SEDI Field Research Protocol
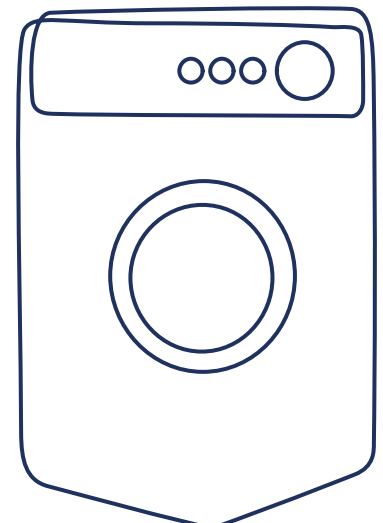
Version 1

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SEDI would like to thank NEEA for its support in preparing this field research protocol. Their initial work on clothes dryer field research lead to the experimental design co-developed with Ecotope and served as a model for the described protocol.

Contents

Introduction

Measuring clothes dryer energy consumption is a surprisingly complex task for several reasons:[1]

1. Clothes dryer performance is dependent upon the composition of the clothes being dried. This includes the weight, volume, fiber composition, physical structure and water content.

2. Clothes dryer performance is dependent upon the mechanical design of the dryer. This includes, but is not limited to, whether the dryer is vented, the insulation, the efficiency of the motor, the accuracy of auto termination, the source of the heat used to remove moisture (e.g. heat pump or electric resistance element), and how the dryer interacts with the home's HVAC system.

3. Clothes dryer performance is dependent upon user behavior. This includes the number of loads dried and the dryer setting used.

Due to the complexity of measuring clothes dryer energy consumption, comprehensive field test data is a critical part of the effort to introduce and promote energy efficient clothes dryers. Field test data will provide utilities, manufacturers, policy makers, and ultimately consumers with both estimates of clothes dryer energy performance and a better understanding of clothes dryer user behavior.

The purpose of this field test protocol is to standardize the data collection process in order to provide comparable data that is both complete in its descriptions and diverse in where and when it is collected. This endeavor will allow utilities to develop incentive programs based on accurate measurements of energy consumption and energy savings. It will give policy makers the information they need to develop improved test procedures that more accurately reflect real world energy usage, and new federal standards that capture greater energy savings. Finally, it will provide utilities and manufacturers a means to assess how washer/dryer pairs can achieve optimal energy savings while still meeting consumer expectations.

This field research protocol covers data acquisition for both domestic washers and dryers designed and sold for use in residences, but may be used for public laundromats and multifamily building laundry rooms, which use similar equipment. This field research protocol is not designed for use in commercial laundry facilities.

SEDI would like to thank the Northwest Energy Efficiency Alliance for its support in preparing this field research protocol. Their initial work on clothes dryer field research lead to the experimental design co-developed with Ecotope, and served as a model for the described protocol.

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[1] For more information on how energy consumption is affected by the composition of the clothing being dried, the mechanical design of the clothes dryer, and user behavior see Appendix G. The appendix also describes how the field test protocol captures these elements.

Background

When the SEDI initiative launched in 2009, very little data existed about clothes dryer energy performance and user behavior. Recent field research has shed some light but has also raised many new questions. There are still significant gaps in our understanding of dryer energy consumption in the field and of consumer usage patterns. With a new generation of energy efficient dryers entering the market, it is important to establish a field research protocol so that research results can be put to the best possible use..

SEDI has created this protocol so that its sponsors can benefit from consistent, high quality data when developing programs to support the purchase of energy efficient clothes dryers. By conducting complementary research at different locations across North America we will generate a robust database of clothes dryer energy performance which can provide insight into the effects of user behavior, climate, housing type, and other variables on estimated savings. This field research protocol is designed to help researchers meet their individual experimental objectives while contributing to our combined understanding of clothes dryer energy performance.

Case study: Northwest Energy Efficiency Alliance (NEEA) field research

In 2011, NEEA conducted a substantial field study of clothes dryer energy use in residential households. The study involved 50 single-family households located in the Pacific Northwest. Due to the relative scarcity of other recent field research into clothes dryer energy performance, the SEDI protocol is largely based on NEEA's field study. The following is a summary of the study:

> *The NEEA field study involved 50 single-family households with conventional washers and dryers that were no more than five years old. Research technicians installed digital data loggers on participants' washers and dryers, and distributed scales, baskets and paper logs to participants from January through March. Laundry data were collected over a four week period, though not the same four week period for each home. At the end of the four weeks technicians retrieved the data loggers and the participant's paper logs.*

> *This staggered approach to equipment distribution and data collection was a practical way to improve data quality and reduce risk by restricting the pool of field staff to known, skilled people. However, it also added some risk because over a longer installation period results from the first participants would be collected during a different season (and therefore under significantly different weather conditions) than the results collected from the last participants.*

> *NEEA's contractors estimated that the field time required to set up participants to for a small study to collect Critical data would be about 4.5 hours per site for the installation technician, including local travel time. Expected time on site for the return visit to collect meters was estimated to be about two hours per site for the installation technician including local travel time. Depending upon the data to be collected, and possibility local regulations, a licensed electrician may also be required.*

> *For their roles in the NEEA study participants were offered up-front incentives of $150 at the initial visit and an additional $150 for successfully logging their laundry use. Participants also received an instruction manual printed on water resistant paper that outlined the specific steps they were expected to follow to record the weights of their laundry and the dryer cycle settings they chose. Finally, participants were also given a magnet reminder to put on their clothes washer to help them remember to weigh and log their laundry. Ecotope recommends that a small digital clock for*

mounting on or near the dryer be included in the package so that participants can note the time of log entries.

SEDI recognizes that the scope and size of field research will be driven by sponsors' available budgets and objectives. While the NEEA field study was comprehensive it is still possible to collect equally valuable data on a smaller research budget by collaborating with other utilities. To help utilities, SEDI has outlined the most important data to collect.

Research Design

Objectives

The goal of this protocol is to provide utilities with information they need to support market development and ultimately standards setting for energy efficient clothes dryers. To that end, this test protocol seeks to answer the following questions:

1. How much energy does the dryer use?
2. What settings are used during operation
3. What clothing types are used?
4. How many cycles are used per year?
5. How many wash cycles are divided into multiple dry cycles?
6. What fraction of the clothing is dried using the dryer?
7. What are the product specifications and features?
8. How big is the household and what are their general demographics?

In addition to the above list, there are a range of questions a utility may consider adding to their research. These questions relate more to program delivery and cost effectiveness rather than performance:

1. How much did the dryer cost?
2. Where was it purchased?
3. How old was the dryer that was replaced?
4. How did the consumer choose the dryer setting?
5. How important is the dryer cycle time? What is an acceptable time?
6. How often is the vent cleaned?
7. How often is the lint trap cleaned?
8. What was the purchase criteria used?
9. What laundry is not put in the dryer?
10. How important is having a matched set (washer + dryer)?

Protocol Overview

The field test protocol provides guidance on research approach, participant selection, duration & timing, data collection, and data recording. In addition, the sections titled "Data Collection Guidance" and "Equipment Recommendations" provide additional guidance on what data should be collected and what equipment to use. Appendices A through E provide detail on the equipment used in the NEEA project, and the templates used for data collection. Finally, Appendix F provides a template for the uniform recording of data.

Research Approach

NEEA's successful approach combined professional equipment installation (electricity consumption data loggers) with participant involvement (weighing clothing and logging laundry data). SEDI has adopted the same research approach for the field test protocol, because it yielded an impressive 98% participant compliance rate despite the burden of data recording over the study period. Furthermore, the benefit of NEEA's approach to recording laundry water content is that it is both relatively cheap and highly effective. It would have been significantly more complicated and expensive if NEEA had devised an alternative approach to measuring laundry water content, without the involvement of participants.

Participant Selection

SEDI hopes to encourage clothes dryer field research in parts of North America with widely varying average daily temperature and humidity. NEEA's field study found a lot of variability in a relatively homogenous sample, which suggests the value of obtaining a mix of end user demographics. To obtain a sizable mix, utilities may want to work together in order to increase the total sample size. If enough utilities utilize this protocol we could in aggregate achieve a sample that more closely represents how dryers are actually used.

In addition to participant selection, it may be in the interest of researchers to select several different dryer models. Through coordination with SEDI a mixture of dryer makes and models will provide diversity. Collecting data on the participant, energy use, dryer settings and load measurements enable SEDI members to in aggregate consider the performance of a range of products and correct for minor variations in their local clothing mixture, ambient conditions, and user demographics.

Duration and Timing

The minimum recommended duration of a field test is to be roughly one month. More data would be useful, but perhaps will not significantly add to the understanding of how the dryer is used or how much energy it consumes. In addition, it may be difficult to maintain good participant compliance over a longer study period.

Energy performance of clothes dryers changes through the different seasons of the year as ambient conditions change and as laundry load composition changes. In an ideal world, the test protocol would be repeated at several different seasons to better understand this impact. It is more likely that the combination of many different field studies will eventually capture the impact of this variability on our understanding of dryer use and seasonal variations of consumer settings.

Data Collection

The complex interaction between machine, laundry, and user, makes it difficult to estimate dryer energy consumption simply by monitoring the energy consumption of a reasonably large sample of dryers over a reasonably long time period. Because so many factors can significantly influence a clothes dryer's energy performance, it is also necessary to gather data on the laundry, and on user behavior.[2]

This protocol defines what data should be collected based on the NEEA filed test study. The protocol also highlights the most important data that every dryer field test project should gather in order to generate a robust estimate of dryer energy performance. Finally "suggested additional data" includes a broader set of field test results including information from the clothes washer (to support total laundry energy consumption estimates) and information about the home to support estimates of a dryer's secondary effects on building HVAC. Studies that also collect suggested data will expand our knowledge of the dynamic interaction of clothes dryers with other household appliances.

Data Recording

The first step to effective data analysis is getting the data collected into a desired format and scrubbing the data for errors. It will be important for utilities to record data in a uniform format so that it can be

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[2] For more information on the complexity of measuring clothes dryer energy consumption see Appendix G.

easily aggregated for nationally representative data analysis. To support this outcome SEDI has provided a suggested uniform template for recording data. An example of the template is shown in Appendix G. A copy of the Microsoft Excel file template is available from SEDI.

The objective is to have each efficiency program or evaluator complete as much of the template as they can. The second step is to generate the various energy use summaries, histograms and tables that characterize how the dryers are used. NEEA's report on their results can serve as a template, but inevitably each utility will have their own slightly different questions and methods for displaying the data.

Data Collection Guidance

Given the complex interaction between machine, laundry, and user, collecting the data outlined below will lead to a more comprehensive understanding of clothes dryer energy performance and user behavior. For the utilities that can, we strongly suggest they also collect the "suggested additional data," because it will significantly improve our knowledge of the dynamic interaction of clothes dryers with other household appliances. The guide has been divided into three sections based on how data is collected.

Automated Data Collection

Technicians install metering equipment at the field site, which automatically records primary energy use data. [3]

1. Continuous, 1 minute interval power demand (Watts) and energy consumption (kWh) over the study period for the clothes dryer. Data loggers should be able to apply a time stamp to each data point.

2. Hot water temperature measured at the tap closest to the clothes washer.

Participant Data Collection

Study participants collect data about their laundry behavior and record it in logging sheets. [4]

3. Measured weight of all loads laundered during the study period including dirty (before being put in washer), wet (after washer, before dryer), and clean (after dryer).

4. Information on the composition of laundry loads including textiles and descriptions of clothing.

5. Dryer cycle selected for the weighed load, time cycle started, and time laundry removed from dryer.

6. The washer cycle chosen for each load of weighed laundry.

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[3] Primary energy performance is a measure of the energy used directly by a dryer to dry laundry, without considering the interaction of the dryer and washer or other secondary energy effects.

[4] Having study participants collect data themselves raises questions about data consistency, quality, and the introduction of bias. It should be possible to minimize bias by limiting the transfer of information about experimental objectives to participants during recruitment and training. NEEA's experimental design was able to effectively address data consistency and quality concerns. They were able to collect high-quality participant log data from 49 of the 50 measurement sites over the measurement period, a 98% compliance rate. The combination of incentives and training provided to participants by Ecotope seem to have been very effective and should be strongly considered. Based on their experience, Ecotope recommended also recording start and stop times. It may be necessary to include a simple clock in the participant package so that participants will have this information easily at hand.

Technician Data Collection

Technicians collect demographic and equipment data when they install the metering equipment at the field site.[5]

7. Household demographic and socio-economic data, collected both at the beginning and end of the study period (to document potential changes).

8. Make, model, and age or manufacture date of the washer and dryer.

9. Inventory of household HVAC and DHW equipment including fuels, vintage and make and model number if available.

10. Electric and natural gas utility account numbers associated with laundry equipment and customer permission to access historic utility data.

Essential Data

The above list provides a comprehensive overview of the type of data that can be collected during a field study. SEDI strongly recommends that the following items constitute the minimum data captured:

1. Continuous, 1 minute interval power demand (Watts) and energy consumption (kWh) over the study period for the clothes dryer. Data loggers should be able to apply a time stamp to each data point.

2. Measured weight of all loads laundered during the study period including dirty (before being put in washer), wet (after washer, before dryer), and clean (after dryer).

3. Make, model, and age or manufacture date of the washer and dryer.

4. Basic household demographics.

In the course of collecting "essential data," it should be relatively inexpensive to collect all of the data described in this guide. Doing so will make it possible to combine the results from several clothes dryer field research studies into a larger meta-study with higher statistical precision.

Suggested Additional Data

The data collection items described above do not adequately cover all areas of potential interest. First, both the weight and RMC of laundry going into the dryer are influenced by the characteristics of the washer (as well as by user choice). We know that over 60% of dryers are sold in matched pairs with clothes washers and there may be a difference in a dryer's energy performance with its matched washer

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[5] SEDI suggests that sponsors design field research to collect items 7, 8, 9, & 10 and record the data in a uniform manner so it can be aggregated in a central source, possibly a results database. If a results database were created it could include specific participant information such as names or address, but each record should include a unique identifying number so that the original researchers can identify the participant if necessary. Sponsors could also keep their own separate database containing participant identifying, and utility account data for cross-referencing with the results database for possible follow up research.

versus another machine. When combined with the "essential" data items, the "suggested additional data" items support a complete analysis of laundry energy use across both the washer and the dryer.

1. Metered volume and temperature of cold water feed at clothes washer during wash cycle.

2. Metered volume and temperature of hot water feed at clothes washer during wash cycle.

Second, initial estimates suggest that up to 10% of the potential estimated savings from heat pump dryers (compared to conventional vented dryers) may come from secondary HVAC savings. Unvented dryers eliminate building air exchange associated with dryer venting.

3. For vented dryers: flow rate and relative humidity of exhaust air at outdoor vent measured in 1 minute intervals continuously during the study period.

4. Ambient air temperature and relative humidity of laundry room measured continuously during the study period.

5. Blower door test results for house.

The task of removing water from clean laundry is shared between the washer (which spins it out) and the dryer (which evaporates it). By tweaking the designs of both the washer and dryer in a matched pair, the manufacturer can optimize the energy performance of the total laundering process. A dryer's energy performance should be understood both as a component of the pair, and when used with a different washer.

We expect that laundry load composition and the number of loads laundered per week to change between seasons in a given location, and to be different between locations with different climates. Vented dryers function by pulling conditioned air from a room and venting the air to the outside after using it to dry clothes. This decreases air pressure inside the home and may accelerate the infiltration of unconditioned exterior air. Even when it is not being operated, a vented dryer's ductwork can provide a direct path for air to pass through the home's thermal envelope.

Equipment Recommendations

Energy, Electricity Demand, Temperature and Relative Humidity

Electric dryer energy and demand metering is pretty straightforward, with the caveat that most North American electric clothes dryers are designed to use 230 VAC, 60 Hz current. Short interval, continuous metered electricity consumption of the electric dryer is necessary to determine annual energy consumption because, like most modern household appliances, dryers tend to experience stand-by electrical losses even when they are not in operation. SEDI recommends that researchers use a high quality data logger such as the Onset U30 or equivalent. Such loggers also accept inputs from temperature and humidity sensors. Data loggers should be capable of storing recorded data for the length of the study if necessary.

Laundry Weight and Dryer Cycle

In order to capture the remaining moisture content of laundry going into the dryer each study participant needs to weigh the clothing before washing, after washing (before drying), and after drying. Participants should also record in their logbooks whether any clothing has been removed between washing and drying or if the washer cycle is divided into multiple dryer loads. Without these data it is very difficult to sleuth out what a complete dyer cycle actually consists of.

NEEA's approach was to provide each participant with a laundry basket and a scale for weighing laundry. Providing each participant with the same model of scale and basket minimized potential errors from the use of different equipment. Participants were also allowed to keep the basket and scale at the end of the study as an additional incentive for participation. The scale chosen for the NEEA study was a digital bathroom scale with a remote display that could be easily read while a basket was on the scale. The basket NEEA used was a standard, plastic, 60 liter sturdy polyethylene container that participants could easily move between washer, dryer and scale.

Participant Materials

In the NEEA study, participants received a water resistant, paper log notebook for logging information about the washer and dryer cycles chosen and for recording three laundry weights (before washing, after washing, and after drying) for each load. During the initial visit, the research technician installed the data loggers and also showed participants how to record their laundry cycle and laundry weight information. The notebook contained printed instructions on how to log laundry information correctly, and participants also received magnets to put on their washer and dryer to remind them to complete the log entries.

To simplify the logging process, NEEA suggested that the participants assign numbers to their top three washer cycles and top two dryer cycles (in addition to the 'Timed Dry' cycle option) and record which cycle they chose by entering the corresponding number into their log. This approach was based on the results from a previous study of laundry equipment that found participants regularly use three of the available cycles on their washing machines and two of the available cycles on their dryers.

Test Hardware

Getting field data can be a time consuming and cumbersome process if not streamlined. The approached used by NEEA resulted in the ability to provide very non-invasive equipment that both the

washer and dryer were plugged into. This hardware package had two pigtail cords plugged into the outlets and two receptacles (120v and 240V) that the washer and dryer plugged into. The contractor hired to run the test procedure placed the collection "box" unobtrusively on the floor behind or alongside the laundry equipment. The all-in-one nature allowed for quick deployment and kept homeowners from possibly tampering or inadvertently disabling it.

Appendix A contains the specification for the test hardware used in the NEEA field study. This specification describes both the accuracy as well as the data capacity needed to provide more than one month's worth of detailed dryer performance data.

Appendix A – Test Equipment

The following provides a detailed summary of the equipment used in NEEA field research study. This has been provided for information purposes only. SEDI does not endorse any specific brand or manufacturer of equipment.

Participant data collection
- Digital scale with movable display, minimum capacity 150 lb, 0.2 lb resolution
- 60 liter sturdy polyethylene container for weighing laundry
- Homeowner instruction book (printed on water resistant paper) and logging sheets
- Small digital clock
- Reminder magnet

Automated data collection

Custom-built NEMA enclosure which included a Continental Controls WNB-208-3Y Option P3 WattNode and Magnelab or Dent Engineering 0-333 mVAC split core current transformers. The site washer and dryer cords were plugged into approved electrical receptacles on the outside of the enclosure. The CTs were installed onto pigtails coming off of the receptacles and wired back to the WattNode (which also received 120VAC from one of the receptacles). Short SO-type cords with approved plugs were then plugged back into the house receptacles to enable normal laundry equipment operation.

This approach was chosen over custom field-wiring since NEEA believed it would be safer and save time.

Output from the WattNode was recorded with Onset Computing optically-isolated pulse counters. One was installed for the washer and one for the dryer. The WattNode measured true (RMS) power. A pigtail of signal wires started at the pulse output channels of the WattNode and exited the enclosure via a strain-relief fitting. The installing technician crimped the appropriate signal wire to the pulse counter wires.

Pulse counters were connected to an Onset Computing U30 datalogger. The U30 also had 3G wireless communication capability that was not used. The datalogger was set up to sample every 5 seconds and record (log) every minute.

The dryer exhaust relative humidity and temperature were also measured on the same interval with an Onset Computer S-THB-M008 relative humidity (RH) sensor installed in the dryer exhaust vent.

The NEMA enclosure measured about 16x12x8 inches and the U30 about 8x8x6 inches. Either could be mounted on a wall or hidden behind the laundry equipment and rest on the floor. The RH sensor and pulse counters each had 8 meter cables.

Dryer airflow

A custom volumetric capture hood was used to measure dryer airflow before and after any dryer maintenance. Measurements were taken at the dryer vent system terminus so that all system effects were included.

Appendix B – Metering Installation Protocol

Checklist

- Assess/sketch dryer venting system for functionality; decide if any preliminary repairs are needed
- Measure dryer venting system CFM pre- and post-lint screen cleaning
- Position/mount NEMA box and U30; plug in U30 & record serial number on form
- Crimp pulse counters to signal wire leads
- Label pulse counters and temp/RH sensor in Hoboware
- Set U30 to log 5 sec readings every minute (5 sec sampling, 1 minute logging)
- Confirm pulse counters respond
- Confirm temp/RH sensor responds; measure dryer CFM in fan-only mode & record temp/RH
- Confirm washer and dryer each work after logging equipment installed
- Educate participant on laundry logging procedure
- Leave log book at site
- Give participant incentive
- Take pictures/make notes

Site level

- Dryer CFM, pre- and post-cleaning
- Make and model of equipment

Per load of laundry

- Weight of load coming into and going out of washer and dryer
- Time of transfer
- Color and type of fabric
- Washer and dryer cycle used
- Other washer and dryer settings
- Whether laundry was removed from the load between wash and dry cycles
- Whether dryer sheets were used
- Whether damp signal was used
- Whether there was a delay taking the laundry out of the dryer

Appendix C – Consumer Data Log Template

Please record your **Top 3** most regularly used washer cycles and **Top 2** most regularly used dryer cycles before you start logging your laundry. Please record the exact name of the cycles as they are listed on your machine. You will refer to the numbers that you assign to these cycles when logging your washer and dryer cycles.

TOP 3 WASHER CYCLES

1. _____

2. _____

3. _____

TOP 2 DRYER CYCLES

1. _____

2. _____

LAUNDRY LOG INSTRUCTIONS

Thank you for taking part in this study. The information that you are logging will help us to better understand your laundry habits, including when you do your laundry, the cycles you regularly use and the water retention of certain fabrics that you wash. We have created this handy journal to help you keep track of your logging. Please create one entry each time you wash and dry a load of laundry. To keep it simple, the Laundry Log Instructions are divided into what you record for the washer cycle and what you record for the dryer cycle.

*As a note, please make sure to accurately log your cycles, even if they don't follow the typical logging of one washer cycle and then one dryer cycle. For example, if you "fluff" your laundry load for an extra 20 minutes after the complete dryer cycle is finished, simply fill out an additional dryer cycle log to reflect that extra dryer cycle.

Also, if you do anything out of the ordinary or something that you think would be noteworthy in your laundry habits, put this information in the Participant Notes section of either the Washer Log or the Dryer Log.

Part One: Before the Washer Cycle

1. **Date/Time**: Record date (MM/DD/YY) and time (HH:MM) that you start the washer in the top section of the Washer Log. Remember to indicate if the time is AM or PM.

2. **Weigh Laundry Load**: Place entire laundry load in the study-provided basket, placing basket squarely on the study-provided scale. Do not use the lid.

3. **Record Weight in Log**: Record weight of clothes in the section labeled "Weight of Dry Clothes." Provide the exact weight (example 3.5 lbs.); please do not round the weight. Do not subtract the weight of the basket.

4. **Describe Color Characteristics**: Check box next to the color description that characterizes **the majority of the items** in that particular laundry load.

5. **Describe Fabric Characteristics**: Check box next to the fabric description that best characterizes **the majority of the items** in that particular laundry load.

Use the fabric descriptions below as a guide:

FABRIC WEIGHT	EXAMPLES	
Light	• Permanent press • Light, casual shirts • Underwear	• Light socks • Pillow cases • Light weight / smaller sheets
Medium	• Heavy shirts • Casual pants • Heavy socks	• Medium weight / larger sheets • Light weight sweat pants and shirts • Pullovers
Heavy	• Towels • Flannel sheets • Jeans	• Heavy work clothing • Heavy sweat pants and shirts

6. **Set Machine**: Set washer cycle and all other options that you will be using for the wash cycle.

7. **Cycle Used**: Check the cycle number (1-3) used for this load in the field labeled "Cycle Used" (To remind yourself of your top 3 washer cycles, refer to the list at the front of your log that you completed with the installation technician). If you did not use one of your top 3 washer cycles, check the "Other" box and write in the name of the cycle that you used.

8. **Record Details of Wash Cycle**: Check the appropriate wash and rinse temperature (or write in other). Record the Spin Speed and Soil Level that the machine is using for this laundry load (Please note: Spin Speed and Soil Level are settings on the machine). Write in this information regardless of whether or not this was a default setting on the cycle or you personally selected the options.

9. **Other Options**: In "All Other Options," list all additional options (if any) that you have used for this washer cycle (e.g. steam cycle or self-clean cycle).

10. **Delay Start**: Check "yes" or "no" to specify whether or not you are using the "delay start" option for this wash cycle.
    o If you check "yes":
        ▪ Record the number of minutes you programmed for the "delay start."
        ▪ Please also describe why you used the "delay start" option (e.g. you wanted to give your clothes more time to soak, etc).

11. **Participant Notes**: Make any notes in the Participant Notes section that you think are important. Things to include could be why you used a particular cycle, why you used the "extra rinse" option, etc.

Part Two: Before the Dryer Cycle

1. **Date/Time**: Record date (MM/DD/YY) and time (MM: HH) that you start the dryer in the top section of the Dryer Log. Remember to indicate if the time is AM or PM.

2. **Separate Out Non-Dryer Items**: Remove clothes from the washing machine and only place those items that are going into the dryer into the laundry basket for weighing. You <u>do not</u> need to weigh the wet items that will be hung or line-dried.

3. **Weigh Laundry Load**: Place wet laundry load in the laundry basket and place basket squarely on the scale. Do not use the basket lid.

4. **Record Weight in Log**: Write weight of clothes in field labeled "Weight of Wet Clothes." Provide the exact weight (example 3.5 lbs.); please do not round the weight. Do not subtract the weight of the basket.

5. **Note if Items Hung/Line Dried**: Check "yes" or "no" in the laundry log as to whether items were removed from the washer that are not going in the dryer.

6. **Set Machine**: Set dryer cycle and all other options that you will be using for the dryer cycle.

7. **Cycle Used**: Check the cycle number (1 or 2) used for this load in the field labeled "Cycle Used" (To remind yourself of your top 2 dryer cycles, refer to the list at the front of your log that you completed with the installation technician). If you did not use one of your top 2 dryer cycles, check the "Other" box and write in the name of the cycle that you used.

8. **For Manual or Timed Dry Cycles**: Check "yes" or "no" to indicate whether you are using a manual or timed dry cycle (these are cycles where you set the time the cycle will initially run). If "yes", record the time that you set the cycle for (in minutes).

9. **For Automatic Cycles**: If you are using an **automatic** cycle for the dryer load, check "yes" or "no" as to whether or not you have manually added or removed time from the default drying time that is set for that cycle. Write in the space provided how much time (in minutes) that you added or removed (if applicable).

10. **Record Details of Dryer Cycle**: Fill in the Drying Temperature and Dryness Level that the machine is using for this laundry load (Please note: Drying Temperature and Dryness Level are settings on the machine). Write in this information regardless of whether or not this was a default setting on the cycle or you selected the options.

11. **Other Options**: In "All Other Options" list all additional options (if any) that you have used for this dryer cycle.

12. **Damp Signal:** Check "yes" or "no" to indicate whether you turned on the damp signal for this cycle. The damp signal is a setting on the machine that provides an alert when your clothes are approximately 80% dry.

13. **Weigh Laundry Load**: After the dryer cycle is complete, place entire dryer load in study-provided laundry basket, placing basket squarely on the study-provided scale. Do not weigh the lid.

14. **Record Weight in Log**: Write weight of clothes in field labeled "Weight of Dry Clothes." Provide the exact weight (example 3.5 lbs.); please do not round the weight. Do not subtract the weight of the basket.

15. **Record Time of Final Weighing:** Indicate the time (HH:MM) that you removed the dry clothes from the dryer and weighed them. Record whether this time is AM or PM.

16. **Dryer Sheets:** Check "yes" or "no" to indicate whether dryer sheets were used.

17. **Participant Notes:** Make any notes in the Participant Notes section that you think are important. Things to include could by why you used a particular cycle, why you used the "steam" option, etc.

Thank you again for participating in this study! If you have any questions as you are filling out your log, please give us a call at **1-877-506-2521** or email us at **laundrystudy@neea.org** (Hotline hours of operation are Monday – Friday, 9am-5pm).

Appendix D – Household Data Template

<div style="background-color:orange">

WASHER LOG

</div>

Date: / /	Time: _____ : _____ ☐ AM ☐ PM	Weight of **Dry** Clothes (before wash cycle): _____ **.** _____ lbs.

Color: *(check one)*   ☐ White   ☐ Mixed   ☐ Colors

Fabric: *(check one – see instructions for fabric examples)*

☐ Light   ☐ Medium   ☐ Heavy

☐ Mixed Light / Medium   ☐ Mixed Medium / Heavy   ☐ Mixed Light / Medium / Heavy

Cycle Used: *(check one – refer to list of your top washer cycles for a reminder)*

☐ 1   ☐ 2   ☐ 3   ☐ Other _____

Wash Temp: ☐ Cold ☐ Warm ☐ Hot ☐ Other: _____   Rinse Temp: ☐ Cold ☐ Warm ☐ Hot ☐ Other: _____

Spin Speed: _____   Soil Level: _____   All Other Options: _____

_____

Use Delay Start: ☐ Yes ☐ No If **Yes**, for How Long? _____ mins.	Reason for using delay start: _____

PARTICIPANT NOTES: _____

_____

DRYER LOG

Date: / /	Time: _____ : _____ ☐ AM ☐ PM	Weight of **Wet** Clothes (before dry cycle): _____ . _____ lbs.
Were items removed from the washer that are not going in the dryer? *(i.e., line dry)* ☐ Yes ☐ No	Cycle Used: *(check one- refer to list of your top dryer cycles for a reminder)* ☐ 1 ☐ 2 ☐ Other _____	
Did you use a manual cycle? ☐ Yes ☐ No If **yes**, how long did you set the cycle for? _____ mins.		
Answer the following only if you used an **automatic** cycle:		
Did you add time to the cycle? ☐ Yes ☐ No If **yes**, how much time did you add? _____ mins.		
Did you remove time from the cycle? ☐ Yes ☐ No If **yes**, how much time did you remove? _____ mins.		
Drying Temperature: _____ Dryness Level: _____		
All Other Options: _____		
Did you turn the damp signal on? ☐ Yes ☐ No	Weight of **Dry** Clothes (after dry cycle): _____ . _____ lbs.	Time of Weighing: _____ : _____ ☐ AM ☐ PM
Were dryer sheets used? ☐ Yes ☐ No		
PARTICIPANT NOTES: _____ _____		

WASHER LOG

Date: / /	Time: _____ : _____ ☐ AM ☐ PM	Weight of **Dry** Clothes (before wash cycle): _____ **.** _____ lbs..

Color: *(check one)*   ☐ White   ☐ Mixed   ☐ Colors

Fabric: *(check one – see instructions for fabric examples)*

☐ Light   ☐ Medium   ☐ Heavy

☐ Mixed Light / Medium   ☐ Mixed Medium / Heavy   ☐ Mixed Light / Medium / Heavy

Cycle Used: *(check one – refer to list of your top washer cycles for a reminder)*

☐ 1   ☐ 2   ☐ 3   ☐   Other _____

Wash Temp: ☐ Cold ☐ Warm ☐ Hot ☐ Other: _____   Rinse Temp: ☐ Cold ☐ Warm ☐ Hot ☐ Other: _____

Spin Speed: _____   Soil Level: _____   All Other Options: _____

_____

Use Delay Start: ☐ Yes ☐ No If **Yes**, for How Long? _____ mins.	Reason for using delay start: _____

PARTICIPANT NOTES: _____

_____

DRYER LOG

Date: / /	Time: _____ : _____ ☐ AM ☐ PM	Weight of **Wet** Clothes (before dry cycle): _____ **.** _____ lbs.

Were items removed from the washer that are not going in the dryer? *(i.e., line dry)* ☐ Yes ☐ No	Cycle Used: *(check one- refer to list of your top dryer cycles for a reminder)* ☐ 1 ☐ 2 ☐ Other _____

Did you use a manual cycle?   ☐ Yes   ☐ No   If **yes**, how long did you set the cycle for? _____ mins.

Answer the following only if you used an **automatic** cycle:

Did you add time to the cycle?   ☐ Yes   ☐ No   If **yes**, how much time did you add?   _____ mins.

Did you remove time from the cycle? ☐ Yes   ☐ No   If **yes**, how much time did you remove?   _____ mins.

Drying Temperature: _____   Dryness Level: _____

All Other Options: _____

Did you turn the damp signal on? ☐ Yes ☐ No	Weight of **Dry** Clothes (after dry cycle): _____ **.** _____ lbs.	Time of Weighing: _____ : _____ ☐ AM ☐ PM

Were dryer sheets used?   ☐ Yes   ☐ No

PARTICIPANT NOTES: _____   _____

Appendix E – Consumer Questionnaire Template

Ecotope Laundry Project || FAQ

About the Toll-Free Line/Email:

Q: What do I do if I have questions about what to log in my laundry log?

> A: Call 1-877-506-2521 or email laundrystudy@neea.org

Q: When can I call for help with my laundry log?

> A: The hours of operation are 9am-5pm, Monday-Friday for the duration of the 4-week study.

Q: If I leave a message for the hotline (or send an email), when can I expect to hear back with a response?

> A: Someone will respond to your inquiry within 24 hours. If you call or email Friday-Sunday, it may take up to the next business day for someone to get back to you.

Q: Who do I contact if I am having issues with or have questions about the metering equipment that was installed on my laundry machines?

> A: Please call our toll-free hotline at 1-877-506-2521 or email laundrystudy@neea.org. We will forward your questions to a technical representative for assistance.

Q: I am an installation technician on the project. Who do I call if I or the participant have questions about the laundry logging process?

> A: You can call or email the same contacts above and we will help you out!

About the Laundry Equipment:

Q: What if any of the equipment breaks or stops working (e.g. the scale, metering equipment, Sterilite tub, etc.)?

> A: Call us at 1-877-506-2521 or email laundrystudy@neea.org and we will help you to replace or fix your equipment/materials.

Q: What if I forgot to log a cycle of my laundry or I forgot to weigh the laundry?

> A: We know you're busy, so just start logging your laundry again for your next cycle.

Q: I have my own bathroom scale at home. Can I just use that to weigh my laundry?

> A: No, please use only the study-provided scale to weigh your laundry. Same for the Sterilite container - please do not use your own laundry basket to weigh your laundry.

Q: What do I do with the Sterilite container and scale after the study is over?

A: As a thank-you for your participation, you get to keep these items for your own personal use at the end of the study.

Q: What if my laundry load does not fit in the Sterilite container for weighing?

A: The laundry items do not need to be flush in the container to be weighed. Try to distribute the weight of the laundry evenly in the container and be sure that the container sits squarely on the scale when weighing so that you get the most accurate weight.

Q: Should I use the lid when weighing my laundry in the Sterilite container?

A: No, don't use the lid when weighing your laundry.

Q: What if my laundry room does not have an accessible outlet to plug the scale into?

A: Your scale is outfitted with a 9 volt battery so that you don't have to plug the scale in to use it.

About the Washer Log:

Q: What if I am unsure about which category to check in the laundry log for the fabric description?

A: Refer to the fabric description examples in the Laundry Log instructions and try to give it your best educated estimate. If you are still unsure, feel free to give us a call or shoot us an email (p: 1-877-506-2521 or e: laundrystudy@neea.org).

Q: What if I am not using one of the top 3 washer cycles that I recorded in my log?

A: Simply check the "Other" box and write in the exact name of the cycle that you are using (as it appears on your machine).

Q: What box do I check if I am using "Very Hot" (not just "Hot") as the water temperature for my wash cycle?

A: Check the "Other" box and write in "Very Hot."

Q: What is delay start?

A: Delay start is an option you can select on your washing machine that will start the wash cycle a certain amount of time after you push the "Start" button. This is most often used to time the wash cycle when participants are out of the home or to allow clothes to soak for a longer period of time.

Q: What do I put in the "Participant Notes" section?

A: You are not required to record anything in the Participant Notes section. Please feel free to record things such as why you used a particular cycle or option, or anything that is out of the ordinary about this particular laundry cycle. Any details that explain why you chose the options that you did would be helpful for us to know.

Q: What does Soil Level mean?

A: Soil Level is an option on your washer that you are able to set according to how dirty you perceive your laundry load to be. Typical options include light, normal and heavy.

Q: What if some options are not available on my machine (e.g. Soil Level)?

A: Please note that this option is not available on your machine in that section of the log form.

About the Dryer Log:

Q: What if I am not using one of the top 2 dryer cycles that I recorded in my log?

A: Simply check the "Other" box and write in the exact name of the cycle that you are using (as it appears on your machine).

Q: What if some options are not available on my machine (e.g. Dryness Level)?

A: Please note that this option is not available on your machine in that section of the log form.

Q: What do I put in the "Participant Notes" section?

A: You are not required to record anything in the Participant Notes section. Please feel free to record things such as why you used a particular cycle or option, or anything that is out of the ordinary about this particular laundry cycle. Any details that explain why you chose the options that you did would be helpful for us to know.

Appendix F – Suggested Template for Recording Data

This section of the SEDI Field Test Protocol is under development. Several organizations will utilize the suggested template; as a result, it is important for them to provide their input into the development of the template. CLASP is coordinating with SEDI technical working group members to develop the suggested template. Any organizations wishing to participate in this process can contact Christopher Wold at cwold@clasponline.org.

Appendix G – Clothes Dryer Energy Performance Explained

The following three sections describe in more detail how the composition of the clothing being dried, the mechanical design of the dryer, and user behavior impact energy consumption. It also describes how the test protocol captures each of these elements to provide a complete and useable understanding of dryer performance.

Laundry Impacts

How much energy a dryer consumes is largely dependent on the amount of moisture it removes. Higher initial moisture content will require more energy to dry the clothes. Since the early 2000's clothes washers have gotten better at spinning out the amount of moisture in the laundry. The assumption used in federal standards is that 57% of the weight of the clothes entering the dryer is water. The NEEA field data showed this to be more like 62% in the real world (all washers tested were less than 5 years old). The combined energy factor (CEF) metric (measured in lbs of dry clothing per kWh) is typically lower for laundry that enters the dryer very wet, as the load operates more of the time in its bulk drying condition not in the lower efficiency modes of pre-heating and auto-termination.

The second most important laundry impact of clothing is the type of clothing used. Loads of light weight synthetics use more energy to dry then heavy cotton fabrics. Some fabrics such as bamboo or hemp appear to require longer dry times, as they give up their moisture less easily than other materials even if they have the same thickness and structure. Capturing these variants may be important in understanding how a particular region's clothing mix affects dryer performance. For example, one would expect winter clothing mix in cold climates to differ significantly from spring clothing mix in desert climates.

Hardware Impacts

The following section describes several ways in which hardware (the dryer) design affects energy use of the dryer. The manufacturer goal is to present products that meet or exceed consumer expectations at the best possible price. Until recently these expectations did not include energy efficiency, in addition the federal test procedure was not capable of differentiating some of these differences nor does the test currently reflect their impact on real world drying conditions.

Vented vs. Unvented dryers: Unvented dryers are common in Europe where most homes are not equipped with the necessary exhaust path. In general, a vented dryer will reduce total system energy use (including impacts on HVAC energy use). Dryers that are vented but have a plugged or restricted vent have lower performance. Field data indicates that this impact is small (a few percent) under moderate restriction conditions. When a dryer vent becomes significantly plugged, additional risks (principally fire) increase. This protocol requires vent cfm be measured prior to the commencement of the testing, and cleaning of the vent if air flow is substantially restricted.

Insulation: Dryers that have insulation in between the drum and the outside box operate quieter and have lower heat loss to ambient conditions. Based on US DOE estimates, Insulation can reduce dryer energy by 3 percent to 6 percent.

Heat Exchanger: A dryer equipped with an air-to-air heat exchanger reuses waste heat coming out of the drum to increase the temperature of incoming air. The DOE Technical Support Document evaluated

a condensing exhaust heat exchanger and projected 14 percent savings.(DOE 2010) Additionally a 1984 study by Lawrence Berkeley National Laboratory (LBNL) in which researchers modified and measured a dryer showed a 20-26 percent efficiency gain using a heat recovery ventilator

Reduced Heating: Decreasing the amount of heat put into the drum has been shown to reduce energy use while extending drying time. Reducing the size of the heater element, or through modulation of one or more elements provide similar results. Ecova lab results indicate that 30 percent energy savings is achievable through reduced heating and extending run time.

Variable airflow: Increasing airflow through the dryer increases dryer efficiency, but this is not generally done in current models and is complicated by the size of the load and relative fill of the dryer drum, and the state of the clothing. If air flow through the dryer remains constant as the drying cycle progresses (which is usually the case), the incoming air will evaporate less water from the clothing before being exhausted from the drum. This causes the relative humidity of the exhaust airflow to drop, the temperature to rise, and the energy efficiency of the typical electric clothes dryer to decrease as the drying cycle progresses. This is why a dryer will require far more electricity to go from 10% to 2% RMC than from 50% to 40% RMC.

Efficient motors and fan: In a typical dryer, the motor turns the drum and powers the fan that blows air through the clothes.   The potential for a 3-5% energy reduction is possible through use of more efficient motor or motors (should the fan blower be powered separately) from the drum motor.

Accurate Auto-termination: One of the ways that clothes dryers often waste energy is by continuing to dry laundry that is no longer wet. Older dryers were often equipped solely with timed cycle options and it was difficult for users to estimate how long they needed to set the timer for a given load of laundry. Many dryers now have sensors that estimate the remaining moisture content (RMC) of laundry. Whether or not these sensor-equipped dryers use less energy depends upon the accuracy of the sensors, and on what happens when the sensors determine that the clothing is dry. If the drying cycle is simply terminated, no more energy is consumed. However, dryer manufacturers sometimes reduce, rather than stop, the heat and tumbling in which case energy consumption continues at a lower level.

Condensing Dryers: Dryers (including heat pump dryers) operate in a similar fashion, but employ a closed air loop. Rather than being vented, the cooler, moister exhaust air is directed through a heat exchanger where much of the water vapor is condensed into liquid and collected. This dried exhaust air is then returned to the drum and heated to continue the drying process.

User Operation Impacts

Understanding the technical functioning of clothes dryers sets the stage for understanding the true driver of energy consumption – user behavior. The multitude of choices that users must make to launder clothing at home has a profound effect on residential laundry energy consumption. A short list includes:

- Choosing which washer and dryer to buy
- Choice of which clothing to machine launder (as opposed to hand launder or dry clean)
- Selection of the frequency and timing of washer and dryer use
- Choice of washer and dryer cycles
- Diligence in performing user maintenance including cleaning lint filters and clearing obstructions to venting