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Emerging Technology Dryer Testing

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Executive Summary

The purpose of this project was to conduct laboratory testing of the ENERGY STAR Emerging Technology Award-winning clothes dryer (the Samsung DV457A1) to verify its energy performance under the new "D2" test procedure finalized by the U.S. Department of Energy (DOE) earlier this year (Appendix D2 of 10 CFR Parts 429 and 430) (DOE 2013). The resultant dryer testing data and analysis are intended to help the Northwest Energy Efficiency Alliance (NEEA) determine whether this dryer is likely to deliver real energy savings to consumers. Moreover, this testing provides additional insight into the impact of using real-world clothing rather than DOE test cloths on dryer energy performance.

- The results of this test do not invalidate the dryer's ability to achieve the Environmental Protection Agency's (EPA's) Emerging Tech award criteria, as that was based on an earlier DOE test protocol.

- The dryer as configured would not qualify for ENERGY STAR under EPA's most recent Draft Specification that was released in September, 2013 (EPA 2013).

- This dryer has similar performance to conventional dryers that are slowed down.

- Under the Eco-Normal mode peak demand of the dryer was reduce from over 5400 watts to under 1800 watts, potentially resulting in considerable demand savings.

- Real-world energy savings depend on how often consumers choose to run the product in its most efficient, slowest drying mode. The tested dryer can save twenty-five to thirty percent of its energy use when tested in slow mode relative to fast mode, and can achieve a combined energy factor in slow mode that would meet the most recent ENERGY STAR Draft Specification.

- If the dryer's slowest mode (i.e. "Eco-Normal") was set as the default mode by the manufacturer, D2 test results would be very favorable, however with drying times more than twice as long as typical and consumers may choose alternate settings.

1. Introduction

The purpose of this project was to conduct laboratory testing of the ENERGY STAR Emerging Technology Award-winning clothes dryer (the Samsung DV457A1) to verify its energy performance under the D2 test procedure finalized by the U.S. Department of Energy earlier this year (DOE 2013). The resultant dryer testing data and analysis are intended to help the Northwest Energy Efficiency Alliance (NEEA) determine whether this dryer is likely to deliver real energy savings to consumers. Moreover, this testing provides additional insight into the impact of using real-world clothing rather than DOE test cloths on dryer energy performance.

2. Methodology

Ecova conducted nine valid test runs of the specified dryer, all of which relied exclusively or primarily on the D2 test procedure (DOE 2013). Six of the dryer runs tested the dryer's energy performance when drying the test cloths specified by all DOE test procedures. The other three runs tested the dryer's performance using a test load – designed by the Association of Home Appliance Manufacturers (AHAM) in 1992

While this dryer offers myriad modes for drying, Ecova conducted all of this testing in one of three modes: i) normal with "Eco Dry" (the default mode, which is the mode under which D2 requires the dryer to be tested); ii) normal without "Eco Dry"; and iii) "Eco Normal."[1] For the most part Ecova tested each combination of a mode and a load only once, so greater uncertainty exists than with the full DOE test, which averages three runs using the same mode and load combination.

This dryer's ability to win the Emerging Technology Award focused on its performance in the normal-with-"Eco Dry" mode and in the "Eco Normal" mode. However, the Emerging Technology Award evaluated energy performance under the 2005 version of the DOE test procedure (Appendix D of 10 CFR Parts 429 and 430) (DOE 2005). As a result, Ecova's testing for this project does not indicate the dryer's ability to meet the criteria set by EPA for the Emerging Technology Award.

[1] These three modes are identified as medium, fast, and slow, respectively, due to the dryer's relative speed in drying a load.

3. Findings

Table 1 and Figure 1 show the summary results from the nine valid test runs. When a test run was unable to achieve the required two percent relative moisture content (RMC), the dryness setting was advanced to a higher dryness and re-run. It should be noted that only one setting was run three times to establish a consistent and validated combined energy factor (CEF) number according to the standard test protocols. Other runs conducted can give insight but should not be considered as validated.

The terms "slow," "medium," and "fast" are not settings on the dryer. These adjectives describe the relative speed of the three different test settings of Eco Normal, Normal w/o EcoBoost and Normal w/EcoBoost, respectively.

Figure 1. Test Run Comparison

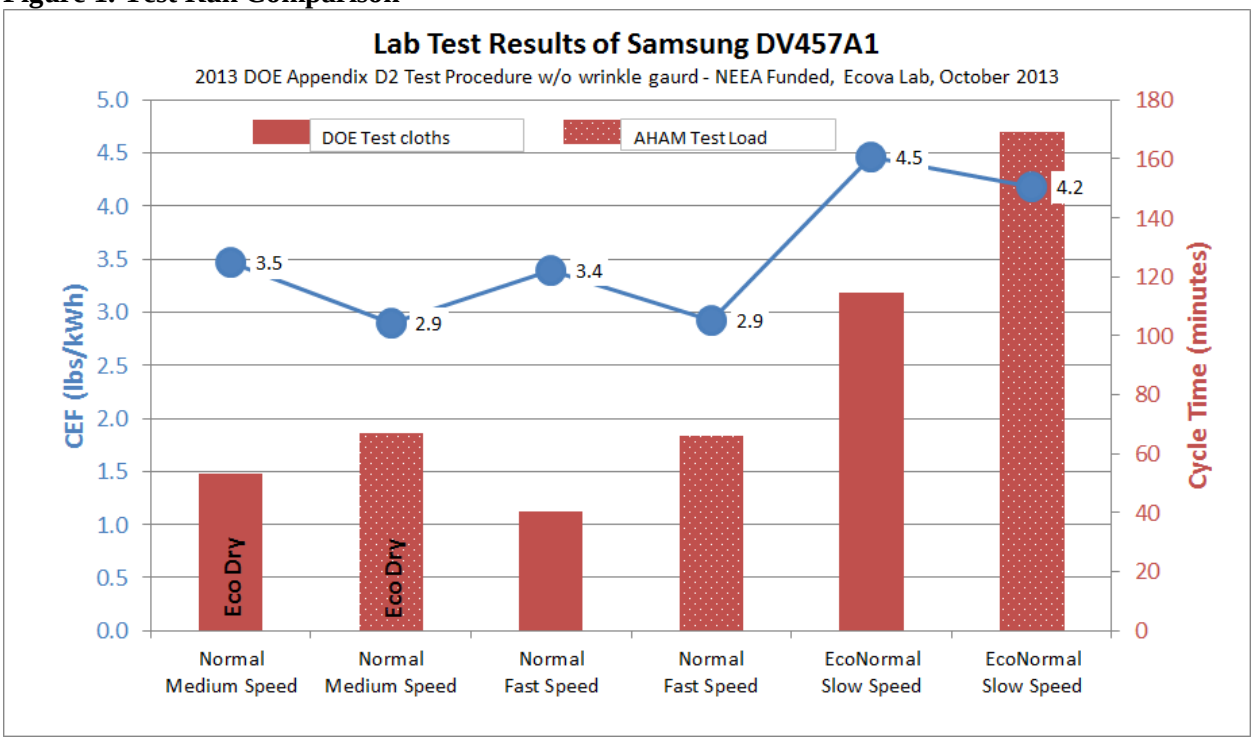


Table 1. Summary of Test Run Results

Test Settings	Test Cloth	Speed	Run #s	Dryer Setting Used in Test	Per Cycle Energy Consumed (kWh)	CEF (lbs/ kWh)	Dry Time (min)	RMC (%)
Normal w/ Eco Dry	DOE	Medium	322	Normal	2.32	3.46	52.0	-0.2%
Normal w/ Eco Dry	DOE	Medium	331	Normal	2.32	3.45	57.0	0.6%
Normal w/ Eco Dry	DOE	Medium	333	Normal	2.28	3.50	50.5	0.6%
Normal w/o Eco Dry	DOE	Fast	323	Normal	2.28	3.52	38.2	-0.2%
Normal w/o Eco Dry	DOE	Fast	327	Normal	2.45	3.28	42.9	0.4%
Eco Normal	DOE	Slow	321	Very Dry	1.78	4.46	114.6	1.4%
Normal w/ Eco Dry	AHAM 1992	Medium	329	Very Dry	2.77	2.90	67.1	0.0%
Normal w/o Eco Dry	AHAM 1992	Fast	334	Normal	2.76	2.96	47.1	1.6%
Eco Normal	AHAM 1992	Slow	330	Very Dry	1.88	4.18	169.4	4.5%

Figures 2 and 3 show the cumulative energy use over time of test runs with both DOE test cloths and AHAM test clothing. Both

Figure 2 and Figure 3 show that fast mode behaves similarly to conventional dryers, with much of its time at 5300 W (the high slope common in the red line). The medium speed mode spends significant time at only 1800 W (medium slope of much of the blue line). The slow mode spends most of the time in no-heat mode (the low slope common in the green line).

In the "valid" slow mode run with the AHAM test load, the dryer effectively dried the clothing, even though it achieved a final remaining moisture content (RMC) of 4.5 percent, which is greater than the two percent maximum final RMC specified by the D2 test procedure. Notably, a uniform 4.5% RMC does feel dry to the touch and is approximately the RMC that all clothing achieves once it reaches equilibrium with the room air moisture several hours after the clothing is dried.

Figure 2. Cumulative Energy Use versus Time in the Three Drying Speeds with DOE Test Cloths

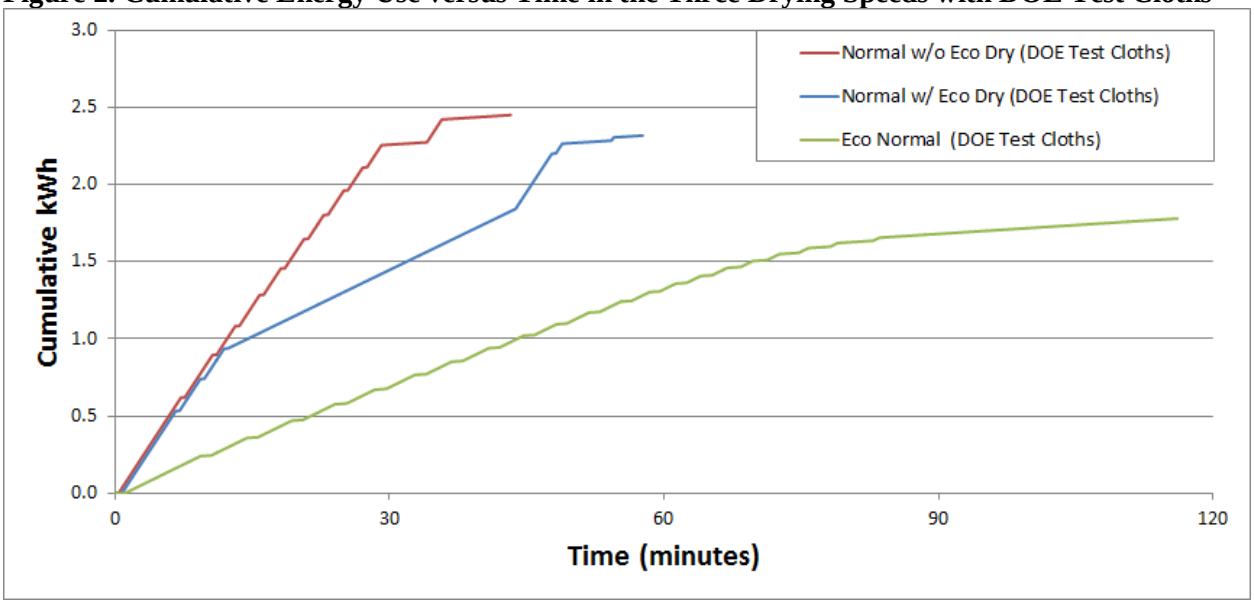


Figure 3. Cumulative Energy Use versus Time in the Three Drying Speeds with AHAM 1992 Test Load

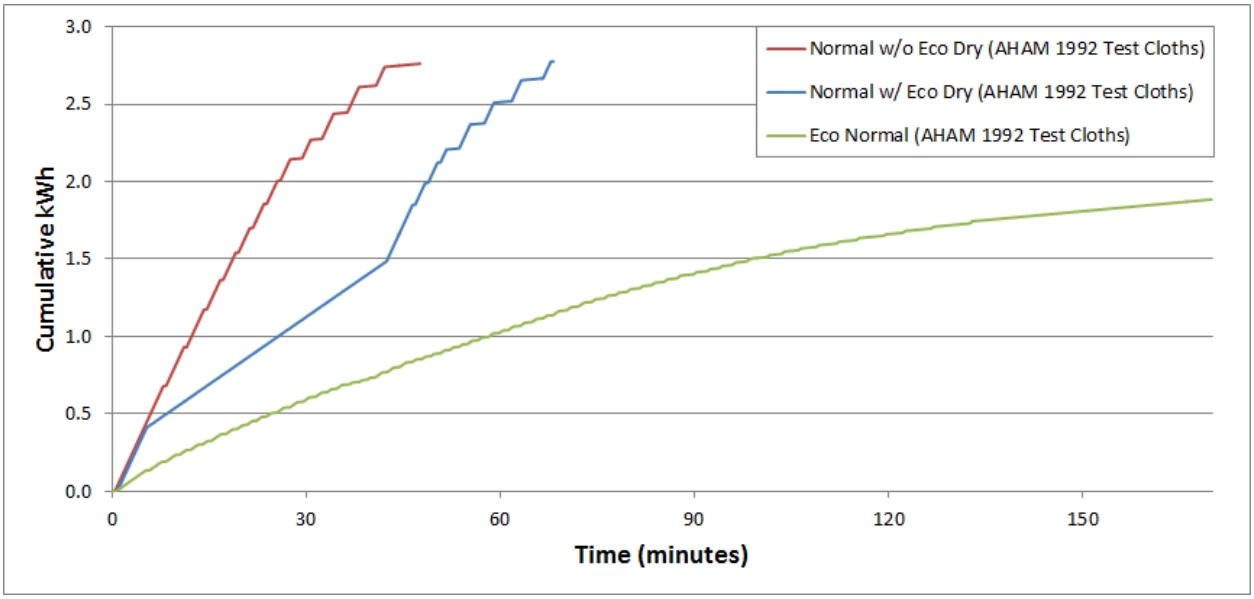


Figure 4 shows the combined energy factor (CEF) vs. drying time of the Emerging Technology (ET) award winner DOE cloth tests in context with other dryers. The fast and medium-speed ET results are typical for conventional dryers. The slow mode is forty-four percent more efficient than the EPA baseline (passing EPA's proposed flat spec line), but takes longer to dry than European heat pump clothes dryers.. The highest blue circle references a European heat pump clothes dryer.

Figure 4. CEF versus Drying Time for DOE 2013 D2 Tests with DOE Test Cloths

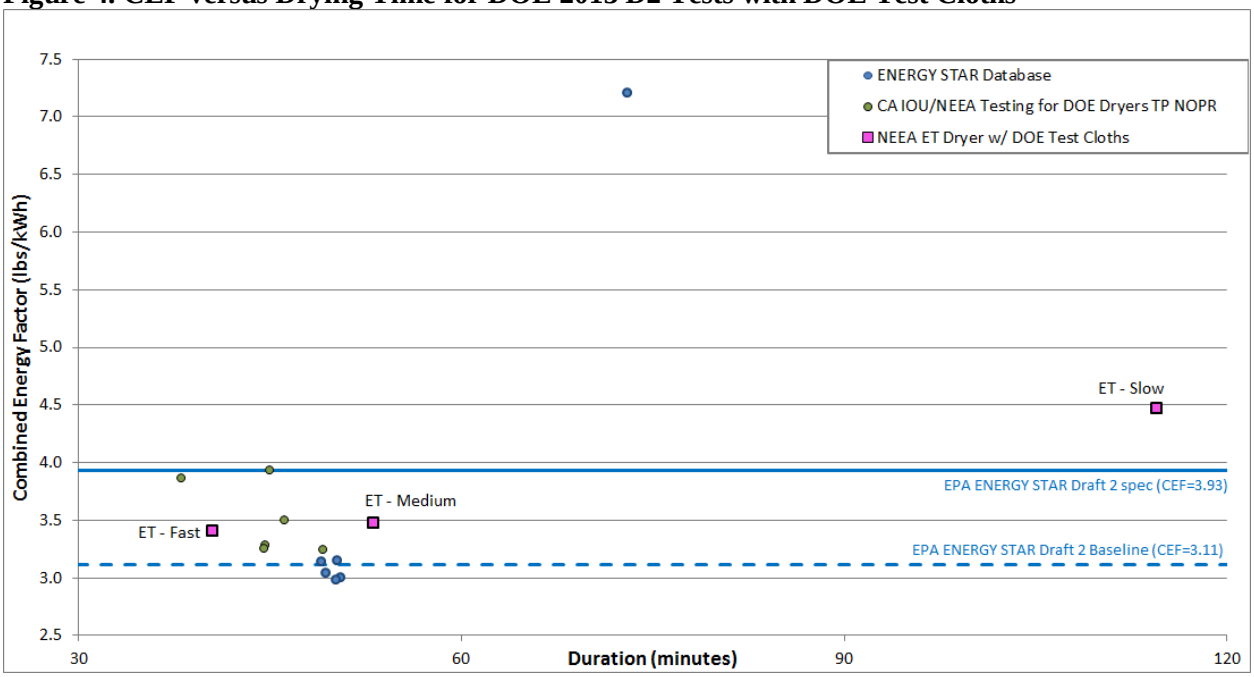
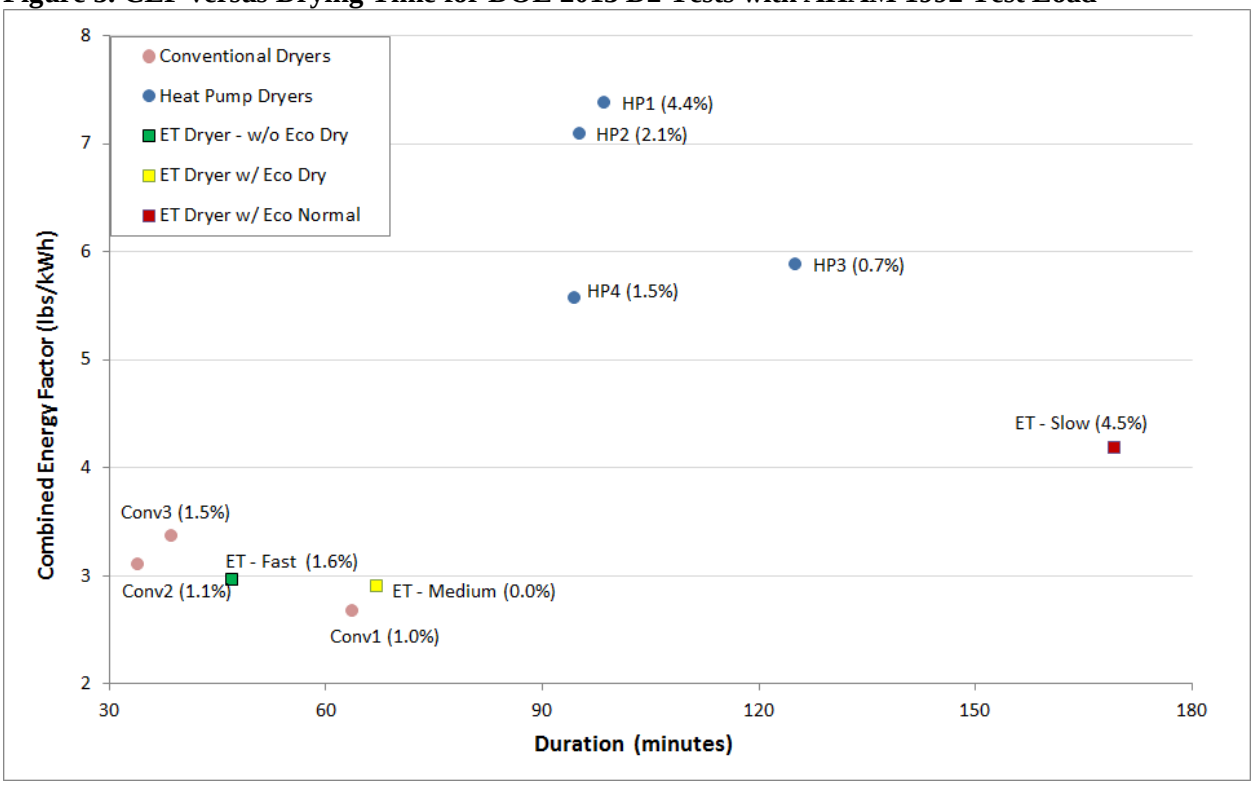


Figure 5 puts the ET AHAM 1992 tests in context with other dryers tested with this test load. The fast and medium-speed ET results are typical for conventional dryers. The fast speed exhibits greater efficiency than the medium speed, likely because the medium speed bone-dried the clothing (medium speed required very dry clothing, while fast speed only required normal dryness). The slow mode demonstrates significantly higher efficiency, but again takes longer to dry than a heat pump.

Figure 5. CEF versus Drying Time for DOE 2013 D2 Tests with AHAM 1992 Test Load



4. Conclusions

- The results do not invalidate the dryer's ability to achieve EPA's Emerging Tech award criteria, as those criteria were based on the earlier DOE test protocol.
- The dryer as configured would not qualify for ENERGY STAR under the Environmental Protection Agency's (EPA's) most recent Draft Specification (EPA 2013).
- The auto termination feature of this dryer currently appears to dry the test cloths to lower RMC values than is required (i.e., less than two percent). This results in both longer run times and higher energy use.
- This dryer does not appear to utilize any breakthrough technologies; it exhibits performance similar to conventional dryers that are slowed down. It does, however, appear to have the capabilities of greater control and power modulation than similar conventional dryers. Though speculative, this dryer may possibly operate more efficiently if these features are fully utilized.
- Real-world energy savings depend on how often consumers choose to run the product in its most efficient, slowest drying mode. The dryer can save twenty-five to thirty percent of its energy use when tested in slow mode relative to fast mode, and can achieve a combined energy factor in slow mode that would meet the most recent ENERGY STAR Draft Specification. However, the drying times observed in slow mode were so long that consumers may not regularly use them.
- If a manufacturer selects a slow drying mode as the default mode, the D2 test procedure would indicate energy savings that consumers may not realize if they regularly choose a more standard, quicker mode. (Samsung did not select such a mode as the default mode for this dryer.)
- Longer run times inherently deliver more evenly-dried clothes, even with heavier test clothes. Setting a higher RMC or using a different method of measuring RMC for long run times may be valid measures.
- The Samsung DV457 dryer is capable of providing substantial demand savings (kW) because of its ability to stage heater elements. If the unit can achieve more accurate auto termination, the combination of both demand (kW) and energy (kWh) savings would make this a compelling product for utility programs.

References

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U.S. Environmental Protection Agency (EPA). 2013. *ENERGY STAR® Program Requirements: Product Specification for Clothes Dryers. Eligibility Criteria,* Draft 2 Version 1.0. Retrieved from https://www.energystar.gov/products/specs/sites/products/files/ENERGY%20STAR%20Draft%202%20Version%201.0%20Clothes%20Dryer%20Specification.pdf