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# CA IOU CASE Team Response to Draft Staff Proposal and Stakeholder Comments for Commercial Tumble Dryers

*Additional submitted attachment is included below.*

# Commercial Tumble Dryers

Codes and Standards Enhancement (CASE) Initiative
For PY 2017: Title 20 Standards Development

**Response to Draft Staff Proposal and Stakeholder Comments**

**Docket: 17-AAER-01**

September 1, 2017

Prepared for:

PACIFIC GAS & ELECTRIC COMPANY

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# 1. Introduction

The Pacific Gas and Electric Company (PG&E), Southern California Edison (SCE), Southern California Gas (SCG), San Diego Gas & Electric (SDG&E) Codes and Standards Enhancement (CASE) Initiative seeks to address energy efficiency opportunities through development of new Title 20 requirements. Individual reports document information and data helpful to the California Energy Commission (CEC) and other stakeholders in the development of these requirements. This document provides recommendations and supporting analysis in response to the CEC Draft Staff Proposal for Commercial Tumble Dryers Testing, Certification, and Marking Requirements published to docket 17-AAER-01 on July 18, 2017.

The California Investor-Owned Utilities (IOU) CASE Team (CASE Team) supports the CEC proposal to require testing and certification (test and list) of commercial tumble dryers. In California, more than 500,000 commercial tumble dryers operate in shared apartment laundromats, coin-operated laundromats, and on-premises laundries (OPLs). These tumble-type dryers use approximately 900 GWh and 260 million therms per year, costing businesses more than$440 million per year to operate. Through their operation, they emit 1.8 million metric tons of carbon dioxide equivalent ($MTCO_2e$) annually. Readily available technologies, such as burner/fan modulation, heat exchangers, and sensing/control, can save 20 to 50 percent of total energy used by commercial tumble dryers. Many of these technologies are in today's models.

Adopting the IOU-proposed test procedure and requiring reporting is the first step to realizing the energy, cost, and greenhouse gas (GHG) emissions savings available from commercial tumble dryers. Reducing commercial dryer energy use by 20 percent for California businesses would mean 180 GWh and 50 million therms annually after full stock turnover, delivering nearly $90 million in utility bill savings, and would reduce emissions annually by 360,000 $MTCO_2e$. The Draft Staff Proposal for Commercial Tumble Dryers supports the aggressive California goal of reducing emissions 40 percent below 1990 levels by 2030 (SB32 2016), as well as other long-term energy and air-quality goals.

Earlier this year, the CASE Team provided the CEC a test protocol[1] and CASE Report[2] to enable the State to measure the energy efficiency of commercial tumble dryers. The purpose of comments herein is to address stakeholder questions that arose in the August 3, 2017, workshop at the CEC and to add some technical detail not included in the December CASE Report. Information on elements of the test protocol – specifically repeatability/reproducibility, ambient condition tolerances, ambient temperature value, textile moving equipment, textile type, and textile handling instructions – are provided. Additional research on the measurement of low power modes, energy-saving technologies, automatic termination, and the importance of multifamily

[1] Foster Porter, Suzanne et al. Energy Efficiency Test Procedure for Commercial Tumble Dryers, Version 2.6. 29 June 2017. Available at: http://docketpublic.energy.ca.gov/PublicDocuments/17-AAER-01/TN219983_20170630T090536_Suzanne_Foster_Porter_Comments_Commercial_Dryer_Test_Protocol_v.pdf

[2] Foster Porter, Suzanne et al. Commercial Tumble Dryers, Codes and Standards Enhancement (CASE) Initiative For PY 2016: Title 20 Standards Development, Analysis of Test Procedure Proposal for Commercial Tumble Dryers. 16 December 2016. Available at: http://docketpublic.energy.ca.gov/PublicDocuments/17-AAER-01/TN215801_20170207T123552_T20_CASE_CommercialDryerTestProtocol_FINAL.PDF

dryers are included. Finally, the CASE Team makes recommendations on scope wording changes. The CASE Team appreciates CEC's careful consideration of all comments provided herein.

## 2. The Commercial Tumble Dryer Test Protocol is both repeatable and reproducible

**Summary:** The CASE Team has high confidence that the test procedure is both repeatable and reproducible. Based on lab data, the CASE Team rigorously designed the test procedure to improve repeatability/reproducibility while reducing cost relative to the United States Department of Energy (U.S. DOE) requirements for residential dryers. Lab data confirm these test protocol design efforts were effective: Repeatability studies show the uncertainty of the efficiency value is small. (The 95 percent confidence interval is ±one to ±two percent of the value.) Given its long history of supporting a highly-regulated industry, and its quality management system, the CASE Team has high confidence in PG&E's Applied Technology Services (ATS) lab to reliably execute the test procedure. Furthermore, the CASE Team plans to complete further empirical reproducibility research.

**Discussion:** The CASE Team based decisions to tighten or relax instrumentation and procedural tolerances relative to the U.S. DOE test procedure on extensive exploratory testing that identified the variables that most impacted the dryer efficiency measurement. The CASE Team began the development of the test procedure by investigating the variables known to impact the efficiency of commercial tumble dryers: load size, load composition, ambient temperature and humidity, initial moisture content, remaining moisture content, settings, and cycle time. The manner in which these variables impact efficiency is summarized in Table 5.5 (page 34) of the CASE Report[3] published to this docket. Part of the purpose of this investigation was to identify those parameters that needed to be carefully controlled to ensure highly repeatable and reproducible results. Key variables – such as initial moisture content, temperature, humidity, textile composition, etc. – were altered one at a time while all other elements of the test run were held constant. This enabled the CASE Team to isolate the impact of specific variables in the test protocol. Figure 5.1 in the CASE Report highlights the results of some of that testing.

Once the most important variables were isolated, the CASE Team estimated (based on its experience in the lab) the anticipated cost of adding additional controls and the uncertainty reduction in the efficiency value expected with that control. The CASE Team picked the lowest hanging fruit (low cost and high uncertainty reduction) to incorporate in the test procedure. These changes relative to the U.S. DOE residential test protocol are summarized on Page 25 and 26 of the CASE Report. Furthermore, this detailed data collection allowed the CASE Team to identify sources of cost in the U.S. DOE test procedure that were not necessary to keep the uncertainty of the tested efficiency value low enough to maintain repeatability and reproducibility. The CASE Team removed those requirements in the U.S. DOE test procedure that were unnecessary, thereby reducing the testing burden (Section 5.2.2 of the CASE Report, page 24 and 25).

The CASE Team conducted repeatability studies of the test protocol with two tumble dryer models (11.4 cubic feet – 30 pounds and 13.3 cubic feet – 55 pounds) to better understand the variability

[3] Foster Porter, Suzanne, et al. Commercial Tumble Dryers, Codes and Standards Enhancement (CASE) Initiative for PY 2016: Title 20 Standards Development, Analysis and Test Procedure Proposal for Commercial Tumble Dryers, Docket #12-AAER-2D. 16 December 2016. Available at: http://docketpublic.energy.ca.gov/PublicDocuments/17-AAER-01/TN215801_20170207T123552_T20_CASE_CommercialDryerTestProtocol_FINAL.PDF

of efficiency measurement. These empirical studies of the Commercial Tumble Dryer Test Procedure confirm that the 95 percent confidence interval of the repeatability is between ±1 and ± 2 percent.

Because the test procedure is relatively new, formal reproducibility studies have not been conducted to date. The CASE Team expects that applying this rigorous uncertainty and cost analysis has enabled a highly reproducible test procedure. However, the CASE team is now embarking on such a reproducibility study to confirm its expectation.

In addition to the careful design of the protocol, the laboratory conducting the dryer efficiency tests has a long history of delivering high-quality results. For more than 40 years, PG&E's ATS Lab has supported the highly-regulated energy industry, including providing calibration and other technical services to the PG&E nuclear power plant. ATS applies known best practices to maintain the quality of the data produced in the dryer lab, and is currently working on incorporating the dryer test protocol into its ISO/IEC 17025 quality management system. Furthermore, before the development of the commercial tumble dryer test procedure began, the PG&E ATS dryer lab reproduced UL energy efficiency results under U.S. DOE and the Utility Test Protocols[4]. The measurements were reproducible within the expected uncertainty for these procedures.

## 3. Environmental condition tolerance in test procedure reduces variance in test result at relatively low cost, improving repeatability and reproducibility

**Summary:** The CASE Team encourages the CEC to retain the ambient condition tolerances of ± 1.5 degrees F and ± 5 percent relative humidity specified in the IOU-proposed test procedure. Although these tolerances are tighter than U.S. DOE-proposed tolerances, they cut in half the variance associated with the ambient condition range (from 4 percent to 2 percent of the measured energy value), significantly improving repeatability and reproducibility of the test protocol. Reducing this variance is accomplished at relatively low cost, especially because control systems have become significantly more advanced in the four decades since the wider tolerances were initially adopted by the U.S. DOE.

**Discussion:** Any test procedures specifies the allowable error for each measurement as well as detailed instruction to enable repeatable and reproducible results that policymakers, manufacturers, distributors, and businesses can trust. The CASE team conducted a comprehensive review of the U.S. DOE residential dryer instrumentation tolerances and testing instructions that impact repeatability, reproducibility, and cost, and sought cost-effective changes that would improve repeatability, reproducibility, and/or reduce overall test burden for commercial tumble dryer manufacturers.

One of the changes that the CASE Team incorporated into the IOU-proposed test protocol is to require tighter tolerances on the range of temperature and humidity allowed in the dryer testing chamber during the test run. This change was made because the CASE Team test results revealed that ambient temperature conditions are second only to load size in their impact on the efficiency measurement of a tumble dryer. The energy efficiency of two dryers (11.4 cubic feet – 30 pound

[4] Ecova on behalf of NEEA and PG&E. Utility Test Protocol for Residential Clothes Dryers, 2015. Available at: https://conduitnw.org/_layouts/Conduit/FileHandler.ashx?rid=2843

and 17.3 cubic feet – 55 pound), the first with conventional technology and the latter with burner modulation technology installed as a retrofit, were evaluated at 75 degrees F and then again with all other variables constant at 95 degrees F. The efficiency of one dryer during the 95 degree F test run improved by 12 percent, and the other dryer improved by 14 percent when compared to the tests run at 75 degrees F.[5] These results reveal that over the range of the U.S. DOE-allowed ambient condition temperatures (± 3 degrees F), the change in the efficiency measurement due ONLY to the change in ambient conditions could be more than 4 percent.

Manufacturer testing results of residential dryers under the U.S. DOE test protocol confirm the CASE Team's findings of high variation of efficiency associated with the U.S. DOE-allowed ambient temperature range during test. In fact, Chapter 5 of the 2011 U.S. DOE technical support document (TSD) related to developing a repeatable energy factor (EF) result for residential clothes dryers states:[6]

> DOE believes that the lack of strong correlation between measured and rated clothes dryer EF can be traced to the tolerances that are allowed in the test procedure, notably for the ambient test room conditions. Whirlpool Corporation (Whirlpool) submitted data to DOE that demonstrates the effect of a change in ambient relative humidity and temperature on EF. Parametric variations in relative humidity from 40 to 60 percent and ambient temperature from 72 to 78 °F, which are the limits allowed under the test procedure, produce measured EFs for an electric compact (120 V) clothes dryer that range from 2.98 to 3.35 lb/kWh.

This 12 percent change in efficiency associated with 6 degrees F change in ambient temperature (and allowed changes in humidity) is larger than the results for commercial tumble dryers (4 percent), suggesting that ambient temperature (and humidity) variation may be more important for the repeatability and reproducibility of the efficiency of residential-platform dryers.

Fortunately, in the IOU-proposed test procedure, this range (and thus the variance) is reduced by half (to 2 percent of the value for larger dryers) at relatively low cost by narrowing the allowed ambient condition temperature to ± 1.5 degrees F. HVAC equipment used for maintaining the ambient conditions can be programed to a tighter algorithm than required for the U.S. DOE test procedure to achieve this tolerance. An estimated one to nine dollars added per test run is expected to pay for additional technician time required to set up algorithm control during the commissioning phase and a few more minutes each test to start the dryer and confirm thermal stability before proceeding with run.[7] The PG&E ATS lab successfully maintains the tolerances in the test protocol, and the cost estimates cited are based on the CASE Team's experience commissioning the test chamber and running the protocol on a variety of dryers.

Furthermore, the humidity of the ambient conditions during test were tightened from ± 10 percent humidity to ± 5 percent. Although humidity did not have a large impact on efficiency for the two units that the CASE Team evaluated, follow up research revealed that humidity may be more important for dryers with heat exchangers.

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5 Foster Porter et. al. 16 December 2016. Figure 5.1, p. 32.

6 U.S. DOE. "Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Residential Clothes Dryers and Room Air Conditioners," April 2011. Available at https://www.regulations.gov/document?D=EERE-2007-BT-STD-0010-0053

7 Foster Porter et al. 16 December 2016. Table 5.3, p. 28.

Finally, the IOU-proposed test procedure requires that ambient temperature and humidity conditions be met only 95 percent of the time as long as the average ambient conditions fall within the required tolerance range. This allows for more flexibility compared to U.S. DOE, where a short deviation in ambient conditions requires a repeat of the entire test run. Short deviations do not have a significant impact on the energy measurement, and are therefore allowed in the protocol to give as much flexibility as possible to commission the test set up and run the test.

Taken together, these ambient condition provisions of the IOU-proposed protocol find an effective balance between cost and variance reduction to give California reliable energy information on commercial tumble dryers while minimizing test burden.

# 4. Ambient test temperature (65 degrees F) in the commercial tumble dryer test protocol is appropriate

**Summary:** The ambient temperature required during a dryer test run (65 degrees F) is an appropriate choice given the extra cost to make the test procedure representative of the whole U.S. while the focus is currently for California only.

**Discussion:** Dryers in laundromats and OPL tend to have fresh air intake vents available to ensure proper make up air for the burners and to ease the impact on HVAC equipment. The temperature specified as the ambient temperature for commercial tumble dryer tests, 65 degrees F, is slightly higher than the population-weighted average outdoor air temperature of the four most populated areas in California (62 degrees).[8]

However, the 2015 average outdoor temperature of the contiguous United States was 54 degrees F.[9] Considering the frequency with which the U.S. government adopts California test procedures, it could be more appropriate to use 55 degrees F for the ambient conditions to make the test procedure more representative of the country. However, maintaining the room at 55 degrees F and approximately 50 percent relative humidity requires extra equipment and is more complicated and costly than maintaining a room at 65 degrees F. It is also close to the set point that standard HVAC systems are designed to achieve (around 70 degrees F), thus standard equipment can more easily control to 65 degrees F.

Furthermore, even when the U.S. adopts California test protocols, this is often done in a rulemaking process where changes can be made to make it representative of the U.S. Many of California's appliance test procedure have been revised at the federal level to make these types of adjustments. In the meantime, the applicability of this test procedure is limited to California, and the representation of California conditions are appropriate.

# 5. Guidance on equipment required to handle large textile loads

**Summary:** All textile load sizes in the test protocol, including the largest possible load (163 pounds), can be moved using laundry carts. The weight of the textiles can be measured on floor

[8] Foster Porter et al. 16 December 2016. Table 5.6, p. 37.

[9] United States National Oceanic and Atmospheric Administration National Climate Report. Accessed 22 August 2017. Available at https://www.ncdc.noaa.gov/sotc/national/201513#over

scales, eliminating the need to move any textiles with a crane or other more expensive piece of equipment.

**Discussion:** A stakeholder at the August workshop expressed concern over costs expected with the need for a crane to move textiles around the lab during while performing the test procedure. The CASE Team has developed an approach using laundry carts and floor scales to accommodate these larger loads. Laundry carts used in large commercial laundries can be lined with impermeable plastic bags, and textile loads can be moved in and out of these carts within the time tolerances required by the protocol. These carts can be pushed onto a floor scale to measure the textile weight (see Figure 5.1). For the largest loads, the textiles can be divided into two carts and the weight can be measured in series on the floor scale. This low-cost method uses readily-available equipment to move and measure textiles in the protocol, minimizing test burden.


**Figure 5.1 Measuring the weight of a laundry cart on a floor scale**

Source: CASE Team 2017

# 6. International Electrotechnical Commission (IEC) cotton textiles are the best choice for testing the energy use of commercial tumble dryers

**Summary:** A number of different loads were considered during the development of the commercial tumble dryer test procedure, and IEC cotton textiles (IEC 60456:2010, Fifth Edition) were chosen because they are:  representative of vended and OPL loads, readily-available in the market, tightly-specified to be repeatable/reproducible, and specified in other dryer energy test protocols (in Europe and elsewhere) to measure the energy use and performance of residential tumble dryers.

**Discussion:** The CASE Team evaluated a number of different textile types when considering which to specify for the commercial tumble dryer test protocol. Textiles considered included U.S. DOE test cloths, IEC cotton textiles, IEC synthetic textiles, and Utility Test Protocol textiles.

Section 5.2.3 of the CASE Report summarizes the benefits of the IEC cotton load to measure commercial tumble dryer efficiency. Specifically, they enable representative results and are:

- available from multiple vendors in the U.S.;
- expected to be reproducible because of tight specifications developed during an international stakeholder process;
- verified by the CASE Team to be repeatable;
- utilized by industry in the U.S. and in Europe to measure both dryer performance (in the AHAM/ANSI HLD-1-2010 and IEC 61121:2012) and dryer energy use (IEC 61121:2012).

However, the CASE Report did not specifically describe the CASE Team's rationale for not selecting the U.S. DOE test load to measure the energy use of commercial tumble dryers. In short, U.S. DOE test cloths have been shown to inaccurately predict (underestimate) residential dryer energy use[10]. DOE textiles are small (approximately the size of a dinner napkin), are 50 percent cotton and 50 percent synthetic, and much easier to dry than typically larger real-world, three-dimensional textiles. Although repeatability and reproducibility of U.S. DOE textiles have been confirmed over time, these textiles do not meet the CASE Team goal to create a protocol representative of real-world energy use. IEC cotton textiles are repeatable, expected to be reproducible, and more representative than U.S. DOE test cloths. Furthermore, we expect it to be cost neutral or to even reduce material costs.

Although the cost of IEC cotton textiles is not expected to be higher than the cost of U.S. DOE test textiles, the commercial tumble dryer protocol includes a method (adapted from IEC 61121:2012 and AHAM/ANSI HLD-1-2010) to enable 80 test runs with the IEC cotton textiles. The U.S. DOE test protocol allows only 25 runs before the test cloths must be retired. More runs per test textile reduces materials costs associated with the application of the commercial tumble dryer test protocol relative to the U.S. DOE method.

# 7. Textile handling instructions effectively protect against changes in textile moisture content, even at low remaining moisture content (RMC) levels specified in the protocol

**Summary:** CASE Team measurements reveal that when textiles are handled according to the test protocol, dryer efficiency measurement uncertainty from RMC changes during textile transfer to the scale is very small (less than ± 0.1 percent) compared to other sources of measurement uncertainty.

**Discussion:** A stakeholder at the August workshop expressed concern regarding uncertainty associated with textile moisture content change at the end of the dryer cycle, especially for lower RMCs (between 0 and 3 percent). The CASE Team conducted an investigation to quantify the impact of measurement uncertainty associated with changes in textile moisture content expected under the protocol's textile handling instructions. Two load sizes – a partial load for a residential-

[10] Dymond, Christopher et al. "Clothes Dryer Testing, Testy Testing Makes for Better Transformation." Published in the ACEEE Summer Study proceedings of 2014. Available at http://aceee.org/files/proceedings/2014/data/papers/9-852.pdf

platform machine (9.4 pound bone dry weight) and a full load for an 83-pound OPL machine (59.6 pound bone dry weight) – were investigated as part of the study. Each load was prepared and then dried to a low RMC (between 0 and 3 percent) using Run A in the test protocol (high heat and timed dry) as a guide. The CASE Team minimized the time to transfer textiles between the dryer and the measurement scale as much as possible to reduce changes to moisture content, including unloading the textiles immediately upon termination of the cycle. Once the textiles were in the vessel and on the scale, the weight of the textiles was recorded for seven minutes with the vessel's lid/cover on and then for seven minutes with the lid/cover off. These additional measurements were to investigate conditions where, in the process of transferring and weighing, the textiles may sit in a closed or open bin for periods of time longer than allowed under the protocol. All measurements were conducted in the conditions of the test chamber (65 ± 1.5 degrees F and 50 ± 5 percent humidity).

Table 7.1 summarizes the measurements for these three points in time after the termination of the cycle:

- the textiles and vessel are placed on the scale with lid/cover on the vessel (time (t) = 0 minutes)
- seven minutes later (t = 7 minutes), after allowing the textiles to sit in a bin with a lid
- seven minutes later (t = 14 minutes), after exposing the textiles to the air for seven minutes (lid/cover removed)

Other relevant information and key discussion points follow.

**Table 7.1 Summary of data during textile transfer**

| | **Partial load for 18-pound residential-platform dryer** | **Full load for 83-pound OPL dryer** |
|---|---|---|
| Bone dry weight of load (pounds) | 9.44 | 59.6 |
| *Textiles in vessel with lid placed on the scale (t=0)* | | |
| Weight of textiles(pounds) | 9.441 | 61.00 |
| Remaining moisture content (%) | 0.00 % | 2.35 % |
| *Note: this is the weight recorded per the test protocol* | | |
| *Textiles in vessel with lid at the end of seven minutes (t=7 min)* | | |
| Weight of textiles (pounds) | 9.444 | 60.99 |
| Remaining moisture content (%) | 0.02 % | 2.34 % |
| Percent change in weight during period compared to initial measurement t=0 (%) | 0.02 % | -0.01% |
| *Textiles in vessel without lid exposed to the air for seven minutes (t=14 min)* | | |
| Weight of textiles (pounds) | 9.452 | 60.98 |
| Remaining moisture content (%) | 0.11 % | 2.32 % |
| Percent change in weight during period compared to initial measurement (t=0) (%)[11] | 0.11 ± 0.01 %[12] | -0.03 ± 0.02 %[13] |

Source: CASE Team 2017

During the measurement period, the textile temperature remained constant within measurement uncertainty. For the 9.44 pound load, the temperature was 130 degrees F, and for the 59.6 pound load, the temperature was 104 degrees F. Because the temperatures of the loads remain constant throughout the investigation, the textile moisture content changes measured while on the scale are expected to closely mimic moisture content changes following the termination of the dryer cycle (during textile transfer to the bin).

[11] Because this investigation focuses on the differences between the measurement over a short period of time, the uncertainty associated with this measurement is the repeatability of the scale, not the accuracy of the scale.
[12] This weight change is positive because the textiles at this temperature are below the equilibrium moisture content with the chamber conditions, so there is condensation of water onto the textiles.
[13] This weight change is negative because the textiles at this temperature are above the equilibrium moisture content with the chamber conditions, so there is evaporation of water from the textiles.

When allowing the textile load to sit for a total of 14 minutes after the end of the dryer cycle (in a vessel with the lid/cover on for seven minutes and then off for an additional seven minutes), the textile weight increased as much as 0.14 percent as the load absorbed water from the air. This increase in weight represents the worst-case scenario for the following reasons:

- The RMC is 0 percent. The load is very dry. The load will more quickly absorb water from the air compared to loads with higher RMC.
- The load is the smallest expected under the protocol. Small loads have the highest ratio of surface area to total mass, providing maximum air exposure. This exposure enables more water absorption by the textiles.
- The load was exposed to the air for seven minutes. (The test protocol only allows for one minute of air exposure during textile transfer from the dryer to the scale.)

The weight change of 0.12 percent contributes ± 0.5 percent uncertainty to the energy factor measurement. Adjusting this uncertainty value to conditions required under the test protocol (only one minute of air exposure) reveals the uncertainty associated with moisture content change at the end of the cycle – even when other conditions are "worst-case" – is less than ± 0.1 percent,[14] very small compared to other sources of uncertainty in the procedure.

The percent change in weight over the 14-minute period for the larger (59.6 pound) load was the same order of magnitude as the repeatability of the scale used to measure the differences in weight (0.02 percent). The change was smaller than the 9.44 pound load because of the higher RMC (approximately 2 percent) and the lower ratio of surface area to total load mass. Even when exposing the textiles to the air for seven minutes, only very small changes in weight were observed.

In conclusion, when the textile handling instructions included in the protocol are followed the uncertainty associated with the change in moisture content is very small, even when measuring low RMC values.

# 8. Measurement of low power modes is important to understanding overall energy use of a commercial tumble dryer

**Summary:** Given the range of power values for low power modes, the possibility of continued increase of energy use in low power modes as more dryers become networked, and the maturity of the technologies available to reduce standby, the CASE Team encourages the CEC to retain requirements for testing and reporting all low power modes for commercial tumble dryers.

**Discussion:** Before electronic controls, many appliances had no standby power, and appliance efficiency test procedures and policy focused on the active mode only. Now that integrated circuits, displays, and other low voltage electronics have been integrated into virtually all appliances, standby power is a notable variable in their energy use. Research on standby power started in the 1990s, and currently more than 20 governments have initiatives to reduce it[15]. While early research

[14] Divided ± 0.5 percent uncertainty by seven to adjust from seven minutes to one minute of air exposure. In practice, loads this small can be transferred into a bin and covered in 20 seconds or less, so uncertainty could be even lower.

[15] Lawrence Berkley National Laboratories is a great resource for current and historical information on standby power. Please see: http://standby.lbl.gov/standby.html

focused only on consumer products, later work has included commercial and industrial appliances as well. For example, the U.S. DOE included standby provisions in commercial water heaters and refrigerated bottle vending machines standards, among others. Commercial tumble dryers are similar to these other commercial appliances, so low power modes for these dryers should be tested and reported as well.

Measurements of low power modes for commercial tumble dryers revealed that there is a range of electronic control technologies and low power mode watt levels found in dryers today [16]. Inspection of the dryer standby circuits reveals some designs have large heat sinks, bigger circuit board packages, and draw as much as 14.5 watts in standby.[17] Other dryers have more sophisticated designs that bring standby power under 4 watts, demonstrating that lower standby power is achievable in the current market.

Low power modes have wide ranges of energy consumption as well. Commercial tumble dryers often default to intermittently tumble textiles after the dryer cycle terminates to prevent wrinkles forming before the textiles are removed. The energy used during this mode, called wrinkle-prevention mode, can vary as much as 300 percent, even within similar dryer sizes. Dryer models differ in the algorithms used to prevent wrinkles in textiles. Some tumble the textiles for longer periods or tumble more often. Some have shorter default run times after the stop of the cycle (e.g., less than an hour), while others have longer than one hour default run times. All of these differences, plus the differences in the size and efficiency of the motors employed by each model, impacts the average power draw in wrinkle prevention mode. Over a one-hour time period following the termination of the cycle, wrinkle-prevention mode of different commercial tumble dryer models varied from 37 to 56 watts in the 30-pound size range, 43 to 173 watts in the 55-pound size range, and 106 to 196 watts in the 75-pound size range. Optimizing these wrinkle-prevention mode algorithms to prevent wrinkles, but also consider energy use, is expected to be a very cost-effective way to reduce low power mode energy use.

Additionally, industry trends suggest that low power mode usage will increase. Although none of the dryers that the CASE Team measured had network connectivity functions, there is an industry trend to bring "big data" to laundry systems. At the 2017 Clean Show, a number of manufacturers[18] were highlighting new dryers that can send data to a cloud-based software platform used for monitoring and controlling machines as well as enabling business analytics at a machine level (see Figure 8.1). While specific data on each machine can be a powerful tool for business owners, the electricity use of tumble dryers in low power modes may increase with this increased functionality. The additional electronics and wireless network employed (Bluetooth, ZigBee, Wi-Fi, etc.) to enable this functionality are likely to impact energy use in network mode, and possibly other modes as well if data transmission occurs during the cycle or at other times (such as during wrinkle prevention). Given this trend, it is important the CEC continue to monitor the impacts of this market development by collecting data on all the low power modes.

[16] Foster Porter et al. 16 December 2016. Figure 4.1, p. 16.
[17] Foster Porter et al. 16 December 2016. Figure 6.7, p. 51.
[18] LG, Electrolux, Alliance Laundry Systems, Dexter, among others.

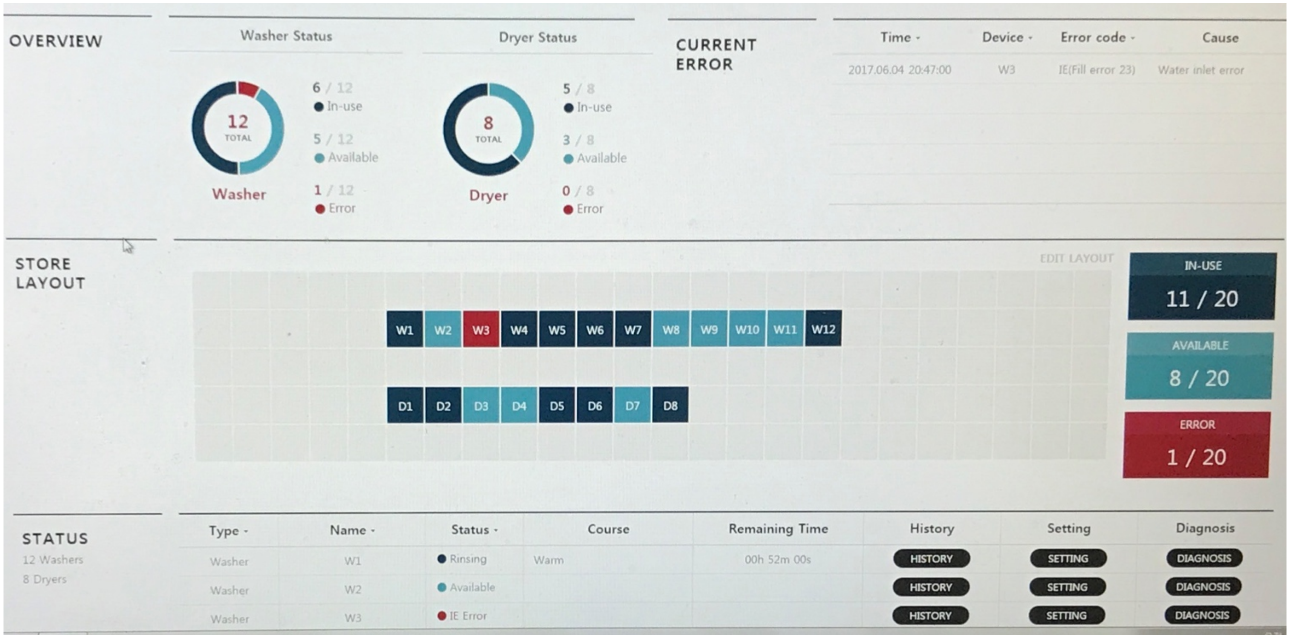


**Figure 8.1 Example of one OEM laundry system software dashboard from Clean Show 2017**

Source: CASE Team 2017

Finally, the CASE Team also expects existing lower power mode saving technologies to be applicable for commercial dryers. The power electronics and integrated circuit industry has been working on optimizing low-power solutions for more than two decades. Many low-power solutions for controls, networking, and displays originally developed for battery-powered devices have come down in cost and are now available for plug-in devices. These technologies are able to reduce energy use in low power mode even if indication of "on" status to the user is required. For example, there are ranges of efficiencies for light-emitting diodes (LEDs) used for liquid crystal display (LCD) backlights. Other technologies, such as motion sensors, can reduce backlight power further when customers (or other users) are not detected in front of the dryer. High-efficiency switch mode power supplies, which convert the line voltage alternating current (AC) to low voltage direct current (DC) improve efficiency and reduce standby associated with low-voltage electronics in all modes of operation. These are just a few examples of the technologies available today to reduce energy use in low-power mode. Given the maturity of this low-power solutions market, the CASE Team expects reducing low power mode consumption for dryers is likely to be cost-effective.

Taken together, the research suggests requirements for testing and reporting low power modes in commercial tumble dryers should be retained.

# 9. A number of energy-savings technologies are in the market today, some of which reduce drying time

**Summary:** Energy-saving technologies are employed in current commercial tumble dryers, as evidenced by the range of energy efficiency seen in the market today. Many of these technologies reduce drying time while improving efficiency. However, careless implementation of energy-saving technologies could lead to increased drying time. The CASE Team supports CEC's proposal to require the reporting of dry time as part of the test and list requirement.

**Discussion:** Over the course of its research, the CASE Team encountered a number of different dryer models from a range of manufacturers that utilize energy-saving technologies. Some of these technologies are discussed in the CASE Report, but 2017 engineering inspections of more-efficient dryer models revealed four more notable energy-saving technologies. Energy-saving strategies not highlighted in the CASE Report include axial airflow, burner and fan right-sizing, heat reclamation, and door insulation. Each is summarized below.

*Axial airflow.* Some dryers employ a radial airflow design. These designs can usually be identified by the presence of a fully perforated drum (Figure 9.1), and air enters the tumbler through the top of the tumbler and exits out the bottom. Although a piece of sheet metal around the perforated surface (the drum liner) helps to guide the air toward the textiles, some air circumvents the load, and does not have an opportunity to pick up moisture from the textiles. In contrast, in axial airflow, the heated air comes through the back planar panel of the tumbler, and exits near the front plane of the door. The air in this airflow configuration is more likely to come in contact with the textiles and therefore pick up moisture. Dryers with axial airflow have partially perforated drums (perforation near the door) or solid metal drums with perforations on the door itself (Figure 9.1). Nearly all residential tumble dryers employ axial airflow.

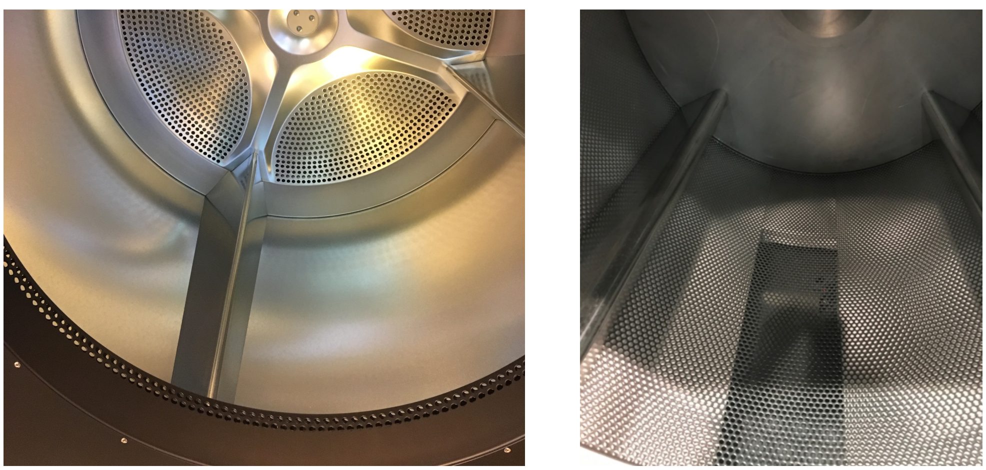

**Figure 9.1 Drum with axial airflow (left) and radial airflow (right)**

Source: CASE Team 2017

*Burner and fan right-sizing.* Many tumble dryers have large burners and fast blowers that are oversized for a full-load of cotton textiles. This over-sizing is presumably to ensure short dry times in all conditions, even for extra heavy or wet loads, but also means that for a full load of cotton textiles, excess heat is produced, consuming more energy than necessary to complete the cycle. As spin cycle speeds have increased in washers, textiles entering dryers as not as wet as they were one or two decades ago, providing the opportunity for dryers to optimize burner BTU output and fan speed. CASE Team results show that dryers with optimized (smaller) burners coupled with slower fans can have program times similar to those with oversized burners and faster fans, even with a full cotton load. For example, two dryers of approximately 75 pounds (Dryer 3 and Dryer 33) – one of which had an oversized burner/fan and the other of which had an optimized burner/fan – both had 40 minute dry times for test Run A (full-sized load, high heat). Under sizing the burner and an excessive reduction in fan speed would likely produce efficiency improvements, but would also lengthen drying time, so engineers must carefully select the ideal burner and fan combination to optimize both drying time and efficiency.

*Heat reclamation* Some tumble dryers draw intake air over components of the dryer that warm with operation, effectively preheating the air before it enters the burner box. Air may be drawn over the motor(s), the drum and other housing panels. Warming the air before it enters the burner box means that the burner can be a slightly lower BTU per hour output or the cycle time is shorter, or both. Heat reclamation is common in residential dryer models.

*Insulated door.* Some dryers have a double-paned tumbler door or a smaller viewing pane in the door to reduce heat loss through the glass. This reduces heat loss through the door.

The presence of these four technologies and other technologies already discussed in the CASE Report[19] is one of the reasons why we see as much as a 60 percent difference in the efficiency measurements of current dryers of similar size[20]. Table 9.1 gives examples of models where the CASE Team has observed implementation of energy-savings technologies.

Some energy-saving technologies (such as tight air sealing and heat reclamation) are not readily observable on specification sheets, but only become apparent with engineering inspection. Because the CASE Team cannot reveal the manufacturer and model information of products that have been tested, the manufacturer and model information is omitted in those cases where engineering inspection is required to identify the energy-saving technology. Finally, all of these technologies can be applied across the entire range of the scope proposed by the CEC staff report, from residential platform dryers to large tumblers.

[19] Foster Porter et al. 16 December 2016. Section 6.1, pp. 44 - 52.

[20] Foster Porter, Suzanne. Commercial Tumble Dryer Test Procedure CASE Overview. Presented 3 August 2017 at the CEC Workshop for docket 17-AAER-01. p. 25. Available at: http://docketpublic.energy.ca.gov/PublicDocuments/17-AAER-01/TN220528_20170802T132351_California_Investor_Owned_Utilities_Workshop_Presentation_Comme.pdf

**Table 9.1 Examples of products with energy-saving technology in the U.S. market today.**

| Technology | Applicable dryer fuel type | Example Product in Current U.S. Market |
|---|---|---|
| Automatic termination or other control schemes | Gas and electric | Many examples, including models[21] from TCATA- and AHAM-member companies. |
| Axial airflow | Gas and electric | Many examples, including models[22] from TCATA- and AHAM-member companies. |
| Burner/fan modulation | Gas and electric | A 2017 model tested by the CASE Team; model is from TCATA-member company. |
| Burner and fan right-sizing | Gas and electric | 2016 and 2017 models tested by the CASE Team; models are from TCATA-member companies. |
| Exhaust recirculation | Gas and electric | A 2017 product line[23] on display at the Clean Show in Las Vegas in June 2017, including dual-pocket (stacked) tumble dryers. |
| Heat exchanger | Gas and electric | Known retrofits installed in U.S.[24] |
| Heat reclamation | Gas and electric | 2016 and 2017 models tested by the CASE Team; models are from TCATA member companies. |
| Heat pump | Electric | A 2017 model[25] on display at the Clean Show in Las Vegas in June 2017. |
| Insulated door | Gas and electric | A 2017 model[26] on display at the Clean Show in Las Vegas in June 2017. |
| Tight air sealing | Gas and electric | 2016 and 2017 models tested by the CASE Team; models are from TCATA member companies. |

Source: CASE Team 2017

[21] Information available at: http://www.unimac.com/technology/optidry.aspx and http://www.adclaundry.com/on-premise/ecodry/ and http://laundrylux.com/on-premises-laundry-equipment/electrolux-on-premises-laundry/dryers/

[22] Information available at: http://www.speedqueencommercial.com/media/845263/stumbler_30lbstack_am17-0037.pdf and http://www.adclaundry.com/on-premise/ecodry/

[23] Information available at: http://www.dexter.com/on-premise-laundry/on-premise-dryers/t-50/ and http://www.dexter.com/on-premise-laundry/on-premise-dryers/t-50x2/

[24] Nexant. "Evaluation of Energy Use with the Rototherm For Commercial Laundry Dryer Heat Recovery." 24 July 2012. Submitted to Southern California Gas Company Emerging Technologies Program.

[25] Information available at: http://www.renzacci-usa.com/rz-series/

[26] Information available at: http://www.adclaundry.com/wp-content/themes/liofolio/library/manuals/on-premise/ES35_OPL.pdf

As discussed in the December 2016 CASE report, energy savings technology can be implemented into dryer designs while maintaining or shortening drying time (also called program time or cycle time). While some energy-saving technologies may lengthen the drying time, many technologies actually shorten it or keep it the same. For example, heat exchangers, axial airflow, burner/fan modulation, insulation, and improved motors are all examples of technology that can be implemented with shorter or the same dry time. Examples of CASE Team measurements and other published research include:

- A 2014 study of a residential dryer with heat exchanger showed 17 percent improvement in energy efficiency and a reduction of drying time by 18 percent.[27]
- A U.S. DOE report from 2005 showed a residential dryer with optimized burner/fan modulation achieved 10 to 15 percent energy reduction and 35 percent reduction in dry time.[28]
- 2016 CASE Team results showed two similarly-sized dryers in the 30-pound capacity range with 60 percent more efficient that the other. The more efficient unit had a number of energy-saving technologies by comparison to the less efficient unit, including axial airflow, burner and fan right-sizing, heat reclamation, and tight air sealing. The more efficient unit had a drying time of 34 minutes, and less efficient unit had the longer drying of 56 minutes when subjected to the same set of tests.[29]
- The CASE Team's 2016 testing of heat exchangers confirmed the drying time of a dryer with a heat exchanger retrofit was nearly identical to the 120-pound dryer without the heat exchanger and had a reduction of energy use by as much as 13 percent.[30]

These are just some examples of CASE Team testing and other research that document energy efficient technologies can lower energy use and decrease dry time simultaneously. Research and testing demonstrate that it is possible to make a dryer more efficient while maintaining customer expectations for drying time. However, careless implementation of energy-saving technologies may result in an increase in dry time. Taken together, the CASE Team supports the CEC's proposal to have program time reported along with the efficiency, so buyers, utilities, and other manufacturers have information available about actual program time of each cycle and use that, along with efficiency, to make purchasing decisions.

# 10. Automatic termination can be applied in vended locations that price per load instead of per unit of time

**Summary:** While the majority of laundromats still price dryer use per unit of time, industry surveys indicate that at least 10 percent of laundromats nationwide now price per load (also called

[27] Denkenberger, D. & C. Calwell, et al. 2014. "The Time is Ripe for Paying Attention to Clothes Drying Technology and Policy in Relation to Efficiency and Drying Time." 2014 ACEEE Summer Study on Energy Efficiency in Buildings Conference Proceedings. Pacific Grove, CA.

[28] Pescatore, P and Carbone, P. 2005. "High Efficiency, High Performance Clothes Dryer," Final Report to: Department of Energy, Contract No. DE-FC26-01NT41260, 2005, Cambridge, MA.

[29] Foster Porter et. all. 16 December 2016. Table 4.2, p. 17.

[30] Foster Porter et. all. 16 December 2016. Figure 6.3, p. 47.

price per turn). Automatic termination, as an energy-saving strategy, could easily be applied in vended dryers that price per turn.

**Discussion:** Sensing and analytics used to implement automatic termination of dryers is principally found in the OPL market, but this technology could also be considered for the vended market. According to a 2015 Coin Laundry Industry (CLA) survey, 11 percent[31] of stores offered full cycle (per load) dryer pricing in addition to, or instead of time-based pricing.[32] The share of stores offering this pricing strategy may be increasing. The same industry survey indicated that in 2016, the share of stores offering full-cycle pricing increased to 15 percent.[33] Furthermore, in a 2013 Coin-Laundry Industry online and telephone survey of customers, 49 percent of regular laundromat customers indicated that they would prefer single-load pricing over traditional time-based pricing.[34] Pricing per load could easily be paired with an automatic termination program cycle, with the price of the dryer based on getting the laundry dry.

Furthermore, manufacturers have many technologies to consider when improving vended and OPL tumble dryers, and may or may not choose to include automatic termination as part of an energy efficiency strategy. The test procedure measures performance, not technology, giving manufacturers the opportunity to develop least-cost pathways to improve efficiency while meeting customer expectations for performance.

## 11. Residential-platform dryers are an important component to the scope of the CEC proposed test and list requirement

**Summary:** Residential-platform dryers are an important component of the CEC staff-proposed scope for test and list requirements for commercial tumble dryers as they help California meet greenhouse gas emission goals and enable utility program opportunities. The residential-platform dryer is technologically similar to commercial tumblers, and the test procedure has been designed appropriately to measure their energy efficiency.

**Discussion:** The CASE Team research reveals a number of reasons why residential-platform dryers are important and appropriate to include in the scope of the commercial tumble dryer test and list requirement:

- *Including residential-platform dryers helps meet greenhouse gas emissions and other policy goals.* The CASE Team estimates that residential-platform dryers represent approximately 20 percent of all GHG emissions of commercial tumble dryers. Understanding their energy use and enabling purchasers to make decisions on the basis of energy efficiency, program time, and other features supports the State's GHG emission reduction goals.
- *Enabling utility program opportunities.* Because residential-platform dryers represent 60 percent of the total stock of dryers, and the highest number of units sold annually, the

[31] This value is 11percent ± 5.3 percentage points at the 95 percent confidence interval.

[32] "2015 Coin Laundry Industry Survey." Gold Book Research Series prepared and published by the Coin Laundry Association. 2015. Available for purchase at: http://www.coinlaundry.org/home

[33] This value is 15 percent ± 5.4 percentage points at the 95 percent confidence interval. Source: 2016 "Coin Laundry Industry Survey." Gold Book Research Series prepared and published by the Coin Laundry Association. 2016. Available for purchase at: http://www.coinlaundry.org/home

[34] "Gold Book Coin Laundry Association 2013 Laundry Customer Survey." Prepared by Readex Research. 2013.Table 37. Available to CLA members at: http://www.coinlaundry.org/home

entities that utilize these dryers are good target for utility commercial tumble dryer energy efficiency programs. Specifically, these products could help acquire multifamily energy savings. Utility customers, such as laundromats with high monthly bills, could also benefit. To exclude them would eliminate the CEC's ability to capture cost-effective savings and a utility's ability to consider incentive programs for this important part of the commercial market.

- *Residential-platform dryers match the technology and function of other commercial tumble dryers.* While it is true that the CEC-staff proposed scope addresses a wide range of commercial tumble dryer sizes, all perform the same function: drying textiles in a tumbler. While residential-platform tumble dryers are smaller, less powerful versions of large commercial tumblers, the design is fundamentally the same: There is an air intake with a heater box/burner, a tumbler, and a fan. The air moves through the dryer, picks up moisture from the textiles and is exhausted out the back.
- *The test procedure for residential-platform dryers is appropriate.* To reduce test burden, the CASE Team chose to have some test elements the same for all categories of dryers (e.g. textile preparation, ambient temperature conditions, and textile type). But, load size – the variable that most impacts efficiency – is tailored to the size of each dryer drum. While it is true that this approach is not perfectly representative of every condition for every tumble dryer, the test protocol represents an effective balance of being representative without having unreasonable test burdens.

## 12. Recommended changes to CEC's proposed scope language

**Summary:** The CASE Team recommends removing the reference to the lower drum volume limit of in the definition of "commercial tumble clothes dryer" to ensure that all future models of commercial tumble dryers are included in the definition of the scope.

**Discussion:** Although the CASE Team agrees with the Commission staff that the current scope of commercial tumble dryers does not include drum volume capacities smaller than 6.0 cubic feet, the Team encourages the CEC to remove this lower limit to enable inclusion of all future commercial tumble dryers that may have slightly smaller capacity. This suggested change will have no impact on the coverage of current products on the market. Specifically, we propose that the text ~~shown in strikeout~~ be removed from the definition.

> "Commercial tumble clothes dryer" means a tumble clothes dryer not covered by 10 C.F.R. part 430.32(h) ~~and~~ that has a ~~capacity larger than 6.0 cubic feet~~ drum volume ~~and~~ less than or equal to 65 cubic feet ~~drum volume~~.