dried in the dryer |

*The Dirty Dry-load Weight going into the washer is often a little higher than the equivalent Bone-dry Load Weight that the DOE uses because of moisture/dirt in the clothing. The Clean Dry-load Weights coming out of the dryer are closer to a Bone-dry Load Weight, considered by Appendix D2 (CFR 2025a), but still have more moisture in the textiles than the Bone-dry Load Weight.

*Notes:* Laundry load weights were measured using a scale provided by the field engineers. Only complete loads were analyzed (i.e., if items were removed to line dry, that load was omitted from the analysis).

Evergreen coded the Occupant Journal data in a series of steps prior to the analysis to ensure consistency of terms and an error-free dataset. Coding included:

- Fixing typos and ensuring naming consistency in reported washer and dryer settings (e.g., "Heavy" was edited to "Heavy Duty")
- Grouping washer settings into seven categories: Bedding/Towels/Bulky, Delicates, Heavy Duty, Normal, Quick Wash, Self-Clean, and Other
- Grouping dryer settings into eight categories: Bedding/Towels/Bulky, Casual, Delicates, Heavy Duty, Mixed Load, Normal, Quick Dry, and Other
- Converting all reported dry weights into pounds (lb)
- Grouping Dirty Dry-load Weights and Clean Dry-load Weights into three bins: Small (0-6.29 lb), Medium (6.3-10.59 lb), and Large (10.6+ lb)[5]
- Grouping months into seasons (winter: December, January, February; spring: March, April, May; summer: June, July, August; fall: September, October, November)

## 3.6 Validated Occupant Journals with Metered Data (VOJM)

An inherent challenge with Occupant Journal data is the potential for human error. However, the Metered Data provide the opportunity to validate the Journal, enabling a higher-confidence dataset. Evergreen adjusted the self-reported start times of laundry cycles to align with observed, time-stamped energy usage data through several steps:

- Relevant usage data for each piece of monitored laundry equipment were reviewed to ensure the observed values were accurate and reliable
- Metered data were plotted against the Occupant Journal to visually identify any discrepancies
- Occupant Journal data discrepancies were aligned manually with the Metered Data to ensure accuracy

The resulting combined dataset is referred to as the Validated Occupant Journals with Metered Data (VOJM). It includes detailed information on cycle start and end times, minute-by-minute energy usage, settings of laundry cycles in the study, and wet and dry weights associated with washer and dryer loads. In cases where the Occupant Journal and Metered Data could not be aligned, they were omitted from this dataset.

## 3.7 Clothes Washer Remaining Moisture Content (RMC) Calculation

To calculate a clothes washer field RMC, Evergreen used the weight of the load before and after drying as recorded in the Occupant Journal. RMC was calculated by taking the difference between the Wet-load Weight (coming out of the washer) and the Clean Dry-load Weight (coming out of the dryer) to determine the weight of water removed in the drying process. Then, the total weight of water removed was divided by the Clean Dry-load Weight to yield RMC. [6] This calculation was only

[5] The weight bins were centered around the DOE test load value of 8.45 lb (CFR 2025a).

[6] This field RMC is not identical to a lab-tested RMC as loads coming out of the dryer do not have zero moisture in a real-world setting. Lab tested RMCs would be slightly higher than field RMCs because the Bone-

performed on complete wash and dry cycle loads, where Occupant Journals confirmed that the entire load was dried in the dryer and that no textiles were removed for line drying (the dry weights of line-dried textiles were not documented, so they could not be calculated accurately). RMC is expressed as a percentage, and a value near or above one indicates a relatively high amount of water remaining in the load. RMC values closer to zero denote a relatively low amount of water remaining in the load.

### 3.8 Calculation of Time Lapses Between Washer Cycle End and Dryer Cycle Start

Evergreen used the VOJM dataset to calculate the time between the end of a wash cycle and the start of the dry cycle. Only those start and end times that were consistent with both sources were used for the time lapse analysis.

### 3.9 Clothes Dryer Efficiency Calculation

To calculate clothes dryer efficiency, Evergreen used the Metered Data and Occupant Journals. The Clean Dry-load Weight at the end of the dryer cycle (from the Occupant Journal) was divided by the total cycle energy consumption for that dryer cycle, as recorded in the Metered Data.

## 4 OBEC Results

### 4.1 Overview of Resulting OBEC Datasets

The data collection, Occupant Journal coding, dataset validation, and calculations resulted in these key OBEC datasets:

1. Laundry equipment characteristics (LEC) dataset
2. Metered Data (monitoring equipment results only)
3. Occupant Journals (participant self-reported data only)
4. Validated Occupant Journals with Metered Data (VOJM) (dataset includes only the data from Occupant Journals that accurately correspond to the Metered Data)
5. Calculated parameters (washer RMC, time lapse between washer and dryer cycles, and dryer efficiency)

Figure 1 illustrates how these datasets relate to one another.

dry Load Weights (as defined by Appendix D2 in CFR 2025a) are slightly lighter than the Clean Dry-load Weights used for these calculations.

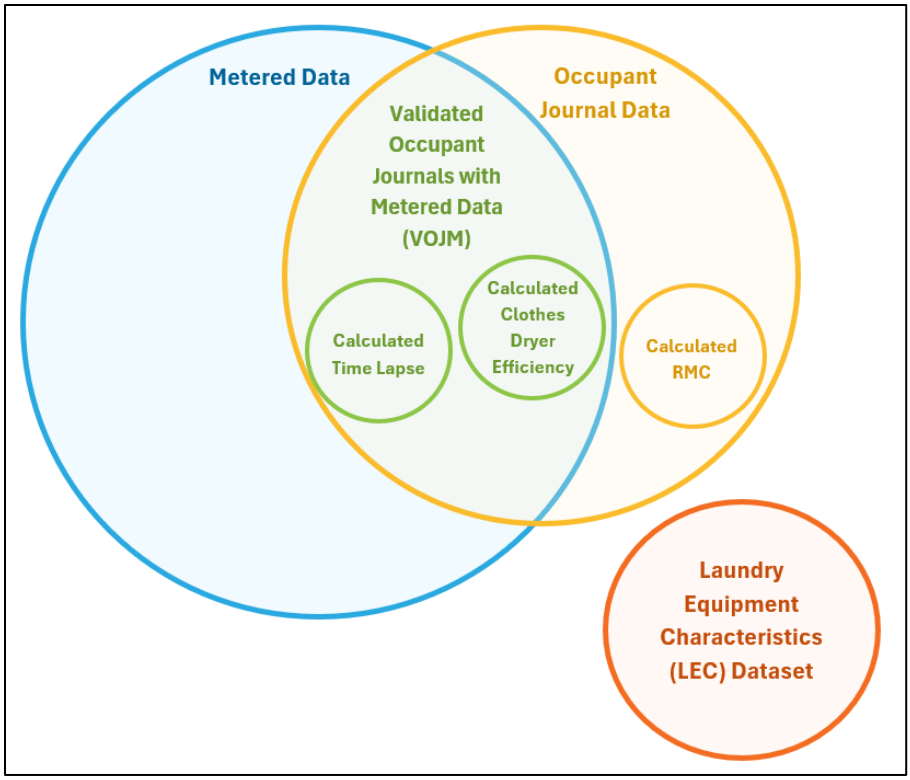


**Figure 1. OBEC datasets**

Many of the analyses presented in this report use more than one of the resultant datasets. The dataset(s) used are noted for each analysis. All results in this section are unweighted by any variable (demographic or other).

## 4.2 Sample Selection Summary

The OBEC effort included extensive laundry field work for eight months in 2023, collecting consumer laundry behaviors for one month in each of the 63 homes in three distinct climate zones. Table 7 provides an overview of the available demographic attributes of the participant sample.

**Table 7. Participant sample demographic attributes (n=63)**

| Demographic Attribute | Number of Households | Percentage of Sample |
|---|---|---|
| 1-person household | 11 | 17% |
| 2-person household | 29 | 46% |
| 3-person household | 6 | 10% |
| 4+ person household | 13 | 21% |
| Senior(s) | 19 | 30% |
| No senior(s) | 42 | 67% |
| No children | 45 | 71% |
| 1-2 children | 15 | 24% |
| 3+ children | 1 | 2% |
| $49,999 or less | 13 | 21% |
| $50,000 to $99,999 | 22 | 35% |
| $100,000 to $199,999 | 19 | 30% |
| $200,000+ | 2 | 3% |
| High school graduate | 3 | 5% |
| Some college | 5 | 8% |
| Associate's degree | 10 | 16% |
| Bachelor's degree | 22 | 35% |
| Advanced degree | 19 | 30% |
| OR - Eastern | 13 | 24% |
| OR - Western | 35 | 56% |
| WA - Eastern | 15 | 24% |
| Rural | 17 | 27% |
| Urban | 46 | 73% |

## 4.3 Summary of Laundry Equipment in Use

The OBEC data collected on LEC attributes in the sample are summarized in Table 8.

**Table 8. Summary of laundry equipment characteristics (LEC) dataset (n=62)**

| Attribute | |
|---|---|
| **Washers (n=63)** | **Summary of Data** |
| **Manufacturer** | 13 manufacturers represented, including Amana, Electrolux, Frigidaire, General Electric, Inglis, Kenmore, LG, Maytag, Miele, Performa, Samsung, Sears, and Whirlpool |
| **Model** | 62 washer models |
| **Vintage** | Despite efforts to collect the vintage of the equipment, this information was available for only eight washers and five dryers and was therefore excluded from the analysis. |
| **Front or top load** | 37 top load, 25 front load, 1 undetermined |
| **ENERGY STAR** | 39 non-qualified, 22 ENERGY STAR certified, 2 unknown |
| **Networked/smartphone application** | 4 networked or wi-fi enabled, 56 not networked, 3 unknown |
| **Dryers (n=63)** | **Summary of Data** |
| **Manufacturer** | 13 manufacturers, including Amana, Electrolux, Estate, Frigidaire, General Electric, Inglis, Kenmore, LG, Maytag, Samsung, Sears, Speed Queen, and Whirlpool |
| **Model** | 62 dryer models |
| **Dryer type** | 56 electric, 4 electric heat pump, and 3 natural gas |
| **ENERGY STAR*** | 45 Non-qualified, 12 ENERGY STAR (electric), 1 ENERGY STAR (gas), 5 unknown |
| **Venting style** | 55 vented, 4 ventless (condensing), 4 unknown |
| **Networked/smartphone application** | 5 networked or wi-fi enabled, 57 not networked, 1 unknown |

*The dryer ENERGY STAR qualification was confirmed by referencing the ENERGY STAR Qualified Product List for dryers (ENERGY STAR 2023).

*Notes:* The following equipment attributes were collected as part of the OBEC effort but were not summarized here: washer and dryer capacity (in cu ft), washer and dryer program setting choices available on each model, distance (in ft) from the clothes washer to the water heater, the location of the washer and dryer equipment, and the general condition and length of the dryer duct. These data are available for analysis later, if deemed useful.

## 4.4 Outcome of Validated Occupant Journals with Metered Data (VOJM)

The Occupant Journals documented 934 washer cycles and 912 dryer cycles. Table 9 provides a breakdown of all self-reported cycles and the number of those that were validated using Metered Data. The VOJM dataset contains 41 washers and 48 dryers.

**Table 9. Cycles documented in the Validated Occupant Journal with Metered Data (VOJM) dataset**

| Equipment | Equipment Sub Type | Occupant Journal Cycles | Validated Metered Cycles | Percent Validated |
|---|---|---|---|---|
| Washers | Front Load | 421 | 250 | 59% |
| | Top Load | 513 | 279 | 54% |
| | **Total** | **934** | **529** | **57%** |
| | ENERGY STAR | 369 | 248 | 67% |
| | Non-qualified | 544 | 263 | 48% |
| | Unknown Qualification | 21 | 18 | 86% |
| | **Total** | **934** | **529** | **57%** |
| Dryers | Heat Pump ENERGY STAR (electric) | 37 | 34 | 92% |
| | ENERGY STAR (electric, excluding heat pump) | 169 | 129 | 76% |
| | ENERGY STAR (gas) | 14 | 10 | 71% |
| | Non-qualified (electric) | 613 | 310 | 51% |
| | Non-qualified (gas) | 24 | 24 | 100% |
| | Unknown Qualification | 55 | 52 | 95% |
| | **Total** | **912** | **559** | **61%** |

*Notes:* This table summarizes the full VOJM data set. Gas dryer energy usage data were excluded from any energy use analysis, but were included in other analyses. Only two gas dryers (one ENERGY STAR and one Non-qualified) had validated meter cycles.

Combining these data provides a powerful analysis tool to evaluate questions regarding consumer behavior and laundry equipment performance that are often elusive to researchers. Some illustrations, provided in the next section, compare different equipment observed to show analytical possibilities with the OBEC data.

## 4.5 Illustrative Examples Using OBEC Data

Using the LEC dataset, VOJM dataset, and calculated parameters, Evergreen developed illustrative usage profiles of different washing machines and dryers, showing the following information:

- Detailed information about the equipment, such as the washer axis type (for washer cycles) and ENERGY STAR rating
- Minute-level average power throughout the laundry cycle
- Total cycle energy consumption (in kWh)[7]
- Occupant Journal information on selected settings, load composition (textile types and thicknesses), and dry-load weight
- Calculated washer RMC
- Calculated dryer efficiency (pounds of dry textiles per kWh)

**The graphics shown in this section are not intended to be representative of all the washers and dryers in the dataset; however, they illustrate interesting variations in how different types of laundry equipment use energy as they clean and dry fabrics.**

### *4.5.1 OBEC Data Illustrations for Washers*

Figure 2 shows three examples of clothes washer cycles from a Non-qualified top load, an ENERGY STAR top load, and an ENERGY STAR front load. The program settings, spin speed, load textile type, Clean Dry-load Weight (weight of the laundry after removal from the clothes dryer), and washer RMC are relatively similar. The Non-qualified top load washer (top graph) used more electricity over a longer cycle compared to the two ENERGY STAR washers shown in the lower portion of the figure.[8] Note that the RMC was the highest for the top loading clothes washers and lower for the front loading ENERGY STAR qualified washer. A lower RMC is better from an efficiency perspective because less water must be removed in the dryer, enabling lower energy use for that cycle.[9]

[7] The reported electricity usage relates solely to the individual appliance (i.e., the clothes washer or dryer), and never includes water heater energy use associated with the wash cycle.
[8] Washer energy use in this case, and throughout the report, refers to the energy used by the washer itself and does not include energy use of hot water heaters or drying energy use.
[9] Although this is not a finding of this study, it is well understood by the U.S. DOE and other researchers that a lower RMC in the washer reduces energy use in the dryer (CFR 2025b and 2025c).

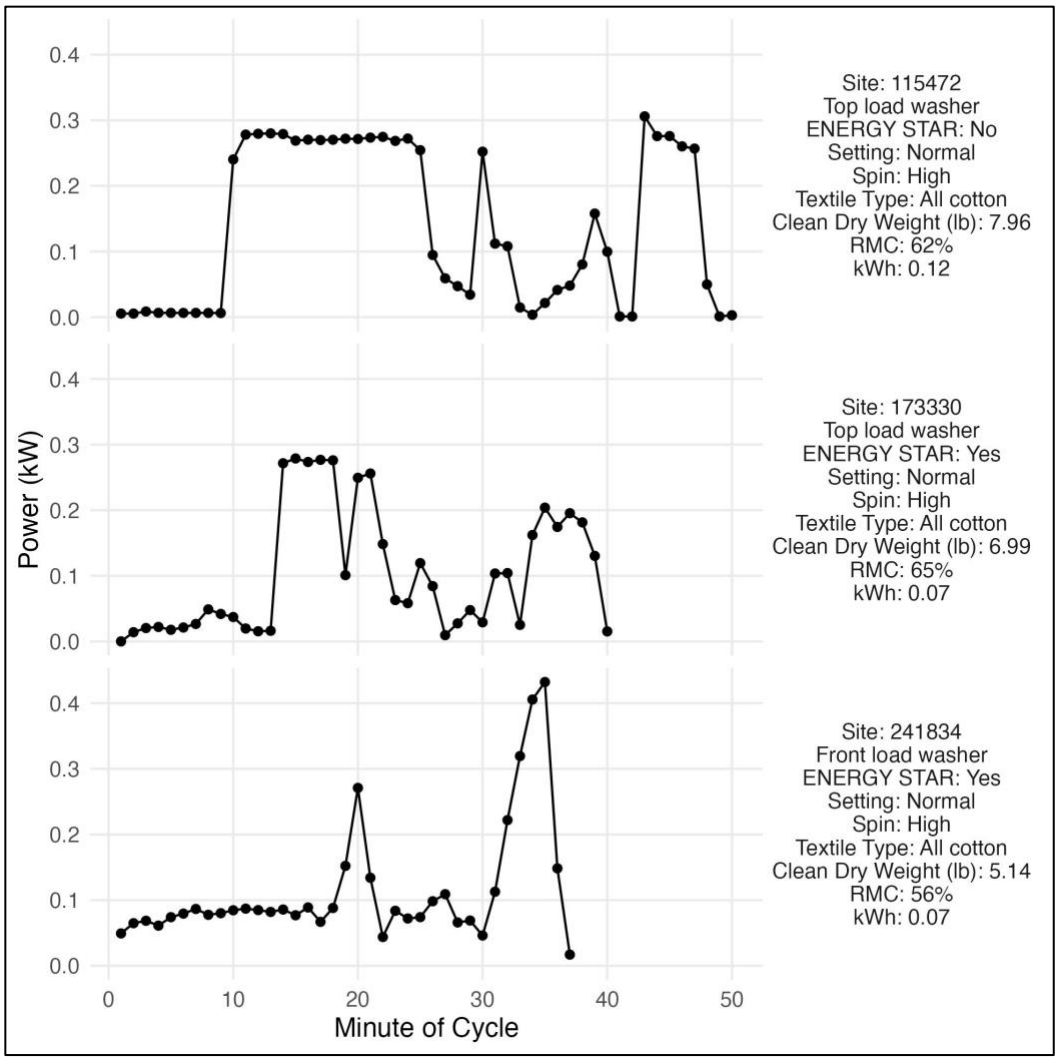


**Figure 2. Illustrative comparison of washers using Normal program and High spin speed settings**

Figure 3 shows how one Non-qualified top load washer (the top graph) compares to an ENERGY STAR front load washer (the bottom graph) when the spin speed is Medium. The ENERGY STAR front load washer uses less electricity, and the laundry cycle is completed in under 50 minutes. In contrast, the Non-qualified washer uses more electricity and takes over an hour to complete. The ENERGY STAR-qualified front load washer also achieved a lower RMC compared to the Non-qualified top load washer, ultimately reducing energy use in the dryer. [10]

[10] Although not a finding of this study, this is well understood by researchers (see prior footnote).

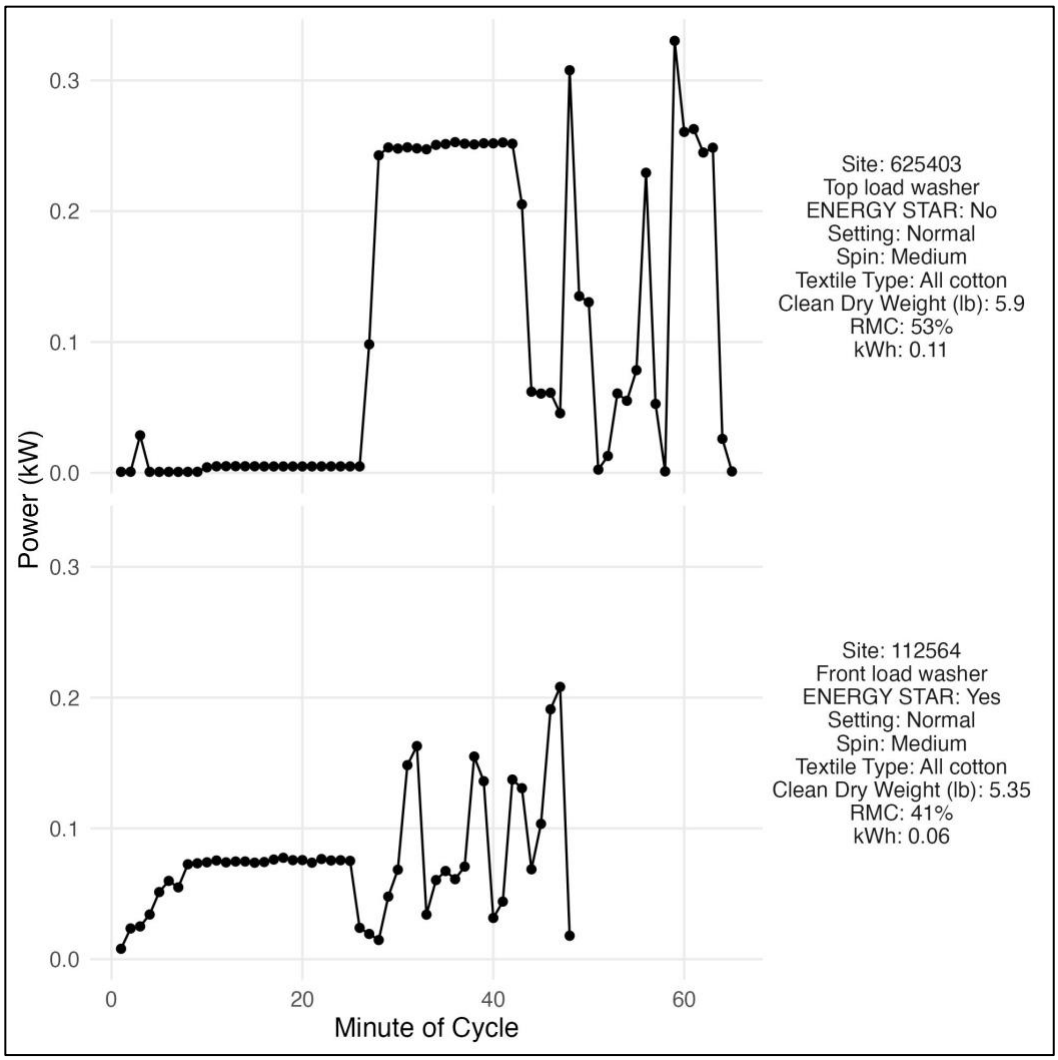


**Figure 3. Illustrative comparison of washers using Normal program and Medium spin speed settings**

### *4.5.2 OBEC Data Illustrations for Dryers*

Figure 4 compares cycles from a Non-qualified dryer, an ENERGY STAR dryer, and an ENERGY STAR heat pump dryer with a relatively consistent load textile type (All Cotton), Eco mode use, and dryness level settings (Very Dry), but different washer RMC of the load going into the dryer at the start of the cycle. The Non-qualified dryer (top graph) exhibits the highest energy use and has a fluctuating power usage pattern. The ENERGY STAR dryer (middle graph) shows a more stable power usage pattern. The ENERGY STAR heat pump dryer (bottom graph) has the lowest electricity usage. Despite a similar runtime and peak demand, the ENERGY STAR dryer used less energy to dry clothes with a higher initial RMC compared to the Non-qualified dryer. The ENERGY STAR heat pump dryer, on the other hand, has a considerably longer cycle time, but also uses significantly

less power on average, resulting in total dryer electricity usage that is less than one-third of the energy usage of the other dryers.

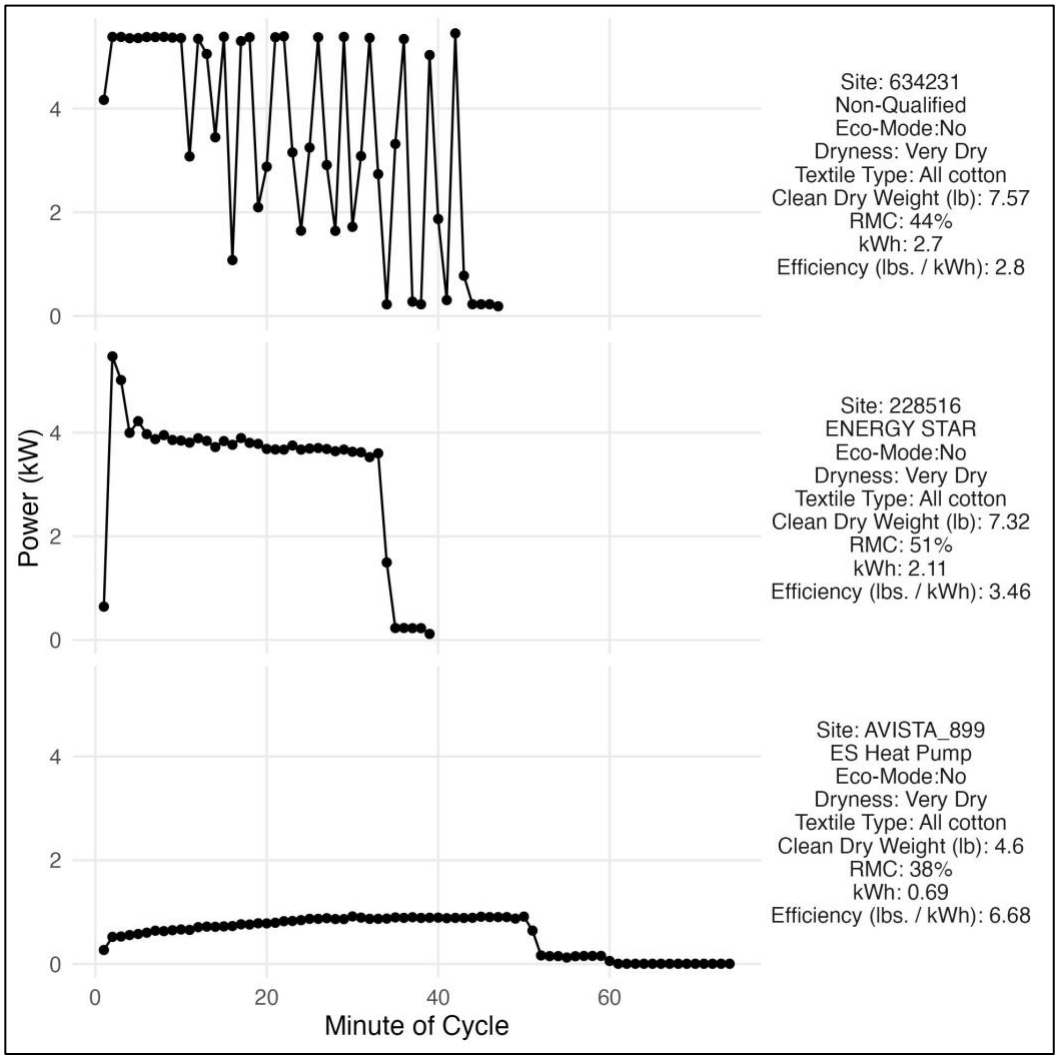


**Figure 4. Illustrative comparison of dryers using Very Dry dryness and no Eco mode settings**

Figure 5 compares a Non-qualified dryer, an ENERGY STAR dryer, and an ENERGY STAR heat pump dryer when using the Very Dry setting with Eco mode engaged, Medium dryness, and a Small-sized, All Cotton fabric load. Both the Non-qualified and ENERGY STAR dryers exhibit a fluctuating energy pattern as the heating element turns on and off during the drying process. The ENERGY STAR dryer had a higher efficiency than the Non-qualified dryer, though much of this difference could be attributed to the larger load size and lower RMC for the load in the ENERGY STAR dryer. The ENERGY STAR heat pump dryer had the highest efficiency.

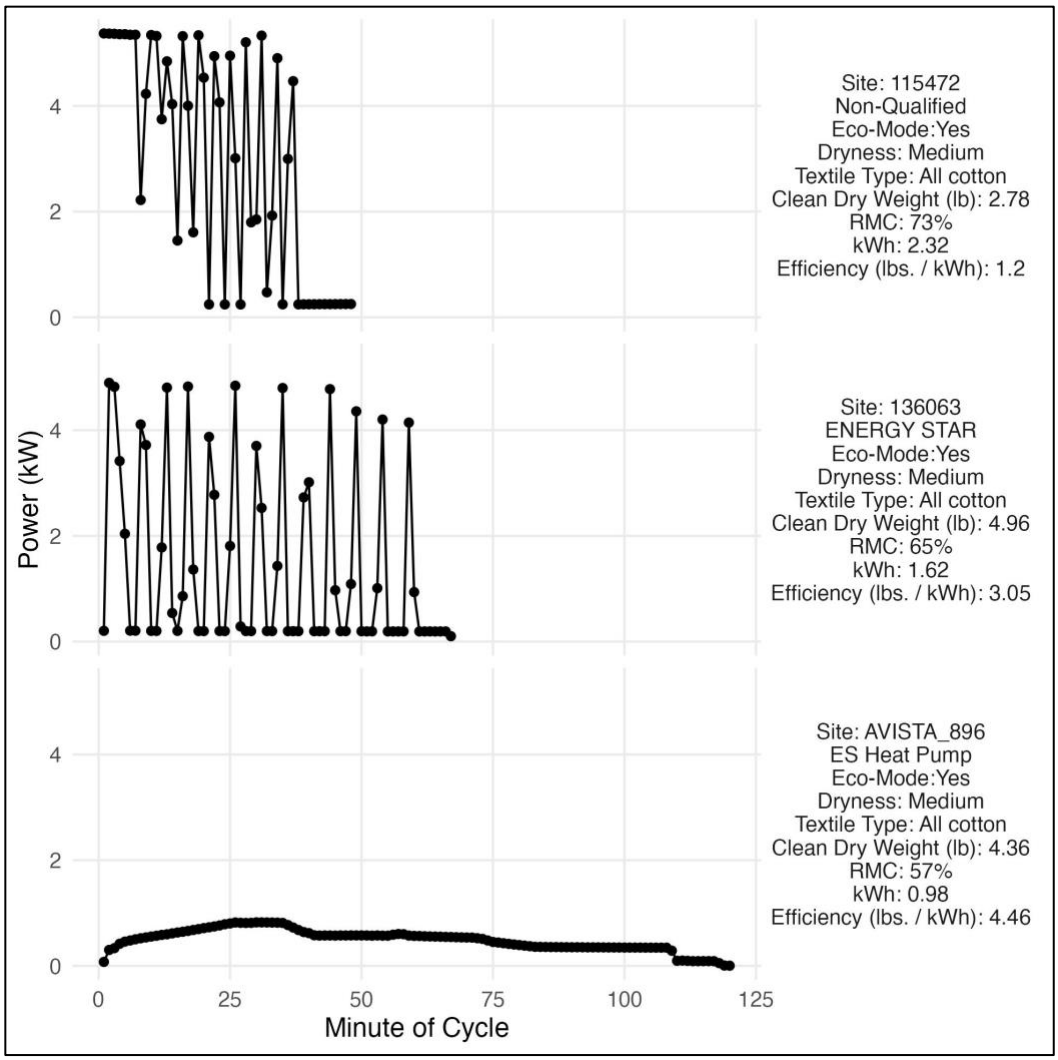


**Figure 5. Illustrative comparison of dryers using Medium dryness and Eco mode settings**

## 4.6 Clothes Washer Results

### *4.6.1 Washer Program Settings*

The washer program setting analysis is based on the LEC dataset and the Occupant Journals. Of the 934 washer cycles recorded in the Occupant Journals, 625 included information on the washer program settings. This analysis omits those cycles where washer program information was not recorded. The results are unweighted.

Figure 6 shows that most cycles (66%) were washed on the Normal program setting, indicating that it is the preferred choice for most households. The next four most common program settings were Quick Wash, Heavy Duty, Bedding/Towels/Bulky, and Delicates, each accounting for a usage range of 7% to 10%. The Self-Clean program was used for 2% of the cycles (to clean the washer itself), while other specialized program settings (e.g., Activewear, Stain, Permanent Press, Casual)

together accounted for only 1% of all cycles. While households predominantly rely on the Normal setting for their laundry needs, a notable proportion also utilize specialized program settings for a faster cycle or specific textile types.

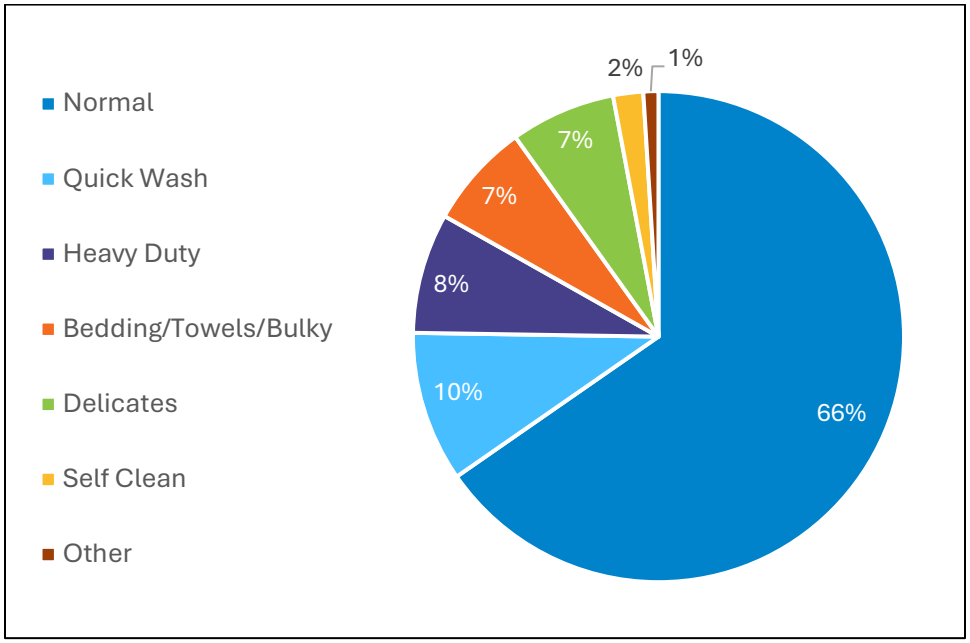


**Figure 6. Washer settings for all cycles that included washer program information (n=625 cycles)**

Washer temperature settings, spin speed settings, and water fill settings were recorded in the study but not analyzed for this report.

### Non-qualified and ENERGY STAR Washer Program Settings

Setting selections on Non-qualified and ENERGY STAR washers were compared to assess any behavioral differences in selection between these two washer types (Figure 7). The Normal setting was the most frequently used for both groups, accounting for 71% of cycles for Non-qualified washers and 61% for ENERGY STAR washers. Quick Wash was the second most common setting for ENERGY STAR washers, utilized for 14% of cycles. Heavy Duty was the second most common setting for Non-qualified washers, utilized for 12% of cycles. Households with ENERGY STAR washers performed more Quick Wash cycles (14% vs. 5% for Non-Qualified) and fewer Heavy-Duty cycles (3% vs. 12% for Non-Qualified). The overall distribution reveals that while the Normal setting dominates washer usage, significant use of specialized settings occurred for specific laundry needs or for faster cycles. Participants with ENERGY STAR washers were slightly more likely to use these specialized settings.

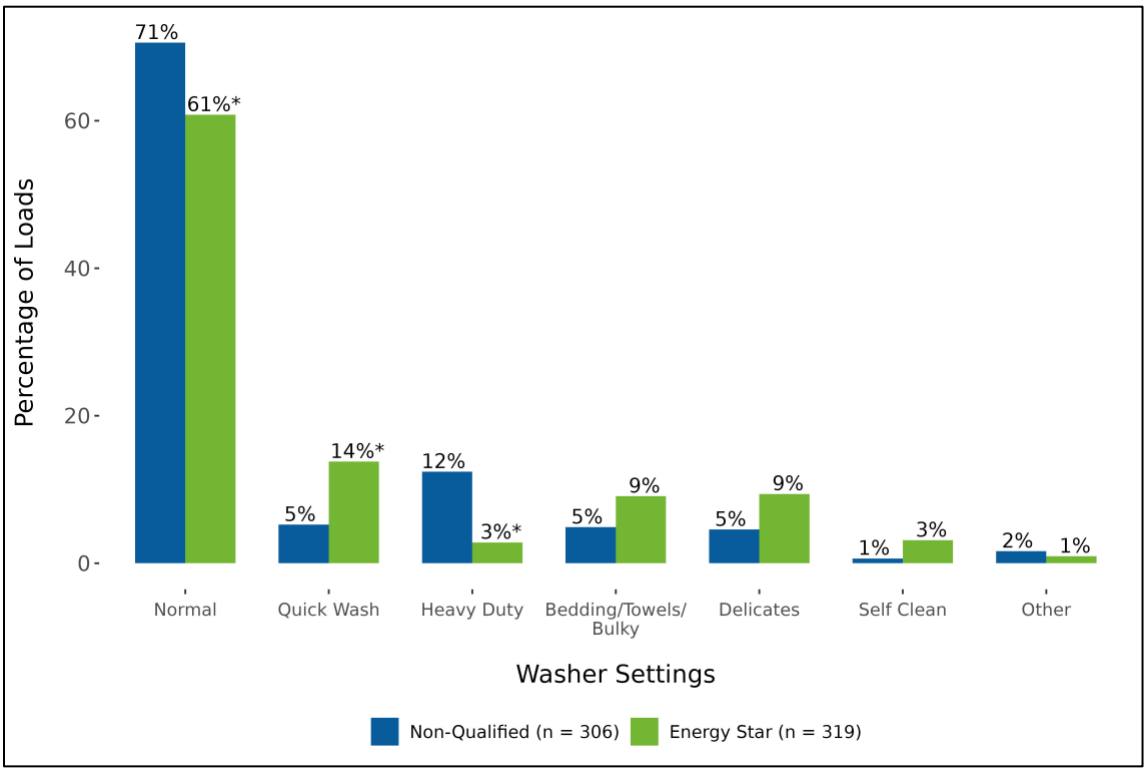


**Figure 7. Settings comparisons between ENERGY STAR and Non-qualified washer cycles**

*Notes:* Values are rounded to the nearest percent. Evergreen performed a two-proportion z-test to determine whether specific settings differences were statistically significant. Those marked with a "*" are statistically different from one another.

### *4.6.2 Washer Load Textile Types*

The Occupant Journal data were analyzed to understand the distribution of textile type of loads that went into the washer (All Cotton, Mix of Cotton and Synthetic, and Nearly All Synthetic). Of the 934 washer cycles recorded in the Occupant Journals, 867 had information on the textile type and are included in these unweighted results. Journal entries lacking information about the textile type were excluded from the analysis.

Table 10 shows the percentage of cycles by textile types. Most cycles (67%) were All Cotton and Mix of Cotton and Synthetic loads. All Cotton loads made up 28% of the total, while Mostly Synthetic loads were the least common, accounting for only 5% of loads. This distribution suggests that households predominantly wash mixed-textile loads, with a significant but smaller proportion dedicated to All Cotton loads.

**Table 10. Textile types (n=867 cycles)**

| Textile Type | n | Percentage |
|---|---|---|
| All Cotton | 242 | 28% |
| Mix of Cotton and Synthetic | 581 | 67% |
| Mostly Synthetic | 44 | 5% |

### *4.6.3 Washer Load Fabric Thickness*

Participants were asked about the thickness of fabrics in their washer loads. Of the 934 washer cycles recorded in the Occupant Journals, 846 included this information.[11] Loads with a Mix of Fabric Thickness and Weights were the most common, representing 55% of all cycles (Table 11). Loads consisting of All/Mostly Heavy/Thick fabrics accounted for 22%, and those with All/Mostly Light and Medium Weights made up 23%. This distribution suggests that households often wash loads with a Mix of Fabric Thicknesses and Weights, with a relatively equal likelihood of washing loads that are either predominantly Heavy/Thick or Light/Medium.

**Table 11. Fabric thickness distribution (n=846 cycles)**

| Fabric Thickness | n | Percentage |
|---|---|---|
| All/Mostly Heavy and Thick | 186 | 22% |
| Mix of Thicknesses and Weights | 462 | 55% |
| All/Mostly Light and Medium Weights | 198 | 23% |

### *4.6.4 Washer Load Sizes (Weights)*

Next, Evergreen Economics considered the distribution of textile types in the three weight bins: Small (0–6.29 lb), Medium (6.3–10.59 lb), and Large (10.6+ lb). The analysis includes 863 washer cycles recorded in the Occupant Journals. These cycles contained recorded information on both the Dirty Dry-load Weight (the weight of the load going into the washer) and the category of textile type: All Cotton, Mix of Cotton and Synthetic, or Mostly Synthetic. Those cycles with one or more of these attributes missing from the journal were omitted from these results. Results are unweighted.

Nearly all the Mostly Synthetic loads tended to be lighter, with 73% falling in the Small weight bin (Table 12). All Cotton loads were equally likely to be Small (40%) or Medium (40%), and less likely to be Large (20%). Loads of laundry consisting of a Mix of Cotton and Synthetic fabrics were most frequently Medium (50%), followed by Small (29%), and then Large (21%). This distribution suggests that synthetic fabrics are generally washed in smaller loads, while mixed fabrics are predominantly washed in medium-sized loads. Larger loads appear to be used less frequently, regardless of textile type.

[11] Again, those cycles without that information were omitted from the analysis and the results are unweighted.

**Table 12. Load textile type distribution by Dirty Dry-load Weight (n=863 cycles)**

| Weight (lb) | # All Cotton | % All Cotton | # Mix Cotton Synthetic | % Mix Cotton Synthetic | # Mostly Synthetic | % Mostly Synthetic | # All Textile Types | % All Textile types |
|---|---|---|---|---|---|---|---|---|
| Small 0–6.29 | 96 | 40% | 168 | 29% | 32 | 73% | 296 | 34% |
| Medium 6.3–10.59 | 96 | 40% | 290 | 50% | 11 | 25% | 397 | **46%** |
| Large 10.6+ | 49 | 20% | 120 | 21% | 1 | 2% | 170 | 20% |

### *4.6.5 Washer Load Remaining Moisture Content (RMC)*

Evergreen analyzed the remaining moisture content (RMC) of wash loads, investigating how various settings (spin speed and wash program), textile type, and washer axis affect RMC.[12]

This analysis is based on the LEC dataset, the Occupant Journals, and the calculated RMC. For cycles to be included in this analysis, the Occupant Journals needed to have relatively complete washer and dryer cycle information, including:

- Wet-load Weight
- Clean Dry-load Weight (from the dryer)
- And at least one attribute of interest: washer spin speed setting, washer program setting, or textile type

The number of cycles where Occupant Journals recorded both the load weight and one attribute of interest varies by attribute. The number of loads that could be included for each analysis is provided in the discussion below. The RMC results are also matched with the LEC dataset to examine RMC by the washer axis type: vertical (top load) and horizontal (front load). Finally, some attributes—certain washer programs and the low spin speed setting—were excluded entirely from this analysis because there were relatively few cycles to analyze. All results in this section are unweighted.

#### Washer RMC Distribution by Program Setting

Figure 8 shows the RMC distribution for loads from 251 cycles in 35 washers using different washer program settings: Normal (n=183), Bulky (including Bedding, n=21), Heavy (n=20), Quick (n=16), and Delicates (n=11). The vertical axis represents the RMC (expressed as a percentage), with all RMCs above 100% grouped together. RMC values near or above one indicate relatively high amounts of water remaining in the loads, and values closer to zero indicate relatively low amounts of water remaining in the loads. The horizontal axis is the number of occurrences within each spin speed setting. The black vertical line indicates the average (mean) RMC for each spin speed.

[12] Details on RMC calculations are found in Section 3.7.

The cycles represented in Figure 8 include cycles comprised of all textile types, load sizes, and spin speed variations allowed within each dryer program. The Normal setting has the lowest RMC (46% on average) and is also the most common setting. Loads using the Heavy or Delicate settings tend to have higher RMCs (65% and 63% respectively) while Bulky (56%) and Quick (55%) have similar average RMC but high variation.

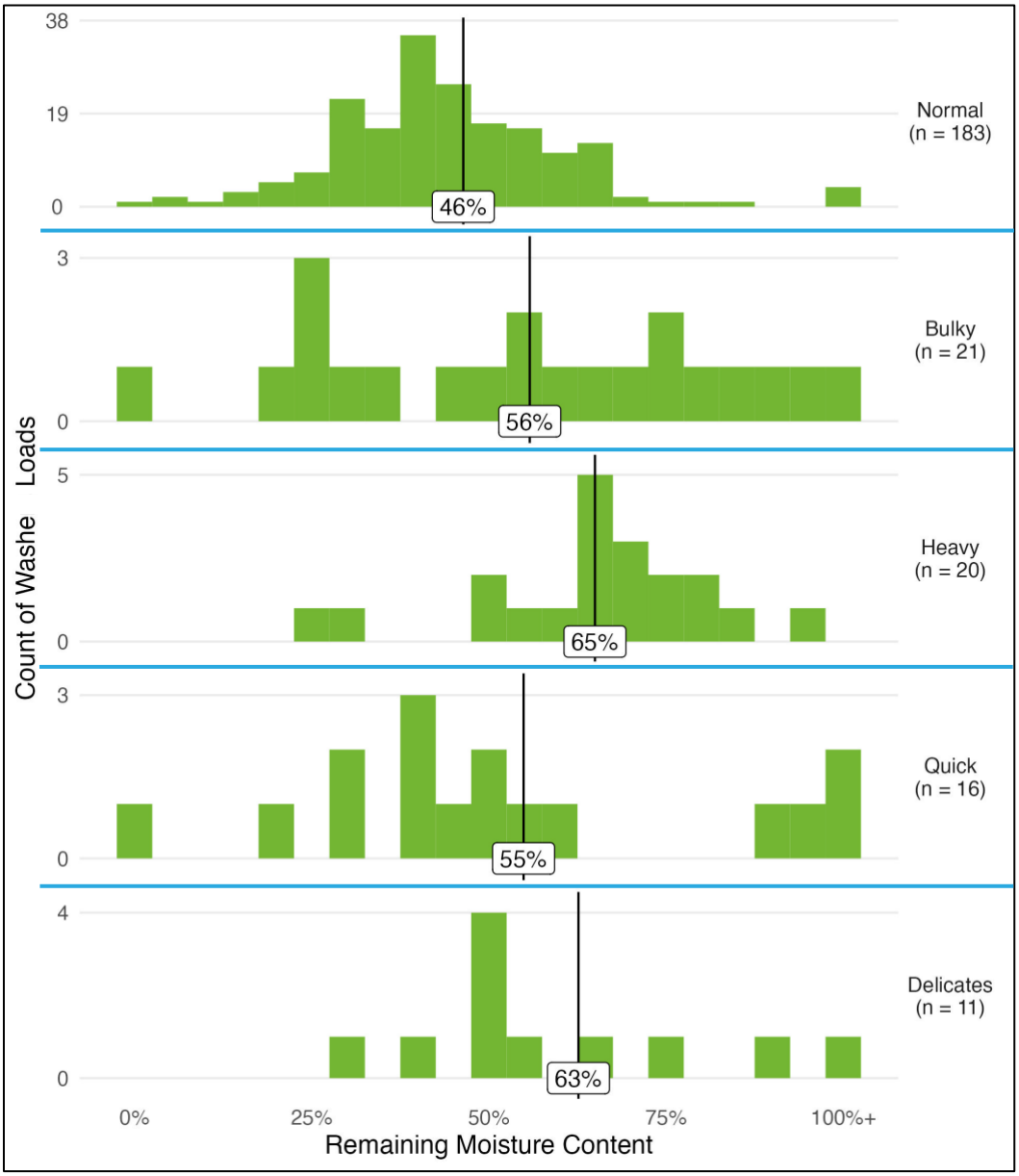


**Figure 8. RMC distribution by washer program setting (loads from 251 cycles in 35 washers)**

Figure 9 shows the distribution of washer RMCs for 251 cycles across three different spin speed settings: Extra High (n=51 cycles), High (n=130), and Medium (n=70). Low spin speed was excluded since it was used infrequently and did not have enough cycles to include in this analysis. As

expected, when a High spin speed is used, RMC tends to be lower (44% RMC on average for Extra High spin and 48% RMC for High) than when a Medium spin speed is used (57% RMC); however, these distributions show variations.

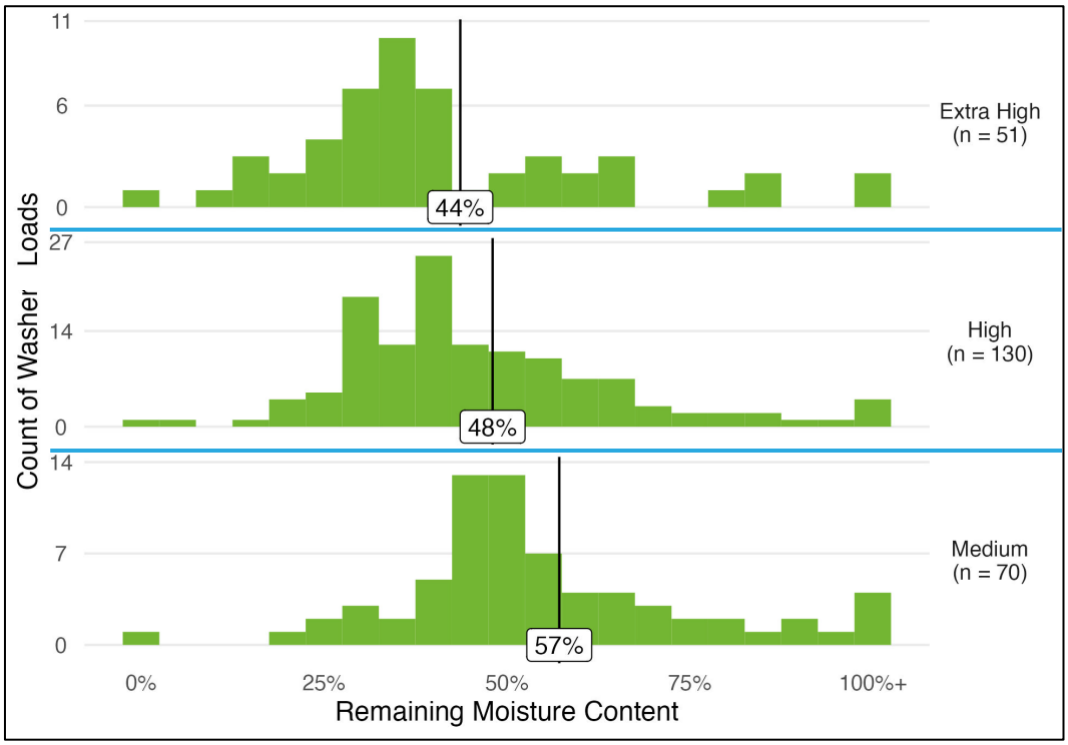


**Figure 9. RMC distribution by spin speed setting (loads from 251 cycles in 33 washers)**

Figure 10 shows the distribution of RMC from 306 cycles for three different load textile types: All Cotton (n=93), Mix of Cotton and Synthetic (n=188), and Nearly All Synthetic (n=25). Generally, loads that are Nearly All Synthetic have low RMCs (36% on average) with limited variation, while All Cotton loads have higher RMCs (60%) with more variation. Unsurprisingly, loads that contain a Mix of Cotton and Synthetic fabrics are between these extremes (49% RMC).

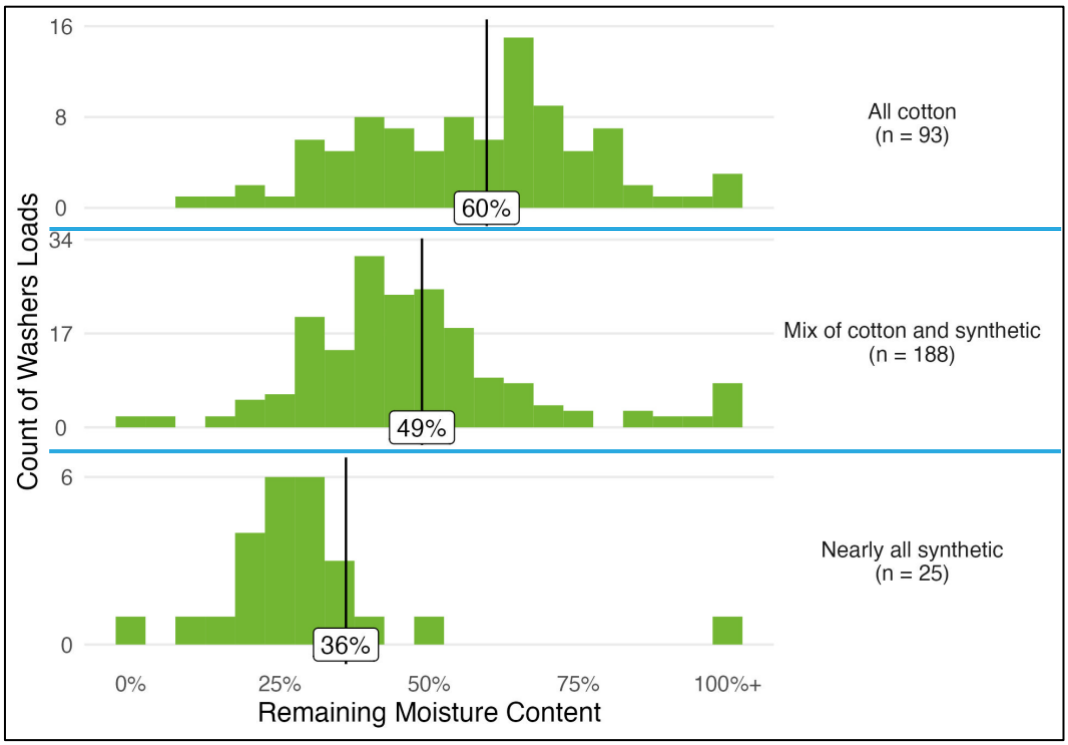


**Figure 10. RMC distribution by textile type (loads from 306 cycles in 38 washers)**

Figure 11 shows the distribution of the RMCs of 319 loads for the two different washer types: front load washers (n=156 loads from 18 washers) and top load washers (n=163 loads from 20 washers). The overall field average RMC for all clothes washers was about 51%. On average, front load washers have a lower RMC (48%) than top load washers (54%), though high variation is present. Note that lab-tested RMCs would be slightly higher than these field RMCs because the Bone-dry Load Weights (as defined by Appendix D2 in CFR 2025a) are slightly lighter than the Clean Dry-load Weights used for these calculations. See Section 3.7 for more information.

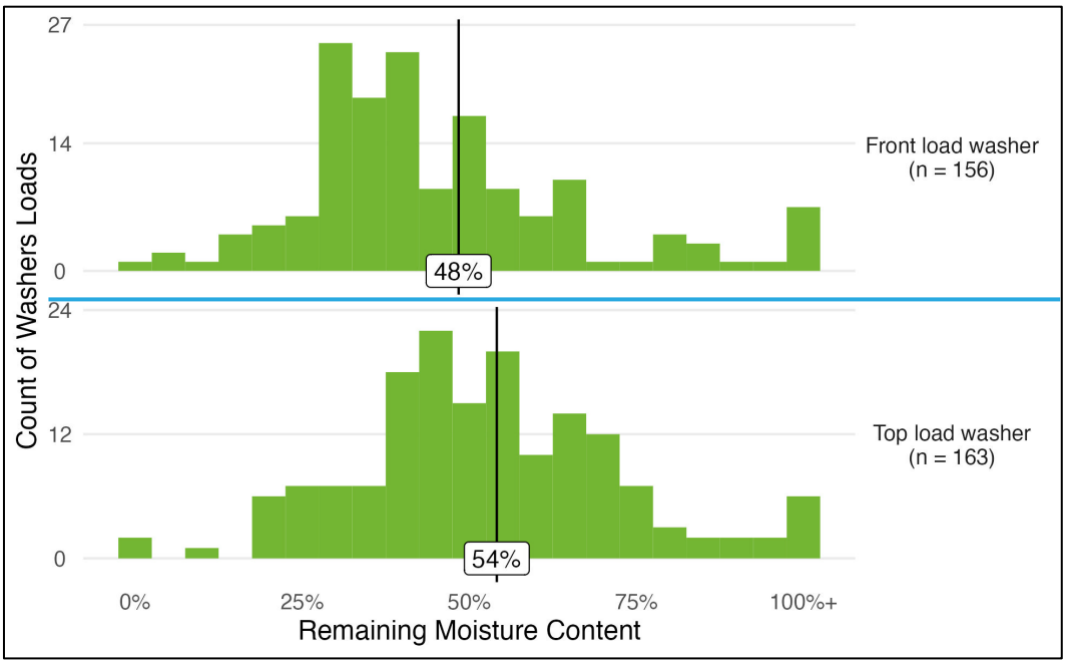


**Figure 11. RMC distribution by washer axis (loads from 319 cycles in 38 washers)**

### *4.6.6 Washer Cycle Time and Energy Use Relationship*

Evergreen analyzed the relationship between cycle time and total energy usage to gain a better understanding of how washers use energy. For consistency with other analyses in the report, this analysis is based on the LEC dataset and the VOJM dataset. The results included 448 cycles from 40 washers. To ensure accuracy, approximately 80 cycles were excluded due to uncertainties regarding the end times of the washer cycles.

Figure 12 shows the relationship between washer cycle time and energy usage, with the vertical axis representing energy usage in kWh and the horizontal axis representing cycle time in minutes. The blue line represents the trend line, indicating a weak positive correlation (adjusted R-squared value of 0.304) between cycle time and energy usage.

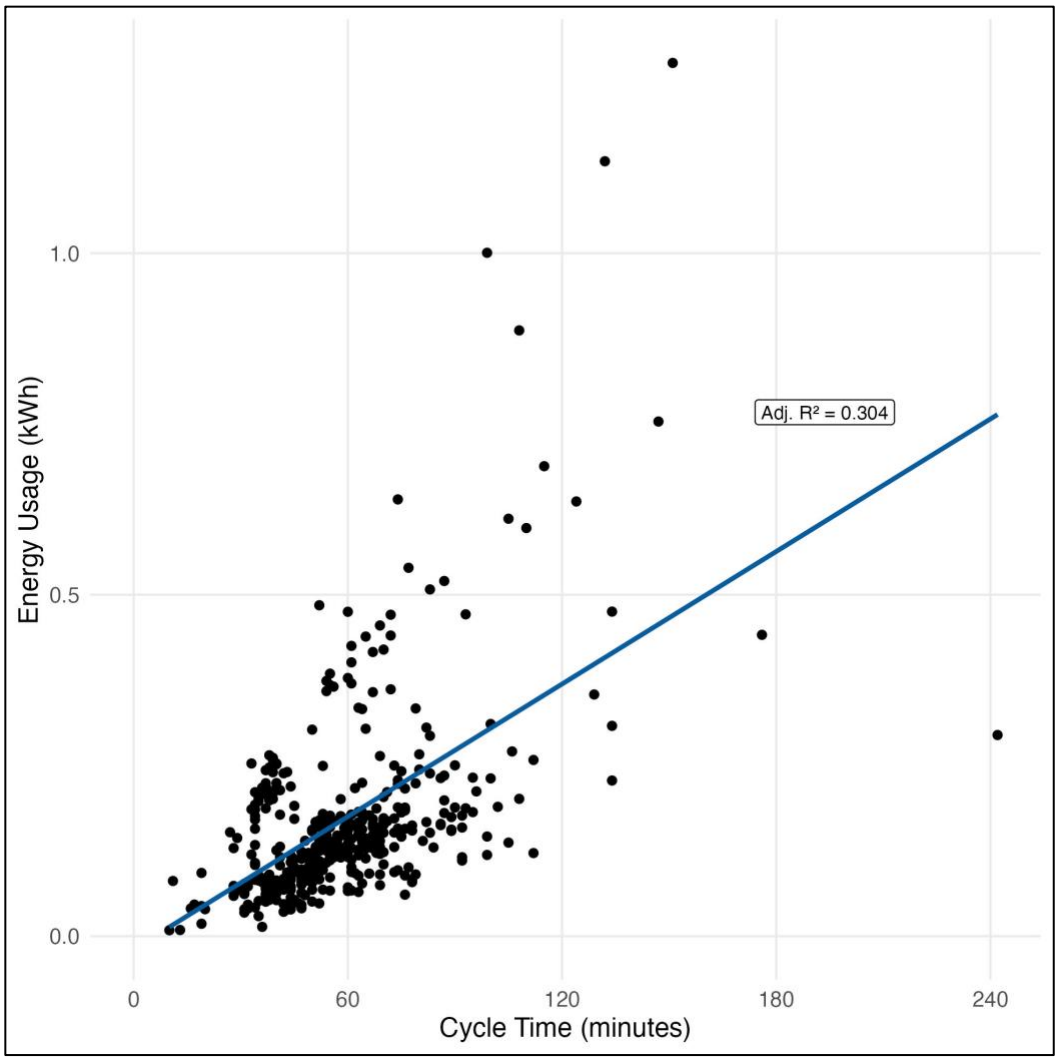


**Figure 12. Washer cycle time and energy usage relationship (n=448 cycles from 40 washers)**

Figure 13 shows the relationship between washer cycle time and energy usage with two trend lines: the light blue line for top load washers and the dark blue line for front load washers. Both indicate a positive correlation between cycle time and energy usage. While there may be a linear relationship between energy use and cycle times for both types of washers, drawing broader conclusions is difficult given the variation observed in washer cycle time and washer energy usage (the top load adjusted R-squared: 0.115, front load R-squared: 0.382).

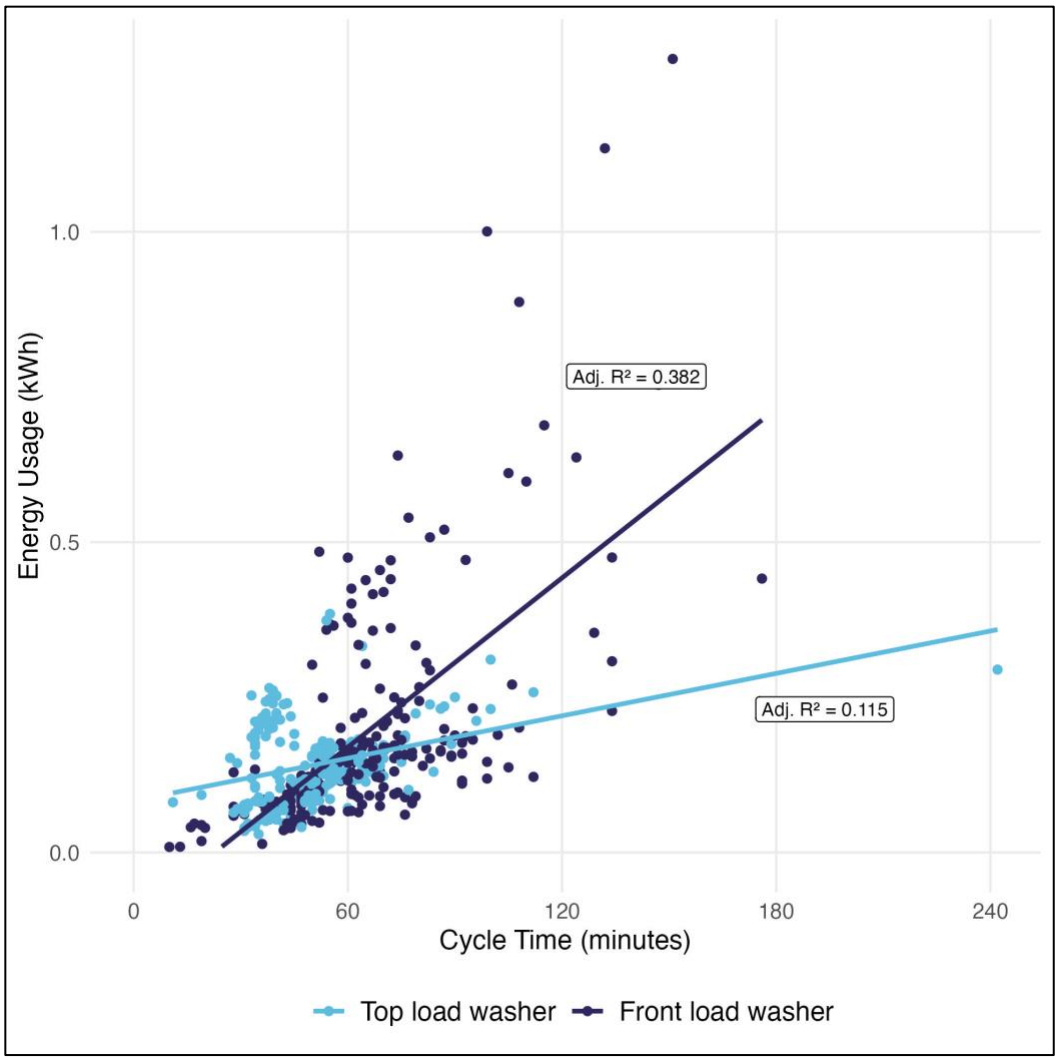


**Figure 13. Washer cycle time and energy usage relationship by axis type (n=448 cycles from 40 washers)**

## 4.7 Time Lapse Between Washer Cycle End and Dryer Cycle Start

NEEA's interest in the typical time between the end of a washer cycle and the start of a dryer cycle stems from a new technology opportunity: combined heat pump washer dryer units ("all-in-one" washer dryers) that eliminate the time gap for consumers while saving significant energy during the drying cycle (due to the heat pump drying system).

This analysis is based on Metered Data combined with Occupant Journals. The Metered Data provided the estimated time at which the washer stopped running, which was not recorded in the Occupant Journal. This includes a total of 447 washer and dryer cycles from 41 households. Approximately 80 cycles in the dataset were excluded because reliable start or end times could not be established.

Data revealed that the median time between the end of a washer cycle and the start of a dryer cycle is 28 minutes. Figure 14 shows the distribution of time intervals in the dataset. The most common time interval is 0–15 minutes, accounting for 34% of all cycles. Additionally, 69% of wash loads are transferred within the first hour, indicating that a significant number of households wash and dry loads in a timely, consecutive manner. However, the distribution also shows that one-third of wash loads remained in the washer significantly longer before being transferred to the dryer, with 22% waiting more than 1.5 hours.

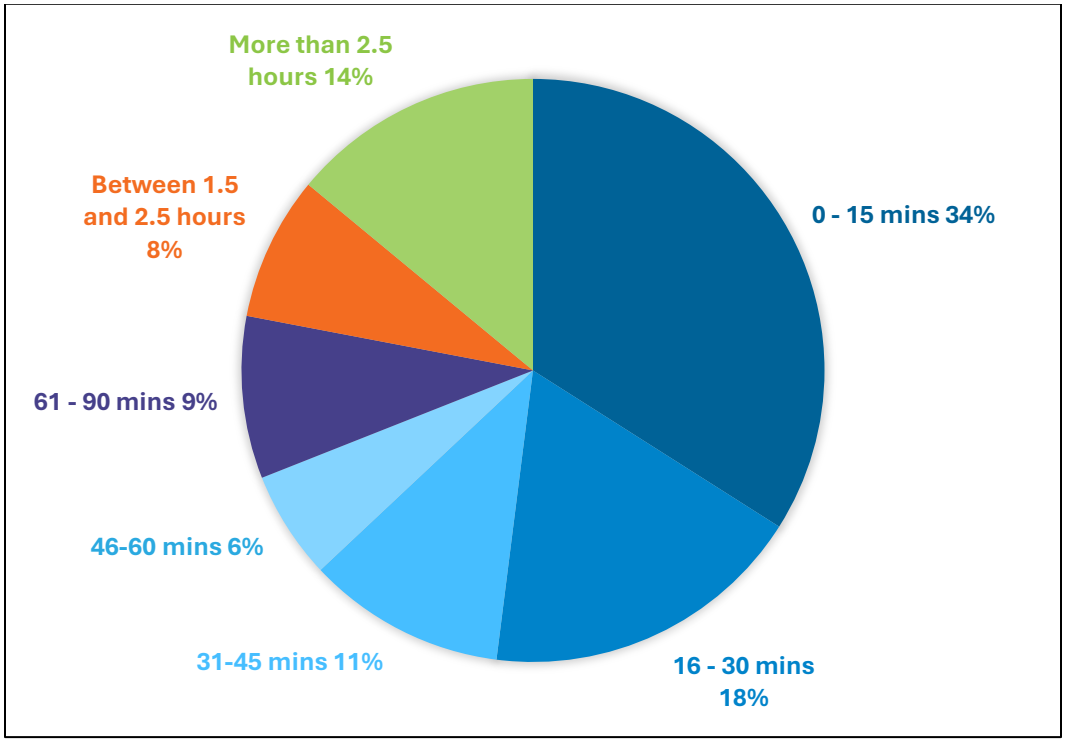


**Figure 14. Time-lapses between washer end and dryer start for all cycles (n=447 cycles from 41 households)**

## 4.8 Clothes Dryer Results

### *4.8.1 Dryer Program and Eco Mode Settings*

The clothes dryer program setting analysis of the OBEC data is based on the LEC dataset and the Occupant Journals. Participants recorded settings for 837 of the 912 dryer cycles, including program settings and cycle modifiers such as Eco mode. This analysis omits those cycles where dryer program settings were not recorded. Additionally, the four dryers with an unknown ENERGY STAR qualification (as shown in Table 8) were identified as Non-qualified and included in the Non-qualified group. In total, results from 60 dryers were available. The results are unweighted.

Figure 15 summarizes the program settings (both ENERGY STAR and Non- qualified) used in this dataset. Participants used a Timed dryer setting approximately one-third of the time, and the remaining two-thirds of the cycles were operated using an Automatic Termination program. Normal constituted the most common Automatic Termination program (40% of all cycles). Heavy Duty, Delicates, and Bedding tied for the second most common, representing 5% of all cycles for each. All other Automatic Termination programs were each less than 5% of all cycles.

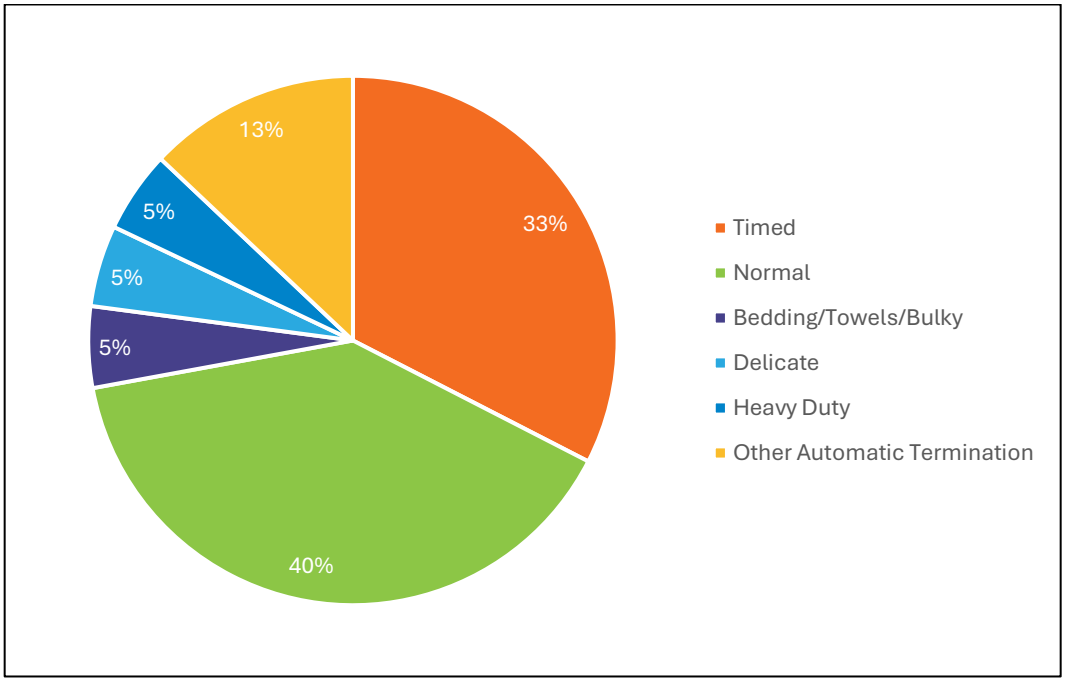


**Figure 15. Dryer program settings for all cycles (n=837 cycles)**

### Non-qualified and ENERGY STAR Dryer Program Settings

Setting selections on ENERGY STAR and Non-qualified dryers were compared to assess consumer behavioral differences in program selection between these two dryer types. As shown in Figure 16, Timed Dry is a much more common program with Non-qualified dryers (40% of cycles for Non-qualified, but only 12% of cycles for ENERGY STAR models). The most common Automatic Termination program for both types of dryers is Normal.

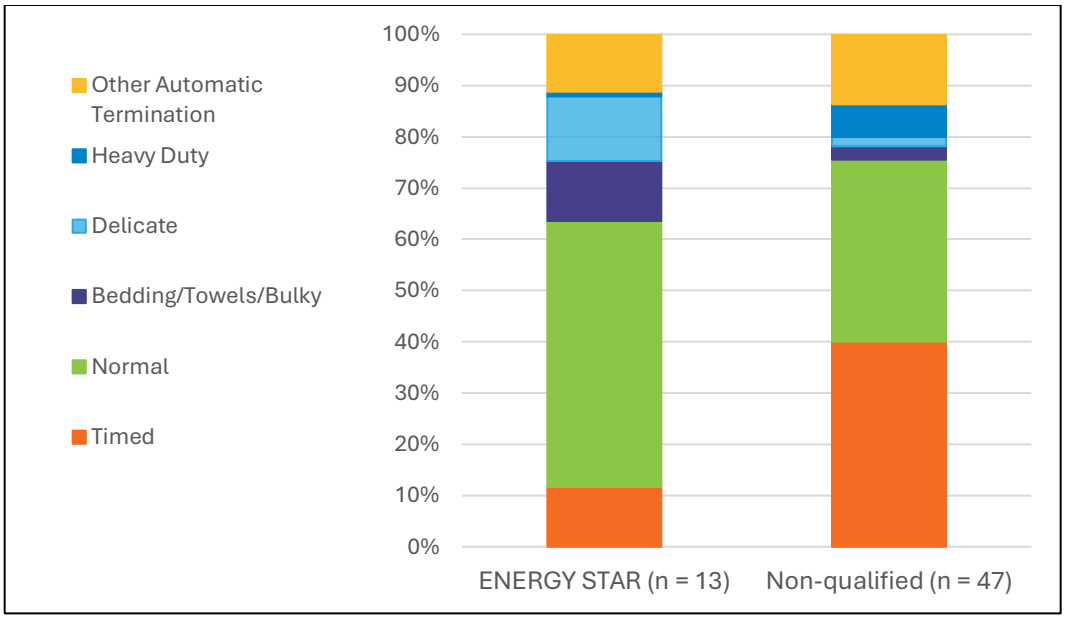


**Figure 16. Program setting comparison of ENERGY STAR and Non-qualified dryers**

Heavy Duty is more commonly used with Non-qualified dryers, while Delicate is used more in ENERGY STAR dryers. Specific percentages are shown in Table 13.

**Table 13. Dryer Timed and Automatic Termination settings summary (n=60 dryers)**

| Dryer Program Type | Program Setting | All Dryers (n= 837 cycles) | ENERGY STAR (n= 13 dryers and 214 cycles) | Non-qualified (n=47 dryers and 623 cycles) |
|---|---|---|---|---|
| **Timed Dry** | **All Timed Dry** | **33%** | **12%** | **40%** |
| **Automatic Termination** | **All Auto Termination** | **67%** | **88%** | **60%** |
| | Normal | 40% | 52% | 36% |
| | Heavy Duty | 5% | 1% | 6% |
| | Bedding/Towels/Bulky | 5% | 12% | 3% |
| | Delicate | 5% | 13% | 2% |
| | Other | 13% | 11% | 14% |
| | **Total/Overall** | **100%** | **100%** | **100%** |

*Notes:* Due to independent rounding, some sums may not be 100%.

### ENERGY STAR Dryer Eco Mode Modifier Setting

This ENERGY STAR Dryer Eco mode modifier analysis of OBEC data utilizes a combination of LEC dataset and the Occupant Journals. One hundred eighty-nine Automatic Termination cycles from 13 ENERGY STAR dryers were analyzed to determine consumer use patterns of Eco mode modifiers. The prevalence of Eco mode in Timed Dry cycles was excluded from this analysis. Given this, the Eco mode results in this discussion only apply to 13 ENERGY STAR dryers with Automatic Termination programs (88% of the cycles shown above in Table 13).

The LEC dataset revealed that most of the 13 ENERGY STAR dryers in the sample have an Eco mode cycle modifier available (Table 14). Of the nine conventional ENERGY STAR dryers in the sample, eight had an Eco mode cycle modifier. Three of the four heat pump ENERGY STAR dryers also had an Eco mode cycle modifier. Eco mode was not used during Automatic Termination programs 50% of the time for all ENERGY STAR dryers in the sample (n=13). For those ENERGY STAR dryers that had Eco mode available (n=11), it was turned off 35% of the time during Automatic Termination programs (Table 14).

**Table 14. Prevalence of Eco mode use in Automatic Termination programs of ENERGY STAR dryers (conventional vs. heat pump)**

| Dryer Type | Eco mode not used (% of all cycles) for all dryers (n=13) | Eco mode option available? | Eco mode not used (% of all cycles) with dryers that have Eco mode available (n=10) |
|---|---|---|---|
| ENERGY STAR conventional dryers | 53% | 7 of 9 models | 40% |
| ENERGY STAR heat pump / hybrid heat pump | 43% | 3 of 4 models* | 24% |
| Total ENERGY STAR dryers | 50% | 10 of 13 models | 35% |

*Three manufacturers are represented in these heat pump models.

Table 15 examines Eco mode use by program cycle for all 13 ENERGY STAR dryers (those with and without Eco mode available). In half of the Automatic Termination cycles (50% of those cycles), consumers do not operate ENERGY STAR dryers with the Eco mode cycle modifier engaged. In the Normal and Delicate programs, Eco mode was not used approximately half of the time, and in the Bedding/Towels/Bulky program, it was not used 72% of the time. For all other programs, Eco mode was not used 60% of the time.

**Table 15. Eco mode prevalence for ENERGY STAR dryers (n=13) and (n=189 cycles)**

| Program Cycle | Overall share of all Automatic Termination program use, excluding Timed Dry (% of total cycles) | ENERGY STAR dryers Eco mode not used (% of cycles of that program) |
|---|---|---|
| Normal | 66% | 47% |
| Bedding/Towels/Bulky | 19% | 72% |
| Delicate | 8% | 50% |
| Other | 7% | 60% |
| Total/Overall | **100%** | **50%** |

Settings for dryness level and heat setting (temperature) were collected but not included in the analysis for this report.

### *4.8.2 Dryer Load Weights*

The analysis of the weights of dryer loads leverages the Occupant Journal and LEC dataset. Eight hundred twenty-four of the 912 Occupant Journal cycles included measured Clean Dry-load Weights. Those cycles that did not have Clean Dry-load Weights recorded were excluded. Furthermore, program cycle setting information was essential for analyzing load size by program setting. For the purposes of this analysis, four dryers with unknown ENERGY STAR qualification (as shown in Table 8) were identified and included as Non- qualified.

Table 16 shows that for all dryer cycles (both Timed and Automatic Termination), 45% of the dryer loads were Medium in size with a weight similar to DOE's test method load size of 8.45 lb (Appendix D2 in CFR 2025a). In comparison, 40% of all dryer cycles had Small loads (0 to 6.29 lb) and 16% had Large loads (greater than 10.6 lb). ENERGY STAR dryers in this sample tended to have smaller load sizes than the average overall (45% of ENERGY STAR loads were 0 to 6.29 lb). Table 17 provides load sizes for three common Automatic Termination programs for both ENERGY STAR and Non-qualified dryers, with the most common load size for each dryer program cycle in bold font. Notably, the Small load size (0 to 6.29 lb) is the most frequent for some commonly used programs, including Normal, Bedding/Towels/Bulky, and Delicate.

**Table 16. Load size for ENERGY STAR and Non-qualified dryers (n=60 dryers)**

| All Dryer Cycles | Load Size (dry weight in lb) | All Dryers (n=60) % of cycles (n=824 loads) | ENERGY STAR (n=13) % of cycles (n=200 loads) | Non-qualified (n=47) % of cycles (n=624 loads) |
|---|---|---|---|---|
| Timed and Automatic Termination | Small (0–6.29) | 37% | **46%** | 35% |
| | Medium (6.3–10.59) | **45%** | 42% | **46%** |
| | Large (10.6+) | 18% | 11% | 20% |

*Note:* Values may not add up to 100% because of independent rounding.

**Table 17. Load size for three common Automatic Termination programs for ENERGY STAR and Non-qualified dryers (n=60 dryers)**

| | Program | Load Size | All Dryers (n=60 dryers) % of cycles | ENERGY STAR (n=13 dryers) % of cycles | Non-qualified (n=47 dryers) % of cycles |
|---|---|---|---|---|---|
| Automatic Termination | Normal | Small | **40%** | **45%** | **38%** |
| | | Medium | 36% | 40% | 35% |
| | | Large | 23% | 14% | 26% |
| | Bedding/ Towels/Bulky | Small | **57%** | **53%** | **58%** |
| | | Medium | 26% | 35% | 23% |
| | | Large | 17% | 11% | 19% |
| | Delicate | Small | **88%** | **61%** | **95%** |
| | | Medium | 12% | 39% | 5% |
| | | Large | 0% | 0% | 0% |

*Note:* Values may not add up to 100% because of independent rounding.

### *4.8.3 Dryer Energy Efficiency*

Evergreen calculated clothes dryer energy efficiency (lb of dry textiles per kWh) using the VOJM dataset. The LEC dataset was leveraged to compare Non-qualified and ENERGY STAR dryers to one another. This analysis excluded cycles from heat pump and natural gas dryers, as well as other dryer cycles with insufficient energy usage and load weight data. In total, 456 cycles were analyzed, and the results are unweighted. Results in Table 18 show that ENERGY STAR dryers are more efficient than Non-qualified dryers (higher efficiency is better).[13]

**Table 18. Average annual efficiency for ENERGY STAR dryers vs. Non-qualified**

| Group | Number of Households | Efficiency (lb dry textiles per kWh) |
|---|---|---|
| Overall | 42* | 3.45 |
| ENERGY STAR | 8 | 3.76 |
| Non-qualified | 34 | 3.36 |

*One Non-qualified dryer was excluded from this analysis because the participant did not provide Clean-dry Weights.

### *4.8.4 Dryer Cycle Time and Energy Use Relationship*

Evergreen analyzed the relationship between cycle time and total cycle energy use for dryers, based on the LEC and VOJM datasets (VOJM to ensure consistency with other analyses in this report). The results included 524 cycles from 46 dryers. One dryer was excluded because it had insufficient data for this analysis.

Figure 17 shows the relationship between dryer cycle time (horizontal axis) and energy usage (vertical axis). The points and trendlines have been colored by the type of dryer represented: ENERGY STAR heat pump dryers (ES Heat Pump), other ENERGY STAR dryers (ENERGY STAR), and Non-qualified dryers. On average, Non-qualified dryers used more energy than ENERGY STAR dryers with the same cycle time, and ENERGY STAR heat pump dryers used even less energy. While all three dryer types have a linear relationship between energy use and cycle times, the R-squared values show considerable variation (Non-qualified adjusted R-squared: 0.328, ENERGY STAR: 0.533, ENERGY STAR Heat Pump: 0.661), indicating that additional factors contribute to the relationship.

Based on this analysis, 63% of all dryer cycles are completed within 60 minutes. For ENERGY STAR dryers, 57% complete within 60 minutes, and for ENERGY STAR heat pump dryers, 53% complete within 60 minutes.[14] A slightly higher share of dryer cycles in Non-qualified dryers complete within 60 minutes (65%).

[13] Evergreen calculated the average efficiency for heat pump dryers separately due to the small sample size of these dryers in the study and found an average efficiency of 5.23 (lb of dry textiles per kWh).
[14] Because three of the four ENERGY STAR heat pump dryers are compact (less than 4.4 cu ft drum volume), many of the loads are likely to be smaller and therefore dried faster.

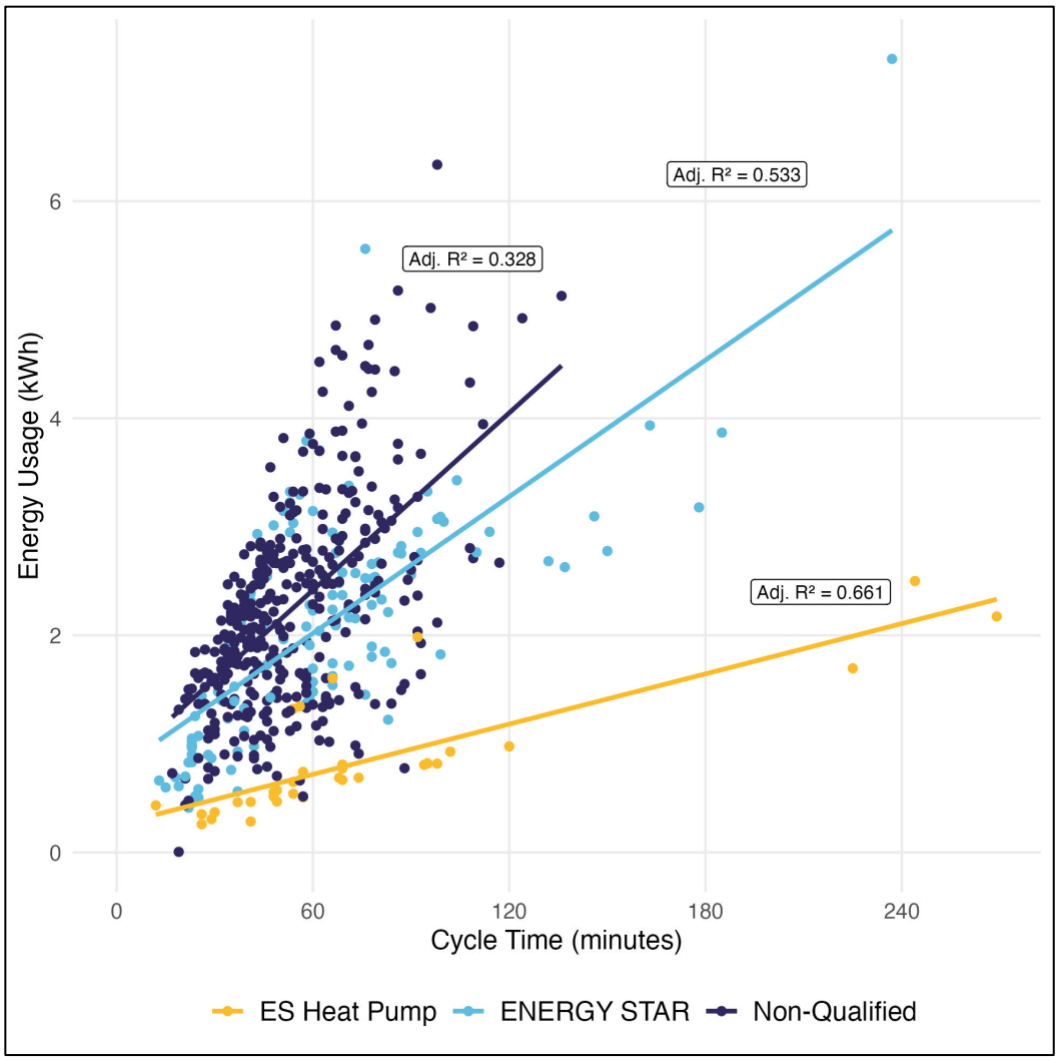


**Figure 17. Relationship of dryer cycle time and energy usage by ENERGY STAR qualification (n=524 cycles from 46 dryers)**

# 5 Annual Cycles and Energy Use Methodologies (EULR)

## 5.1 Overview

NEEA staff analyzed End-Use Load Research (EULR) data of 363 homes to calculate the annual number of cycles for dryers as well as the annual energy use of dryers. This dataset was used because:

- The data included all four seasons of the year,
- Findings were available for a full year (no extrapolation was needed), and
- The larger sample size enabled better statistical information for resulting confidence in the data.

The EULR dataset is distinctive from and does not overlap with the OBEC dataset discussed in other parts of this report.

## 5.2 EULR Annual Dryer Cycle and Electricity Use Calculations

NEEA considered whether EULR data could be used to estimate the number of washer and dryer cycles and the annual dryer electricity use. Because it was difficult to count cycles and energy use from a clothes washer circuit—which sometimes includes other end-use loads—NEEA was unable to count washer cycles. Furthermore, the EULR instrumentation could not determine the hot water use of the clothes washers, which is an important contributor to clothes washer energy use. Therefore, no EULR results on clothes washer annual cycles or energy use are detailed herein. However, the EULR data did facilitate identification of dryer cycle counts and dryer annual energy use, which is discussed next.

### *5.2.1 EULR Electric Dryer Sample*

NEEA started with 363 EULR sites with electric dryers metered at the home's panel.[15] 115 sites (about 32 percent) were eliminated because they did not yet have a full calendar year of data (January 1 to December 31). A full calendar year of data ensured that seasonal variation was included in dryer cycle counts and annual energy use. An additional 10 sites (3% of the original 363 sites, 4% of the remaining sites) were not appropriate to include in the analysis for various reasons:

- Energy use characteristics indicated they were highly unlikely to be dryers.
    - Standby power was greater than 10 W, as this is a relatively high value for dryer standby.
    - Median cycle power was less than 200 W because it takes approximately 250 W to tumble the drum and power the fan even if a consumer does not regularly use the heating element.[16]
- Two dryers were in one household. Given the methodology employed to scale based on household size, these households were excluded.

The 238 sites that remained were 63 percent urban and 37 percent rural. NEEA used classifications defined by the National Center for Education Statistics (NCES 2025) and grouped them into urban and rural categories consistent with NEEA's recently published Northwest Market Characterization Study (Diercksen et al. 2025, pp 2–5). The urban categories were city-large, city-midsize, city-small, suburb-large, suburb-midsize, and suburb-small. The rural categories were rural-fringe, rural-distant, rural-remote, town-fringe, town-distant, and town-remote.

[15] Because the EULR sites included too few gas dryers to draw broader conclusions, this dataset contains only electric dryers. Findings are extrapolated to gas dryers in Section 5.3.

[16] Some consumers air fluff textiles (with no heating element) to soften rack- or line-dried textiles. One dryer with lower median power of 180 W was included in the sample (an exception to this rule), as it was verified as a lower-power compact model.

### *5.2.2 Dryer Cycle Count Methodology*

NEEA developed and applied a dryer cycle count algorithm to the time series dryer data of the remaining 238 sites. The algorithm had the following characteristics:

- It identified a dryer cycle as anytime that the dryer was continuously above 20 Watts for a period longer than 5 minutes.
- If a dryer's power was less than 20 W for two minutes or more, that was considered the end of a cycle.
- To avoid the inclusion of intermittent tumbling as partial cycles (sometimes used to release wrinkles at the end of a cycle), the dryer had to exceed 20 W for 5 minutes or more to count as a cycle. Any period with 20 W or more that was shorter than 5 minutes was not considered a cycle.
- Partial cycles were defined as 5 to 20 minutes in length; full cycles were longer than 20 minutes. The full cycle designation is intended to be comparable to the U.S. DOE definition of a dryer cycle found in the Appendix D2 test procedure (CFR 2025a). Partial cycles are likely used to refresh loads or provide additional drying beyond a normal 8.45 lb load drying cycle.

This algorithm provided the cycle count, the average dryer power (in Watts) during cycle, and other parameters that helped NEEA to validate the algorithm's output. Although this cycle count methodology includes only electric dryers, NEEA assumes that the annual average number of cycles of electric dryers and gas dryers is the same.

### *5.2.3 Annual Energy Use Methodology*

To calculate the annual energy use of the electric dryers, NEEA added total energy use during the year for the dryer in each household. These summations were validated by the product of the cycle count and average power per cycle provided by the cycle count algorithm. Due to standby power, the summation of annual energy was just slightly higher than the energy used during the cycles alone (as calculated by the algorithm).

Finally, to enable comparison to the prior NEEA field research field study, NEEA calculated straight averages of data (unweighted based on household size) before developing weighted average annual cycles and annual energy use, discussed next.

### *5.2.4 Joining Demographic Variables*

To scale this information to the Northwest and US, NEEA used household size, as NEEA's statistical analysis revealed it was the strongest indicator of differences in the number of cycles and energy use. The NEEA team found average cycle counts by household size and then scaled them to the Northwest using the percentages shown in Table 19 below. This table shows sample household counts by household size in comparison to the distribution of household size in the Northwest and US based on U.S. Census Bureau data. Because household size information was not available in all cases, 224 total households are used for the calculations weighted by household size.

**Table 19. Household size distribution for EULR sample vs. Northwest and US distributions**

| | EULR Sample Data | | U.S. Census Data | |
|---|---|---|---|---|
| **Household Size** | EULR # of Sites | EULR Sample Distribution | Northwest Population Distribution | US Population Distribution |
| **1-person** | 31 | 14% | 28% | 29% |
| **2-person** | 98 | 44% | 37% | 35% |
| **3-person** | 33 | 15% | 15% | 15% |
| **4+ person** | 62 | 28% | 21% | 21% |
| **Unknown*** | 14 | NA | NA | NA |

*Source:* U.S. Census Bureau 2024 *Some sites do not have information on the number of people in the household and are therefore excluded from this part of the analysis.

NEEA also examined dryer cycles and energy use of rural and urban areas of the sample. To ensure results were not principally driven by household size, NEEA calculated the average household size of urban and rural households. The average urban household size of 2.75 people was nearly identical to the average rural household size of 2.76 people.

### *Confidence Interval Methodology*

Following are brief definitions of the statistics used for the EULR analysis in the next sections. These statistical measures are helpful to understand how precisely we know the values calculated, and they include random variation in the sample. Statistics for the average number of annual full dryer cycles from Table 21 (following) are used as an example:

**Table 20. Confidence interval methodology definitions and example**

| Statistic | Definition | Table 21 example |
|---|---|---|
| **Average** | Arithmetic mean | **332** cycles |
| **Margin of error** | The amount of uncertainty in the mean, both above and below the mean value, indicating the extent to which results may differ from the true value.<br>Calculating the margin of error requires knowledge of the sample size, distribution of the data for a particular metric, and the confidence level chosen. | **±16** cycles |
| **Confidence interval** | The range of values—determined by adding and subtracting the margin of error from the sample mean—into which the true mean is likely to belong. | **316 to 348** cycles |
| **Confidence level** | The likelihood that a confidence interval contains the true value of a population parameter. The higher the confidence level, the greater the certainty that the true value is within the confidence interval. | **80 percent*** |
| **Weighted Average** | An average value that is weighted by another population parameter to better represent the population. For this report, all weighted averages are based on household size (Table 19). | **307** cycles |

*This is the confidence level used throughout Sections 5 and 6 of this report.

So one can assume that if similar samples were to be collected many times from the same overall dataset, the average number of annual full dryer cycles would range between **316 and 348** in **80 percent** of those cases. (The other 20 percent of the time, the average cycles would fall outside this range.)

The study team chose an 80 percent confidence level rather than the more typical 95 percent confidence level due to the small sample size of the study and to align with the level used in the 2012 NEEA field laundry study (Hannas and Gilman 2014).

The team attempted to remove known sources of error, but not all error is accounted for in the statistical calculations. Sources of error that could shift all the data and therefore may not be considered by the statistical methods employed include:

- A somewhat arbitrary choice to define a full cycle as 20 minutes or longer, and partial cycles as shorter than 20 minutes.
- Energy meter drift in one direction, higher or lower.
- Changes to household size over the period. While we assume some households' sizes increased and others decreased over the metering period, it is not possible to confirm that these changes were random in the sample.

## 5.3 Natural Gas Annual Dryer Energy Use Methodology and Calculations

Kanah Consulting used the results generated by methodologies described in Section 5.2 to estimate gas dryer energy use in the Northwest and the US. Calculation assumptions included:

- The average number of cycles per year for gas and electric dryers are the same.
- The site energy use of gas is approximately 1.13 times that of conventional electric dryers (DOE 2011).[17]
- Nine percent of all gas dryer energy use is electricity and 91 percent of gas dryer energy use is gas.[18]

[17] Natural gas dryers use more site energy than electric dryers. NEEA estimated the increase in site energy for gas dryers using the current mandatory standards levels for electric and gas dryers (DOE 2011). The DOE-required efficiency level for standard-sized gas dryers is a combined energy factor (CEF) of 3.30. Standard-sized electric dryer CEF is 3.73. Dividing 3.73 CEF by 3.3 CEF enables a conversion of energy use from electric dryers to gas dryers and yields a ratio of 1.13.

[18] The mean electrical power during an electric dryer cycle (as calculated by the algorithm described in Section 5.2.2) is 2.44 kW. The electrical requirement for controls, fan, and tumbling in a gas or electric dryer is about 250 W (EPA 2011). Comparing these two values enables NEEA to estimate that 10 percent of the total energy of an electric dryer is for electrical controls, fan, and tumbling. The percentage of site energy use of a gas dryer for electrical controls, fan, and tumbling is slightly lower than 10 percent of the total energy because gas dryers use slightly more site energy for the heater.

# 6 Northwest and US Annual Cycles and Energy Use Estimates (EULR)

## 6.1 Overview

This section reviews the results for annual cycles of washers and dryers and dryer annual energy use. EULR clothes dryer results for both the Northwest and US are presented. For the reasons described in Section 5.2, the EULR data do not include washer cycle count results.

## 6.2 Annual Dryer Cycles and Energy Use

### *6.2.1 Annual Number of Electric Dryer Cycles for the Northwest and US*

Results on the average number of dryer cycles in the Northwest and US in this section are based on measured cycle frequency of electric dryers in the sample. As noted in Section 4.8.3, all gas dryers are excluded from this analysis. NEEA assumes that the frequency of usage of electric and gas dryers is the same, and so the results in this section are applicable to both electric and gas dryers.

**EULR Data – Annual Number of Dryer Cycles for the NW and US (Unweighted and Weighted by Household Size)**

Using the EULR data, NEEA calculated first an unweighted average of the 238 households included in the sample as described in Section 5.3. These unweighted results are shown in the top (blue) row of Table 21. As described earlier in the Confidence Interval Methodology, annual full dryer cycles average 332 with a margin of error of ±16 cycles at an 80 percent confidence level. This means that if NEEA were to replicate the data collection many times, the actual number of annual full dryer cycles would range between 316 and 348 in 80 percent of those instances. This is about one cycle every 1.1 days.

Then, NEEA weighted the EULR sample by household size for the Northwest and the US. Using this methodology, homes had an average of 307 full dryer cycles per year for both the Northwest and the US, or roughly one cycle every 1.2 days (Table 21). Overall results (green rows) are weighted while detailed demographic information is unweighted. Partial and total cycles are also not statistically significantly different for the Northwest and the US. The number of full, partial, and total cycles generally increase with household size, but not all of these increases are statistically significant.

NEEA also examined laundry use pattern differences in rural and urban areas. The full, partial, and total cycles for urban and rural areas are statistically indistinguishable from one another. Rural and urban household sizes are not weighted for household size, and so are slightly higher than the EULR household size weighted average of 307 cycles per year.

**Table 21. EULR annual dryer cycles overall for the Northwest and US (weighted) and by demographic attribute (unweighted)**

| Demographic Attribute | Number of Households in Sample | Average # Annual Dryer Cycles (Full) | Average # Annual Dryer Cycles (Partial) | Average Total Annual Dryer Cycles (Full + Partial) |
|---|---|---|---|---|
| **NW Unweighted Overall** | n=238 | 332±16 | 74±15 | 406±23 |
| **NW Weighted Overall** (weighted based on household size) | n=224 | 307±15 | 60±12 | 367±21 |
| **US Weighted Overall** (weighted based on household size) | n=224 | 307±15 | 59±12 | 366±21 |
| **1-person household** | n=31 | *210*±25 | *41*±13 | *251*±28 |
| **2-person household** | n=98 | *287*±20 | *71*±11 | *358*±25 |
| **3-person household** | n=33 | *311*±28 | *63*±17 | *374*±38 |
| **4+ person household** | n=62 | *470*±39 | *64*±15 | *533*±47 |
| **Rural** (Avg household size 2.76) | n=150 | *329*±26 | *62*±11 | *391*±33 |
| **Urban** (Avg household size 2.75) | n=88 | *334*±21 | *81*±22 | *415*±30 |

*Notes:* All uncertainty values are provided at the 80 percent confidence level.

The margins of error are affected by the distribution of the data and the number of households in the sample. The percentage error shown for partial cycles is higher than the full cycles due to the greater variability in the number of partial cycles among households (many households have hardly any partial cycles while a substantial portion of other households have many partial cycles).

Rural and urban household sizes are not weighted for household size, and so are slightly higher than the EULR household size weighted average. These unweighted values agree well with the unweighted averages (top blue row) in this table.

### *6.2.2 EULR Average Annual Electric Dryer Energy Use in the Northwest and US*

**EULR Data – Average Annual Electric Dryer Energy Use for the NW and US (Unweighted and Weighted by Household Size)**

Using the EULR data, NEEA calculated first an unweighted average of the 238 households included in the sample as described in Section 5.3. All uncertainty values are provided at the 80 percent confidence level. Using a straight average, NEEA calculated 761±36 kWh per year.

EULR results reveal that, based on weighting by household size, electric dryers use an average 694±34 kWh per year in the Northwest and 692±34 kWh per year in the US. The overall results (green rows) in Table 22 are weighted, while energy usages corresponding to different demographic characteristics are unweighted. The energy use increases with household size. The energy uses for urban and rural areas are statistically indistinguishable.

**Table 22. EULR average annual electric dryer energy use overall for the Northwest and US (weighted) and by demographic attribute (unweighted)**

| Demographic Attribute | Number of Households in the Sample | Average Annual Dryer Energy Use (kWh) |
|---|---|---|
| **EULR Overall NW** (weighted based on household size) | n=224 | 694±34 |
| **EULR Overall US** (weighted based on household size) | n=224 | 692±34 |
| 1-person household | n=31 | *430*±51 |
| 2-person household | n=98 | *641*±47 |
| 3-person household | n=33 | *726*±68 |
| 4+ person household | n=62 | *1116*±74 |
| **Rural** (Avg household size 2.76) | n=150 | *752*±63 |
| **Urban** (Avg household size 2.75) | n=88 | *766*±44 |

### *6.2.3 Natural Gas Dryer Annual Cycles and Energy Use in the Northwest and US*

NEEA assumes the annual number of cycles for electric and gas dryers is the same. Using the annual energy methodology described in Section 5.3, NEEA estimates that a single natural gas dryer uses on average 24.3±1.2 Therms in the Northwest and US. Electricity use of gas dryers is 71.0±3.5 kWh per year in the Northwest and 70.8±3.5 kWh per year in the US (Table 23).

**Table 23. Average annual natural gas dryer energy use overall for the Northwest and US (weighted)**

| EULR Overall Estimate of Natural Gas Dryer Energy Use (weighted based on household size) | Average Annual Dryer Energy Use (Therms) | Average Annual Dryer Energy Use (kWh) |
|---|---|---|
| Northwest | 24.3±1.2 | 71.0±3.5 |
| US | 24.3±1.2 | 70.8±3.5 |

### *6.2.4 Summary - Annual Number of Dryer Cycles and Annual Dryer Energy Use*

Figure 18 and Figure 19 summarize the annual number of full dryer cycles and annual dryer energy use by region, household size, and urban vs. rural, based on EULR data. Note that the left-hand regional quantities (shown in green) are weighted by household size, and the remaining demographic values (shown in blue) are unweighted values. Gas dryer usage is shown in Table 23 above.

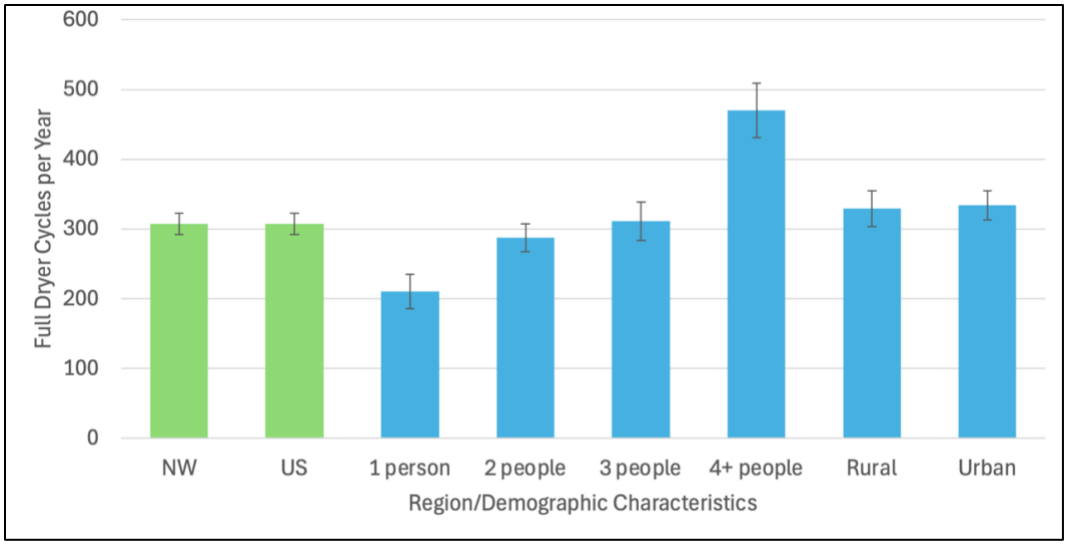


**Figure 18. EULR full dryer annual cycles—weighted averages by region and unweighted demographic averages**

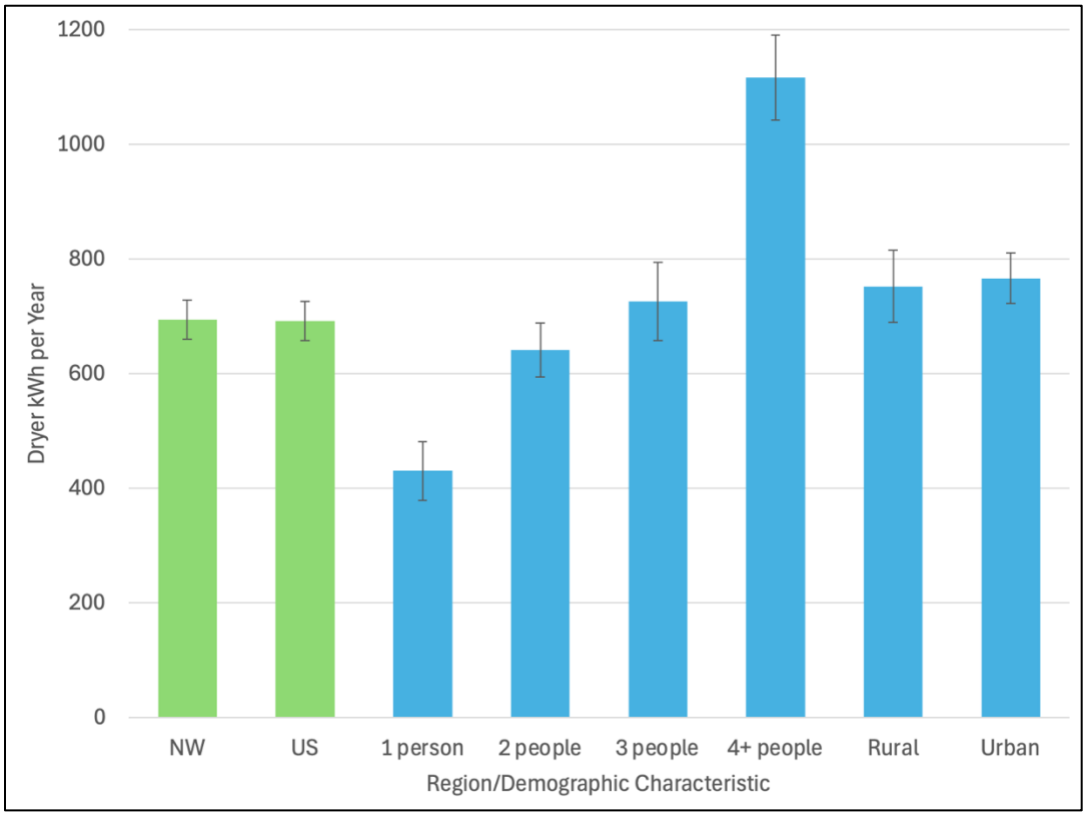


**Figure 19. EULR electric dryer annual energy use—weighted averages by region and unweighted demographic averages**

## 6.3 Dryer Annual Cycles and Energy Use Discussion

NEEA compared its EULR annual cycle and energy use findings to the DOE values used in the test procedures and standards analysis for dryers. The DOE annual cycle numbers are based on data from the U.S. Energy Information Administration (EIA) Residential Energy Consumption Survey (RECS). The EIA uses a questionnaire to ask consumers information about a variety of energy attributes of their household, including use patterns of laundry equipment. The energy use values shown are the maximum allowed energy use for a dryer based on the efficiency standard effective in that year and the number of cycles performed per year as recorded in the relevant RECS.

Figure 20 considers these DOE quantities against the NEEA field research values from 2012 and 2023 (this study). The values are in chronological order from left to right. The study team expects the annual cycles and energy use values in NEEA's field research (in 2012 and in this study) to be higher than the comparable DOE values for a few reasons:

- The dryer vintage in the field is always older than the new dryers sold. Only new dryers are impacted by the required energy standard. Older dryers are likely to use more energy due to less-developed washer and dryer technology. The efficiency of equipment (both washer and dryer) also degrades over time with wear and tear.
- The reported number of cycles in RECS estimates the amount of laundry washed and dried in a household but uses a survey format that relies on human memory and estimation. Consumers completing a survey may overlook additional dryer cycles they may run to refresh or further dry laundry, seeing them as a single cycle or load. In contrast, the measured number of cycles in the field research is based on metered data over a full year. Note that the number of cycles shown in Figure 20 is the number of full (not partial) cycles most comparable to the RECS question and the Appendix D2 test procedure (CFR 2025a).

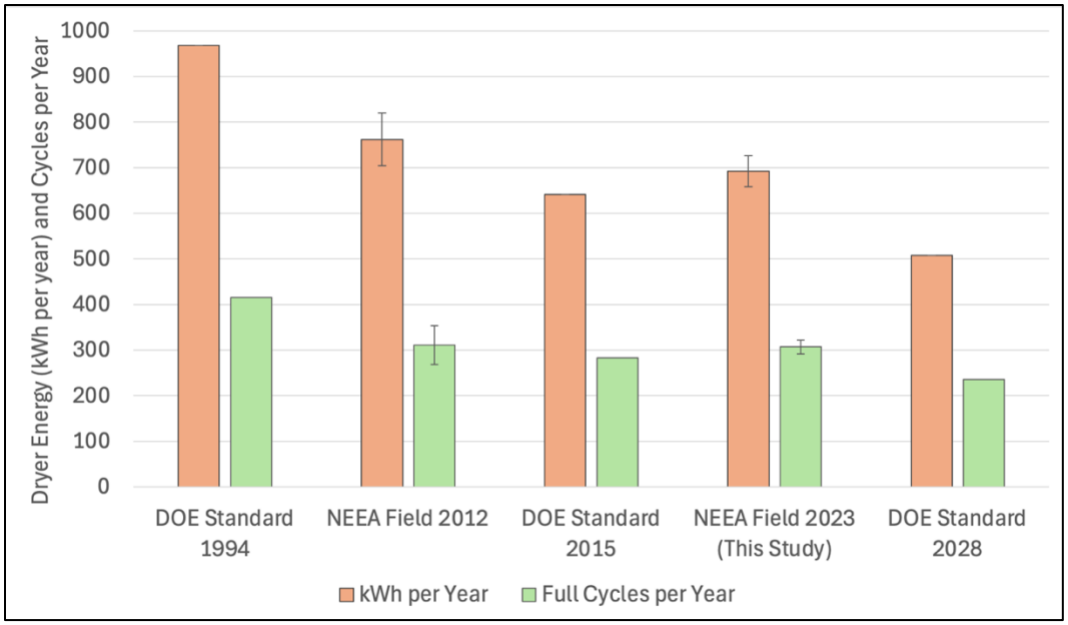


**Figure 20. Comparison of EULR NEEA field study results to DOE values of dryer annual energy use and cycle time**

*Notes:* 1. The year of the standard shown is the date that the standard took effect. Unless otherwise noted below, cycles per year are weighted by household size.

2. For the analysis of the standard that took effect in 1994, DOE estimated 416 cycles per year and a 7.0 lb test load (DOE 2008). The energy factor (EF) was 3.01 (DOE 2025c), yielding 967 kWh per year.

3. The energy use and cycle count for all dryer vintages in the 2012 NEEA field study are from Hannas and Gilman 2014. The cycle count is 311 ±42 (p 13) and the energy use is 762 ±58 kWh (p 41). This study did not weight dryer cycle counts nor energy use by household size.

4. For the 2015 standard, DOE estimated 283 cycles per year (DOE 2021, p 83), an 8.45 lb load (CFR 2023, p 113C), and an EF of 3.73 (CFR 2023, p 845), yielding 641 kWh per year.

5. For this study, we used the US weighted average dryer cycles and energy use by household size (Table 19). The cycle count is 307 ±15 (Table 21) and the energy use is 692 ±34 kWh (Table 22).

6. For the forthcoming 2028 dryer standard, DOE estimated 236 cycles per year (DOE 2021, p 14), an 8.45 lb load, and a combined energy factor (CEF) of 3.93 (DOE 2024a, p 9), yielding 507 kWh per year.

Figure 21 shows the dryer energy use per cycle of the DOE standards and the NEEA field research, again in chronological order. The dryer energy use per cycle has decreased only 8% over the last 30 years of standards. Two observations about laundry equipment technology may help explain this:

- Conventional clothes dryer efficiency has improved only slightly over the last 30 years. The introduction of the heat pump in the last decade could deliver substantial energy savings, but the small sales volume of heat pump dryers means the national average energy use of dryers is not yet impacted by this technology.
- The moisture content of the load has gone down over time as clothes washers have improved their capacity to spin more water out of a load before it goes in the dryer. The DOE test procedure reflects this in its testing. The initial moisture content of the load[19] started at 70 percent when the dryer test procedure was first developed in 1977, but is now specified at 57.5 percent. This reduced amount of water the dryer has to evaporate means less energy use, even as the technology and its efficiency stay relatively static.

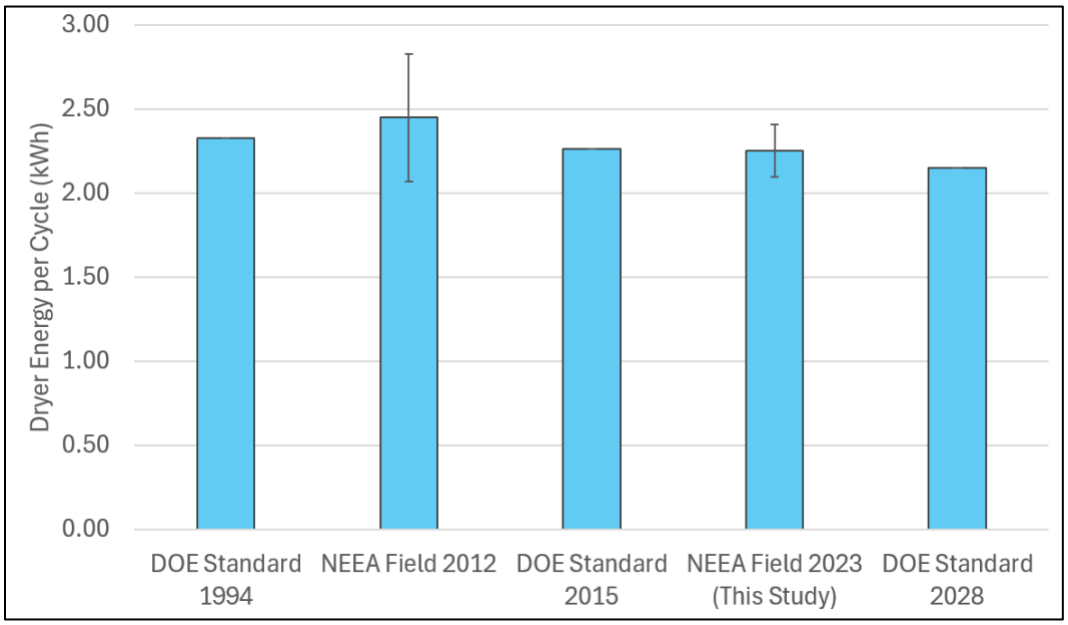


**Figure 21. Comparison of EULR NEEA field study results to DOE values of dryer cycle energy use**

[19] Defined as the total weight of water in the load divided by the bone-dry weight of the textiles alone.

# 7 Summary and Conclusions

## 7.1 OBEC Summary and Conclusions

NEEA's Occupant Behavior and Equipment Characteristics (OBEC) dataset for laundry equipment in the Northwest revealed the following findings for clothes washers and dryers:

**Washer and dryer program settings:**

- **Normal is the most common clothes washer program consumers use (66% of cycles).** Quick Wash, Heavy Duty, Bedding/Towels/Bulky, and Delicates are other common programs, each used in 7-10% of all cycles. ENERGY STAR washers use Quick Wash more often and Normal less often than Non-qualified washers. Heavy Duty is more commonly employed in Non- qualified washers. (Section 4.6.1)
- **Clothes dryer Automatic Termination programs are more common than Timed Dry (67% of cycles).** Consumer use of Automatic Termination was more common with ENERGY STAR dryers (88% of cycles) than with Non- qualified dryers (60% of cycles). (Section 4.8.1)
- **Normal is the most common Automatic Termination program for clothes dryers (40% of all cycles).** Heavy Duty, Bedding/Towels/Bulky, and Delicate were other common programs, each used about 5% of the time. (Section 4.8.1)
- **For all ENERGY STAR dryers with an Eco mode cycle modifier available, Eco mode is turned off 35% of the time.** Eco mode is not used 50% of the time for all ENERGY STAR dryers (with and without Eco mode as an option). (Section 4.8.1)

**Washer and dryer load size:**

- **Almost half of washer and dryer loads are between 6.3 and 10.6 lb (the Medium load represents about 45% of all cycles).** Small loads (less than 6.3 lb) are the second most common load size, accounting for approximately 35% of cycles. Small load sizes (less than 6.3 lb) appear more common for ENERGY STAR dryers (46% of all ENERGY STAR dryer cycles) than for Non-qualified (35% of all Non-qualified dryer cycles). Large loads (10.6 lb+) are the least common for both washers and dryers, accounting for approximately 19% of cycles. (Sections 0 and 4.8.2)

**Load textile types:**

- **Consumers often wash loads with the Cotton-Synthetic Mix of fabrics (67% of cycles).** Loads with All Cotton comprise most of the remaining cycles (28%), while Mostly Synthetic loads comprise only 5% of all cycles. (Section 0)
- **Most washer loads are a mix of fabric thicknesses and weights (55% of cycles).** Loads with Mostly Heavy fabrics or Mostly Light and Medium fabrics comprise the rest of the cycles (about 22% each). (Section 0)

**At the end of the wash cycle:**

- **The remaining moisture content (RMC) of the clothes washer load varied by program, spin speed, textile type, and washer axis type (front and top load).** Nearly All Synthetic textiles had the lowest average RMC (36%). The Heavy and Delicate programs, along with the loads of All Cotton textiles, had the highest average RMCs (60 to 65% RMC). The average RMC for all clothes washer loads was 51%.[20] (Section 4.6.5)
- **Most loads are transferred from the washer to the dryer within one hour of the end of the washer cycle (69% of cycles).** However, about one-third of all wash loads sit for longer than an hour, and 14% sit for longer than two and a half hours before they are transferred to the dryer. (Section 4.7)

**Clothes dryer efficiency:**

- **Calculations of dryer efficiency revealed that heat pump ENERGY STAR dryers were the highest efficiency, followed by ENERGY STAR conventional dryers.** Non-qualified dryers were the least efficient. (Section 4.8.3)

**Cycle time and energy use:**

- The analysis revealed a relatively weak relationship between cycle time and energy use for both clothes washers and dryers. (Sections 4.6.6 and 4.8.4)

## 7.2 Annual Cycles and Energy Use Summary and Conclusions (EULR)

NEEA's EULR research on the household size weighted average annual cycles of dryers and the household size weighted average annual energy use of dryers in the Northwest revealed the following findings:

- The measured annual number of full dryer cycles is 307±15. Consumers ran an additional 60±12 partial loads every year as well.
- The number of dryer cycles per year and annual energy use are statistically similar for the Northwest and the US.
- The annual energy use of an electric dryer is 694±34 kWh in the Northwest and 692±34 in the US. A gas dryer uses 24.3±1.2 Therms in the Northwest and US. Electricity use of gas dryers is 71.0±3.5 kWh per year in the Northwest and 70.8±3.5 kWh per year in the US.
- An electric dryer's energy use per cycle has decreased only 8% over the last 30 years of standards.

[20] Lab tested RMCs would be slightly higher because Bone-dry Load Weights measured in the lab are lighter than the Clean Dry-load Weights used for these calculations. See Section 3.7.

## 7.3 Recommended Additional Research

Evergreen, with support from Driftless Energy, collected a significant amount of OBEC data for clothes washers and dryers. Not all collected data are analyzed in this report. Future analysis opportunities for the OBEC dataset include:

### For both washers and dryers:

- **Characterizing the cycle length for washers and dryers,** including the range, mean, median, and distribution. Understanding the acceptable norm for cycle length could be helpful to support market transformation toward more efficient technologies, some of which may have longer cycle times.
- **Considering seasonal difference in laundry equipment use.** While this study considered full year periods to normalize for seasonal differences in laundry use, no existing research has yet determined the statistical significance of seasonal differences in laundry use. Future analysis of EULR data could examine whether statistically significant differences in laundry equipment energy use by season can be observed.

### For clothes washers:

- **Understanding the clothes washer temperature, spin speed, and fill level settings.** These additional attributes of the clothes washer settings could help inform NEEA's efforts in future DOE rulemakings and ENERGY STAR comments.
- **Quantifying the energy used to heat clothes washer water in the household water heater.** The collected data included gallons of hot and cold water, which could be analyzed to quantify the water volumes and estimate the energy use associated with heating hot water, and then compared to the US test procedure for washers.

### For clothes dryers:

- **Developing consumer usage profiles for clothes dryer temperature settings** (High, Medium, Low, Air Only/Off).
- **Examining the relationship between clothes dryer efficiency (combined energy factor or CEF) and clothes washer remaining moisture content (RMC).** The washer RMC's impact on the dryer's efficiency is well-understood. Further exploring this relationship could reveal the relative importance of improving RMC in the washer's and the dryer's efficiency.
  **Considering dryer efficiency (CEF) variation with different textile types and fabric thicknesses.** Exploring how CEF changes with varying fabric thicknesses could serve as a comparison point to the DOE test procedure, Appendix D2 (CFR 2025a).
- **Investigating dryer efficiency (CEF) with different dryness level settings.** The dryness level setting is expected to impact the efficiency of a dryer (i.e., the weight of the water divided by the Bone-dry Load Weight). Understanding how dryness level in the field affects efficiency could help inform the development of dryer test procedures.

# 8 References

Notable efforts by NEEA include seminal research into test procedures, field research on laundry equipment, extensive lab and field studies of heat pump clothes dryers, investigations of residential laundry washer-dryer pairs and combos, and multiple comment letters to DOE on test procedures and efficiency standards for residential and commercial washers and dryers. The list of references below includes all report citations, as well as other relevant publications and comment letters.

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# APPENDIX A: OBEC FIELD EQUIPMENT INSTALLATION AND DATA COLLECTION METHODOLOGY

The equipment and process used by Driftwood Energy field engineers to collect monitored OBEC data for Evergreen Economics is described below.

### Prepare and Install a Monitoring Box

Hard plastic, lockable cases were prepared to safely store monitoring equipment, allowing for the recording and relaying of sensor and meter data. All penetrations to the case were made prior to being on site. Two penetrations were made to accommodate:

- One 240 V power cord for electric dryers
- One 110 V power cord to power the metering equipment and the clothes washers and/or gas dryer equipment
- One 110 V plug to power the clothes washer and/or gas dryer
- One 240 V plug to power electric dryers
- One communication port to connect to the Sensor Hub

Monitoring equipment encased and locked in the Monitoring Box included:

- **The eGauge Pro**, monitored all power measurements in the study (via wired current transducers (CTs) enclosed within the Monitoring Box) and acquired data from the flow and thermal sensors. Data were routed through the Sensor Hub and connected to the eGauge via CAT-5 cable through the communication port.
- **Current Transducers (CTs).** Four 50-amp CTs were located in the Monitoring Box to monitor the power consumption of the washer and dryer. These CTs monitored the current of the 240 V and 110 V electric lines for the clothes washer and dryer.

### Install Sensors, Meters, and Wi-Fi Access

- **Sensor Board with Mounted Sensor Hub (ESH044).** The Sensor Hub, powered by a mini-USB to standard, 110 V wall outlet, transfers the data collected from:
    - **Two Flow Meters.** The hot- and cold-water lines were attached to pass-through flow meters to monitor water usage for each line.
    - **Temperature Probe Sensors.** Two were attached alongside the flow meters for the hot and cold water lines.
    - **Pulse Sensors.** Two were mounted next to the temperature probes to transfer the data from the flow meters to the Sensor Hub.
- **TP-Link Nano.** Connected to the Occupant's Internet directly with the router, then paired to provide Internet access to the eGauge for Amazon cloud data storage.