**A Specification for**

**Residential Super-Efficient Clothes Dryers**

**Version 1.03**

**June 25, 2015**

This product specification provides dryer manufacturers with a clear roadmap for product development using a utility combined energy factor (UCEF) to estimate real world energy use of clothes dryers. This specification also serves as a foundational document for utility program efforts that will work in partnership with manufacturers to accelerate market adoption of super-efficient clothes dryers.

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## 1.0 Background

Clothes dryer technology in North America has remained relatively constant since the 1950s. Dryers today remain the second largest energy-using appliance in a home. Until recently, all dryers were assumed to have relatively equivalent performance. In the past decade, products using heat pumps and better automatic termination detection successfully entered the market in Europe and Asia. These typically use half the energy that most dryers sold in North America.

A key success factor for European Super-Efficient dryers was the existence of both a test protocol that provides accurate product differentiation and a multi-tiered specification that highlights product improvements in a method consistent with product development cycles.

In 2013 the DOE adopted two new test procedures. Both test procedures use cotton/poly napkins as the basis of a highly-repeatable but less than ideal test load. The DOE test protocol in Appendix D1[[1]](#footnote-2), remains relatively unchanged from earlier versions. Appendix D2[[2]](#footnote-3), provides an optional path for federal minimum standard compliance and tests dryers to the point where they automatically turn off.

Lab and field data indicate that the DOE Appendix D2 test protocol, by itself, does not accurately rank-order performance of dryers nor estimate how much energy they use drying real clothing. To address this, PG&E, NEEA, ECOVA, key manufacturers, and other labs developed a supplemental set of tests that uses real clothing in four different combinations of operational settings. The combination provides an accurate characterization of dryer performance through a weighted average of multiple test conditions. The supplemental test protocol produces a “utility combined energy factor” (UCEF) with units of lbs of clothing dried per kWh.

## 2.0 Purpose

The goal is to provide industry with a clear roadmap for product development and use a real clothing based drying metric (UCEF) to estimate real world energy use of clothes dryers. This specification also serves as a foundational document for utility program efforts that will work in partnership with manufacturers to accelerate market adoption of super-efficient clothes dryers.

This specification addresses the following:

* Common minimum criteria
* Energy - weighted average performance of several operational settings.
* Functionality and features that support lower energy use.

## 3.0 Scope

This specification covers residential electric clothes dryers with a drum volume of 4.0 cubic feet or larger. This includes products that meet the definition of an Electric Clothes Dryer and the definition of a consumer product as specified by the US DOE. Excluded products include: Gas Dryers[[3]](#footnote-4), Commercial Clothes Dryers, Water-Cooled Ventless Clothes Dryer, Combination All-in-One Washer-Dryers, and Residential Clothes Washers with an Optional Dry Cycle.

## 4.0 Dryer Qualification Criteria

The specification has multiple tiers of performance. Tier ranking is dependent on meeting minimum criteria, performance requirements and functional elements described in the following sections. With the exception of Tier 1, the other tiers are based on the dryer’s UCEF value. This value can be increased through functionality credits described in section 4.3. UCEF values are lower than comparable CEF values because they include multiple tests using real clothing, which inherently use more energy per pound of clothing than DOE test cloths.

### 4.1 Common Minimum Criteria.

All dryers to meet the following product evaluation criteria.

1. Dryer must be certified to the ENERGY STAR specification in effect at the time of manufacture.
2. Dryers must be tested according to D2 and the Supplemental Test Protocol and have a UCEF value[[4]](#footnote-5) provided by an approved laboratory.
3. Noise level must not be greater than 65 dB measured as determined in Appendix A
4. Manufacturer warranty must not be less than 12 months and include parts and labor.
5. Dryers must have a drum volume of at least 4.0 cubic feet

### 4.2 Performance Tiers

Dryer classification falls into one of the performance tiers as shown in Table 1 below. CEF values based on the D2 test protocol do not directly translate to UCEF values based on the Utility supplemental test procedure.

|  |  |  |
| --- | --- | --- |
| Tier | D2 CEF  (lbs/kWh) | UCEF[[5]](#footnote-6)  (lbs/kWh) |
| 2014 Baseline |  | 2.73 |
| Tier 1 | 3.93 | ~3.00 |
| Tier 2 | ~4.30 | 3.50 |
| Tier 3 |  | 4.00 |
| Tier 4 |  | 4.80 |
| Tier 5 |  | 6.00 |
| Tier 6 |  | 8.00 |

Table 1: Electric Dryer Performance Data and Tiers

**2014 Baseline** is not really a tier, it is the UCEF value representation of the market average (i.e. performance baseline). Energy savings are calculated from this baseline performance. The current baseline value UCEF value of 3.73 lbs/kWh is based on a market weighted average testing conducted by Ecova[[6]](#footnote-7).

**Tier 1** is the 2014 ENERGY STAR qualification. Products as Tier 1 by achieving either a minimum CEF value of 3.93 lbs/kWh using the DOE test “D2” procedure described in Federal Register 10 CFR 430 Subpart B, or the UCEF credit threshold based on the Utility test protocol. The savings are based on the UCEF metric for consistency with the other tiers, but qualification of Tier 1 is solely based on the ENERGYSTAR qualification.

**Tier 2** is for dryers with a tested UCEF value between 3.50 and 3.99 lbs/kWh. This range is functionally equal to the EPA’s 2014 Emerging Technology Award specification. These units are either very efficient electric resistance units, or more likely a hybrid heat pump design.

**Tier 3** is for dryers with a tested UCEF value between 4.00 and 4.79 lbs/kWh. These units are likely a hybrid heat pump design.

**Tier 4** is for dryers with a tested UCEF value between 4.80 and 5.99 lbs/kWh. These are likely either a hybrid heat pump design or pure heat pump design (no electric resistance heat source)

**Tier 4** is for dryers with a tested UCEF value between 6.00 and 7.99 lbs/kWh. These are likely pure heat pump design (no electric resistance heat source), such as commonly found in European clothes dryer designs.

**Tier 6** is for dryers with a tested UCEF value between 8.00 and 99.99 lbs/kWh. This tier represents the highest likely performance range with the exception of a clothesline.

### 4.3 UCEF Credits

UCEF credits represent rewards those products with characteristics that will result in higher probability that consumers will use them in the efficient operation settings. A UCEF credit value of +0.10 equates to the consumer running the dryer in its efficient mode approximately 15% more frequently. The assumption is that satisfied customers will more likely operate the dryer in its most efficient mode.

Five different UCEF credits were considered (see table 2), but only one was ultimately chosen as having a strongly likelihood that consumers would use the machine more efficiently. A UCEF credit of +0.10 is available for machines that default to their most efficient state any time the machine has not been operated recently.

It is important for energy savings reasons that the machine return to the default test condition (initial on or reset) between cycles because consumers tend to leave machine on a setting. This is especially true for hybrid models where the choice of an “Eco” setting results in a reduced use of the electric resistance element. Test results indicate that Eco settings of hybrid models are 29% more efficient than the “Fast Mode” (Test 4) and 25% more efficient than “Normal mode”. Getting consumers to use the Eco mode will result in increased energy savings. Increasing UCEF value by +0.10 is roughly a 3% reduction in energy use (in a Tier 2 product). This is similar to shifting the weighting factors from 20% on each test, to 40% on the Eco mode and 15% on all other modes.

The UCEF value of a dryer is calculated by the following equation:

UCEF = UCEFtested + Sum of all eligible UCEF credits

Where,

UCEFtested is the value generated by the supplemental test procedure

UCEF credits are provided in table 2

|  |  |  |
| --- | --- | --- |
| Attribute | Min Criteria | UCEF Credit |
| Returns to Eco mode[[7]](#footnote-8) | None | +0.10 |
| Cycle Time[[8]](#footnote-9) | TD2 < 70 minutes | None |
| Displays relative energy efficiency[[9]](#footnote-10) | None | None |
| Noise Level | Noise < 70 dB @ 3ft | None |
| Smart Grid Connected | None | None |

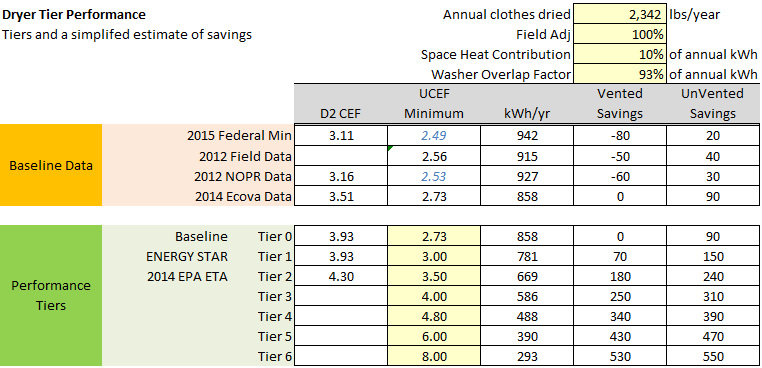
Table 2: UCEF Credits

## 5.0 Additional Information

### 5.1 Estimated Savings

Table 3 shows the approximate energy savings values based on UCEF values. The UCEF values are based on a starting moisture content of 62% and ending moisture content of 4%. Field results indicated an average starting moisture of real clothing is ~30% higher than when conducted in the laboratory with D2 test cloths that are 50% polyester (a hydrophobic material). This allows us to use the UCEF value based on a higher delta RMC as a good metric. A washer overlap factor is included to account for when more efficient are used in combination with an energy efficient clothes dryer.

A more detailed investigation of this overlap and the appropriate initial moisture content is available from the Northwest RTF[[10]](#footnote-11). This investigation includes a more accurate assessment of the space heating impact, relative market share and where the mean UCEF value lies for each tier.



*Table 3: Savings Estimates Based on 2014 Baseline*

### 5.2 Product Qualification

ENERGYSTAR maintains certification for products and the list of qualify products that meet Tier 1 of this specification. Manufacturers with products that exceed a UCEF value of 3.5 that wish to have their products tested to this specification should contact Christopher Dymond, Sr. Product Manager at (503) 688-5454 or [cdymond@neea.org](mailto:cdymond@neea.org) .

### 5.3 Qualifying Products List

There are two qualifying product lists. EPA’s maintains a current list of all ENERGYSTAR qualifying products (Tier 1), while NEEA maintains and tests all higher tier products. Table 4 is a list of qualifying dryers that meet or exceed Tiers 2 and above as of June, 2015. All of these products are have been ENERGYSTAR certified.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Tier 1 Clothes Dryers** | |  |  |  |  |  |  |  |  |
| EPA Website | <https://www.energystar.gov/productfinder/product/certified-clothes-dryers/results> | | | | | | | | |
|  |  |  |  |  |  |  |  |  |  |
| **Tier 2 and above Clothes Dryers** | | |  |  |  |  |  |  | 6/26/2015 |
| **Product Brand** | **Model** | **Tech** | **Type** | **Tier** | **Savings (kWh/yr)** | **IMC** | **UCEF** | **Test Lab** | **Test Date** |
| Blomberg | DHP24400W | HP | Ventless | 6 | 513 | $555 | 8.1 | UL | Q1 2015 |
| Blomberg | DHP24412W | HP | Ventless | 6 | 513 | $555 | 8.1 | UL | Q1 2015 |
| Whirlpool | WED99HED# | Hybrid | Ventless | 2 | 228 | $555 | 3.7 | UL | Q4 2014 |
| LG | DLHX4072## | Hybrid | Vented | 2 | 183 | $555 | 3.5 | UL | Q4 2014 |
| Kenmore | 8159#### | Hybrid | Vented | 2 | 183 | $555 | 3.5 |  |  |

Table 4: Qualifying Products Tier2 and above

Note - UCEF values show include UCEF Credit if applicable.

## Appendix A: Supporting Documents

Supplemental Test Procedure developed by ECOVA funded by PG&E and NEEA.

<https://conduitnw.org/Pages/File.aspx?rid=2843>

The SEDI field test protocol developed by NEEA, CLASP and SEDI.

<http://clasp.ngo/en/Resources/Resources/PublicationLibrary/2014/SEDI-Field-Test-Protocol.aspx>

Performance Baseline Assessment of clothes dryers.

Final report pending

Regional Technical Forum Clothes Dryer Workbook

<http://rtf.nwcouncil.org/measures/res/ResClothesDryers_v1_2.xlsm>

## Appendix B: Equations and Calculations

### Annual Energy Use

Annual energy us of a dryer is based on the following equation

kWh/yr = Annual Dry Load Weight ÷ UCEF x [(SMCdryertest- 4%)/(RMCwasher – 4%)]

Where:

Annual Dry Load Weight = 2342 lbs

SMCdrertest = 62% staring moisture content of the supplemental test procedure

RMCwasher = the remaining moisture content at the end of the clothes washer cycle adjusted for real clothing.[[11]](#footnote-12)

UCEF is calculated based on the equation in section 4.3.

### UCEF Calculation

UCEF is a weighted average of several test conditions, where:

The supplemental test CEF values (CEFSMALL, CEFLARGE, CEFECO, CEFFAST) are generated from several different test modes using real clothing. The details of the test conditions are described in under the supplemental test procedure. The weighting factors (, , , , and ) are initially estimates based on field data. The following table describes the initial values assumed. Weighting factor values may change once additional field data is collected.

|  |  |  |  |
| --- | --- | --- | --- |
| Factor | Tier 0[[12]](#footnote-13) | Tier 1+ | Dryer Test |
| α | 0.25 | 0.20 | Supplemental – Small |
| β | 0.20 | 0.20 | Supplemental – Large |
| γ | 0.10 | 0.20 | Supplemental – Eco |
| δ | 0.25 | 0.20 | Supplemental – Fast |
| ε | 0.20 | 0.20 | DOE Appendix D2 |
| UCEF Credit | N/A | Table 2 | N/A |

Table 3: Weighting Factors

Where,

α weighting factor associated with the CEF generated in the supplemental test with a small load, under normal (default) setting, to 4% RMC (remaining moisture content)

β weighting factor associated with the CEF generated in the supplemental test with a large load, under normal (default) setting, to 4% RMC

γ weighting factor associated with the CEF generated in the supplemental test with a medium load, under “eco” or most efficient setting, to 4% RMC

δ weighting factor associated with the CEF generated in the supplemental test with a medium load, under fastest dry and heavy duty setting, to 4% RMC

ε weighting factor associated with the CEF generated in by the DOE Appendix D2 test procedure

UCEF Credit fixed adjustment factor used to adjust lab to real world conditions, plus the sum of all consumer credit values that the dryer qualifies for (see table 2)

### Washer and Dryer Performance Interaction

The MEF value for washers includes energy of the washing cycle, water heating, standby energy, and a calculated energy needed to take the clothes from their remaining moisture to a final state of 4% remaining moisture content (RMC). This drying energy is based on a dryer efficiency value of 2.0 lbs/kWh. While this creates a small overlap between energy savings calculated by dryers and washer the savings generated in this specification are not reduced for the following reasons:

1. Washer drying energy is underestimated. RMC values are based on D2 test cloths whereas, real clothing retains much more water.
2. Energy added to the washer cycle for drying is based on 2.0lb/kWh, an efficient dryer might be three times as efficient. If the drying energy portion of the washer test was based on the actual dryer used, amount of energy associated with the washer would be considerably less.

The calculation method for paired washer dryer savings is not part of this specification, but involves the following two corrections:

1. Correcting the RMC values used in the washer test procedure to reflect that real clothing holds much more water than the DOE test cloths
2. Correcting the dryer lbs/kWh metric (CEF) so that it is based on the moisture content from the paired dryer.

## Appendix C: Noise Testing

1.0 Test setup:

* Place the dryer against a wall in a room
  + A clothes washer should be located adjacent to the dryer.
  + Ambient noise should be less than or equal to 35dbA.
  + Room walls should be drywall w/o any sound absorbing
* Run the dryer in Eco mode with a medium sized load according to the supplemental test procedure.
* Allow the unit to operate in this mode for 10 minutes before proceeding and ensure that a steady state of operation is maintained during the entire sound measurement procedure.
* Acoustical meter shall be accurate to within +/- 1 dB in the range of 30-60 dB.

2.0 Test procedure:

* Position the sound measurement device as shown in diagrams below
* Record three noise levels at 5-minute intervals while the compressor is operating (if this is a heat pump dryer)
* Take the highest single sound level

Figure 1 – Noise test configuration

## 

## Appendix D: Definitions

Below are the definitions of the relevant terms in this document. Definitions are identical with definitions in the DOE test procedure at [10 CFR 430, Subpart B, Appendix D2 or 10 CFR 430.2](http://www.ecfr.gov/cgi-bin/text-idx?SID=ed928f05cbf5d96cbddce6a156d0639a&node=10:3.0.1.4.18.2.9.7.14&rgn=div9).

A. Electric Clothes Dryer: A cabinet-like appliance designed to dry fabrics in a tumble-type drum with forced air circulation. The heat source is electricity and the drum and blower(s) are driven by an electric motor(s).

B. Gas Clothes Dryer: A cabinet-like appliance designed to dry fabrics in a tumble-type drum with forced air circulation. The heat source is gas and the drum and blower(s) are driven by an electric motor(s).

C. Compact size Clothes Dryer: A clothes dryer with a drum capacity of less than 4.4 cubic feet.

D. Standard size Clothes Dryer2: A clothes dryer with a drum capacity of 4.4 cubic feet or greater.

E. Conventional (Vented) Clothes Dryer2: A clothes dryer that exhausts the evaporated moisture from the cabinet.

F. Ventless Clothes Dryer2: A clothes dryer that uses a closed-loop system with an internal condenser to remove the evaporated moisture from the heated air. Moist air is not discharged from the cabinet.

G. Water-Cooled Ventless Clothes Dryer: A ventless clothes dryer that uses cold tap water for internal condenser cooling.

H. Commercial Clothes Dryer: An electric or gas clothes dryer that is designed for use in:

1. Applications in which the occupants of more than one household will be using the clothes dryer, such as multi-family housing common areas and coin laundries; or

2. Other commercial applications.

I. Combination All-in-One Washer-Dryer: A consumer product designed to clean and dry fabrics in a single drum, where a separate drying cycle uses electricity or gas as a heat source and forced air circulation.

J. Residential Clothes Washer with Optional Dry Cycle: A Residential Clothes Washer that has an optional add-on dry cycle, where drying is accomplished through use of electricity or gas as a heat source and forced air circulation; drying cannot be selected independently from a wash cycle.

K. Combined Energy Factor (CEF): The clothes dryer test load weight in pounds divided by the sum of the per cycle standby and off mode energy consumption and either the total per-cycle electric dryer energy consumption or the total per-cycle gas dryer energy consumption expressed in kilowatt hours (kWh).

L. Basic Model: Units of a given type of covered product (or class thereof) manufactured by one manufacturer, having the same primary energy source, and which have essentially identical electrical, physical, and functional (or hydraulic) characteristics that affect energy consumption, energy efficiency, water consumption, or water efficiency.

M. Consumer Product: Any article (other than an automobile, as defined in Section 501(1) of the Motor Vehicle Information Cost Savings Act) which: (1) in operation consumes, or is designed to consume, energy and (2) to any significant extent, is distributed in commerce for personal use or consumption by individuals.

N. Supplemental Test Procedure: The procedure uses real clothing in a combination of four different operational settings. When combined with the D2 test protocol the result provides a more accurate characterization of dryer performance.

## Appendix E: Discussion

This section presents the background details and rationale for many of the assumptions and design choices of this specification.

**General Discussion**

The multi-tiered specification establishes thresholds for manufacturers that wish to differentiate their product and provides utilities with a weighted average CEF value from which to estimate the energy use of a dryer. This multi-tiered approach also enables utilities to provide incentives to customers, retailers or manufacturers differently depending on the efficiency level of the dryer.

Experience has shown that some manufacturers (power supplies, water heaters, TVs, automobiles, etc.) will modify their product’s operation to achieve a better score under government-mandated test procedures. Such products do not always perform as well under real world conditions. This results in lower confidence in utility of test protocols based on a single operational mode that does not reflect real-world use of the product. The multi-setting nature of the referenced test protocol ensure the product is evaluated on a range of settings.

The inclusion of the multi-setting supplemental test also enables calibration of lab test results to real world performance through field-testing. A properly calibrated UCEF value will generate bankable utility energy savings and justify utility support for products. Utilities should follow the SEDI field test protocol ([CLASP](http://www.clasponline.org/sedi/fieldtestprotocol)) when conducting field tests. This field data test protocol gathers both performance data and data on how consumers operate the dryer. Knowledge of consumer settings is equally important to accurately estimating performance as laboratory test results. How much clothing is dried and on what settings they are dried are essential independent variables that can only be determined through field research.

A multi-tiered specification enables manufacturers to make rational business decisions for investment to improve product efficiency. The cost of improving a product to a higher level of performance can be weighed against the support utilities can provide and benefits of selling a higher efficiency product.

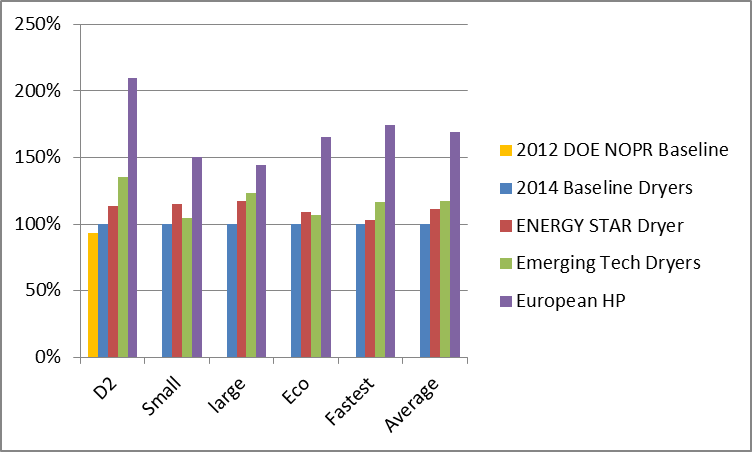


Table 4- shows a comparison of several different performance levels

**Weighting Factors Discussion**

Four approaches were considered to in setting weighting factors for the different test conditions. Three Two based field data and on provided by the manufacturer. The final decision made was to use a compromise of these which equally weights the different results for each test.

The only unique challenge was that Tier-0 (Non-energy star) dryers do not have a clear “eco” cycle setting. Machines without an “Eco” setting are operated in the test procedure with the “Delicates” or nearest equivalent setting. This is not the default and field results showed that the setting was only used about 7% of the time, and that there was a much ligher prevlance to run more Fast loads. For this reason we chose to apply a different weighting factor on machines without an “Eco” setting. Categorically it is not always true that Tier 1 and better have eco settings, but the nature of their test procedure to achieve this requires that their default setting is a most efficient setting.

The result of was a compromised solution of weights shown in table 7. With the exception of old style non-energy star dryers, all dyers with D2 value that qualifies as ENERGYSTAR have a 20% weight applied to each of the five tests. Future field data may review a more nuanced approach is needed, because the this approach produces a result that does not vary much from the test results of the Eco setting the impact of changing weighting factors is relatively small except in the case of dryers without an Eco cycle setting.

  
Table 7 – UCEF Test Weighting factors by tier

**Customer Credit Values Discussion**

Consumer credit values correlate to energy savings. A CEF increment of +0.05 is equal roughly 9kWh per year of additional savings, or about 1.4% increase in the unit’s savings. The assumption is that if a dryer meets these metrics, users will be more apt to operate the dryer in its most efficient or “Eco” mode. Consider the following example:

Two ENERGY STAR dryers are identical except dryer #2 has a display that indicates the relative energy use of any particular combination of user settings. Under the proposed specification, dryer #2 would have +0.05 added to its base UCEF value. This is energy equivalent if the consumer used the eco option roughly 7% more often than they did without the display feature.

At present we cannot correlate the credit amount to the energy savings. We estimate that the amount of the credit is conservative and changes the estimated energy use in way consistent with expectations of dryer performance. No dryer would likely receive a UCEF credit greater than +0.2. Such a credit would result in the same energy savings as occurs if a dryer operates in its most efficient mode roughly 28% more often. This amount would not move a product from one tier all the way to another, but may be enough to nudge a product into the next tier if it is already close. Consumer satisfaction with dryer performance will ultimately be the key determinate if the dryer is operated in its efficient mode. Because of this, we believe assigning a small credit to meeting a tier based on consumer preferences is rational and reasonable.

Recent consumer testing of clothes dryers shows the importance of drying time on the likelihood that consumers will operate their dryer in its most efficient setting. The Florida Solar Energy Center provided 2013 Emerging Tech Awardee models to zero net energy homeowners. Preliminary responses clearly showed that consumers were not willing to use efficient settings if they take too long to dry the clothes. Of the eight test homes, none continued to use the dryer in its most efficient setting where the drying time exceeded 2 hours.

1. “D1” procedure described in Federal Register 10 CFR 430 Subpart B, Appendix D1. [↑](#footnote-ref-2)
2. “D2” procedure described in Federal Register 10 CFR 430 Subpart B, Appendix D2. [↑](#footnote-ref-3)
3. Gas dryers may be added in future version of this specification [↑](#footnote-ref-4)
4. Except for Tier 1 which is based on CEF values only using D2 test protocol [↑](#footnote-ref-5)
5. UCEF value here includes any functionality credits as described in section 4.3 [↑](#footnote-ref-6)
6. NEEA Report pending Q2-2015 [↑](#footnote-ref-7)
7. if mode returns to most efficient mode within 2 hours of the last run cycle [↑](#footnote-ref-8)
8. if D2 cycle time is less than 70 minutes – based initial moisture content of 57.5% [↑](#footnote-ref-9)
9. The display must indicate at least 3-5 levels performance where the least efficient mode displays the lowest level, and the most efficient level displays the highest level. Intermediate levels are based on the lb/kWh use of a medium supplemental test load. [↑](#footnote-ref-10)
10. RTF workbook for washers and dryers can be found at <http://rtf.nwcouncil.org/> [↑](#footnote-ref-11)
11. Field data indicates that remaining moisture content from the clothes washer is highly dependent on the type of clothing in the washer. Real clothing retains 140%-160% more moisture after the washer spin cycle than the D2 test cloths retained in the DOE washer test procedure. [↑](#footnote-ref-12)
12. Tier 0 applies to all Non-ENERGY STAR dryers. 30% for small and Fast are based on NEEA field data, no “eco” setting exists for Tier 0 dryers – 10% represents the fraction that people use the delicates setting [↑](#footnote-ref-13)