DOCKETED

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TN #:	220528
Document Title:	Presentation - Commercial Tumble Dryer Test Procedure CASE Overview
Description:	Developed by Suzanne Foster Porter, of Kannah Consulting on behalf of the California Investor Owned Utilities (PG&E, SCE, SDGE & SoCalGas), for the August 3, 2017 Workshop.
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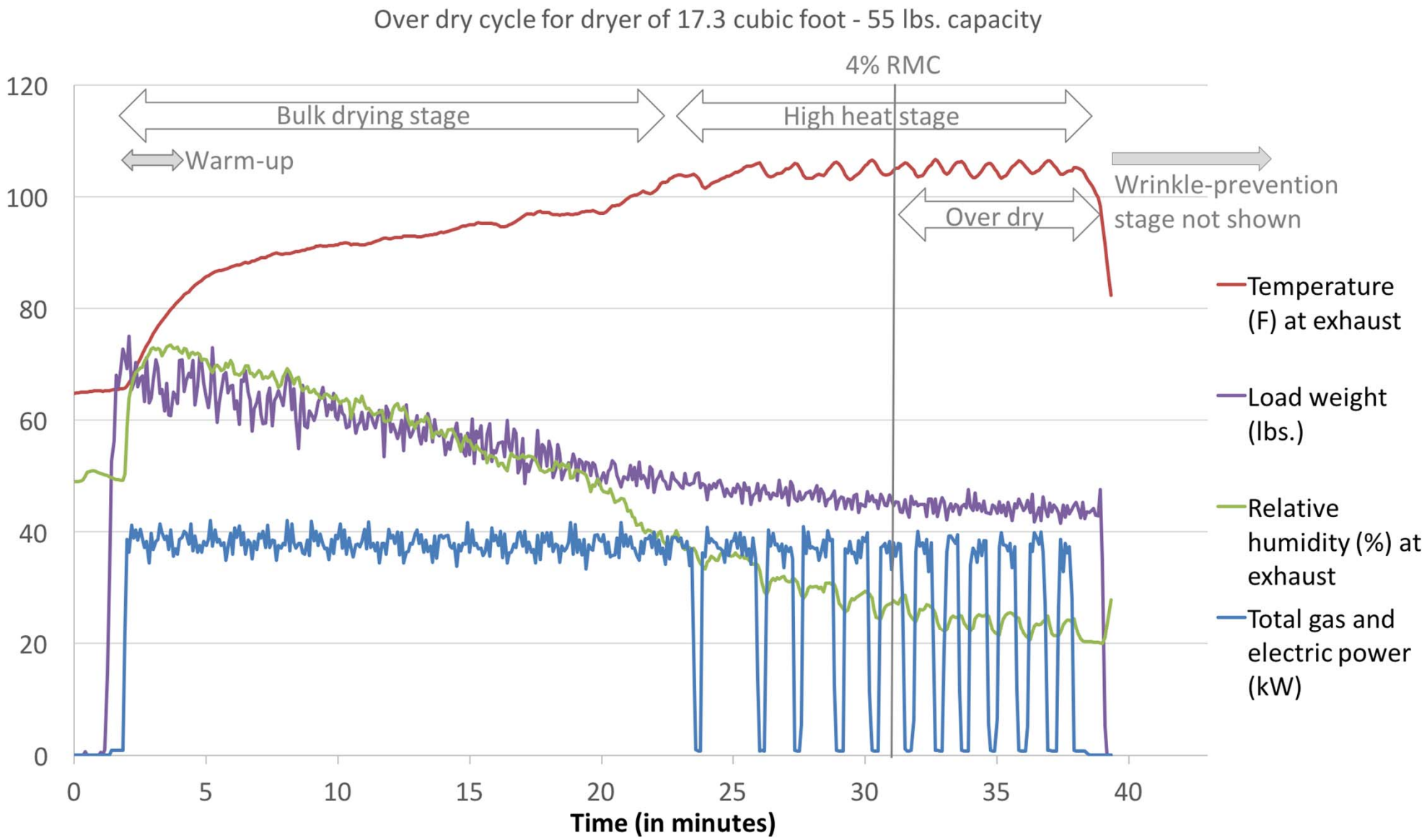
Commercial Tumble Dryer Test Procedure CASE Overview

Developed by Suzanne Foster Porter, Kannah Consulting
on behalf of the California Investor-owned Utilities

August 3, 2017

How Does a Commercial Tumble Dryer Work?


Over dry cycle for dryer of 17.3 cubic foot - 55 lbs. capacity
4% RMC
Bulk drying stage
High heat stage
Warm-up
Over dry
Wrinkle-prevention stage not shown
120
100
80
60
40
20
0
0
5
10
15
20
25
30
35
40
Time (in minutes)
Temperature (F) at exhaust
Load weight (lbs.)
Relative humidity (%) at exhaust
Total gas and electric power (kW)

Commercial dryers in three kinds of facilities

Multifamily

60% of the total stock
20% of carbon emissions
Gas and electric fuel
Vended controls

7.5 ft^3 (18 lb.)

Laundromat

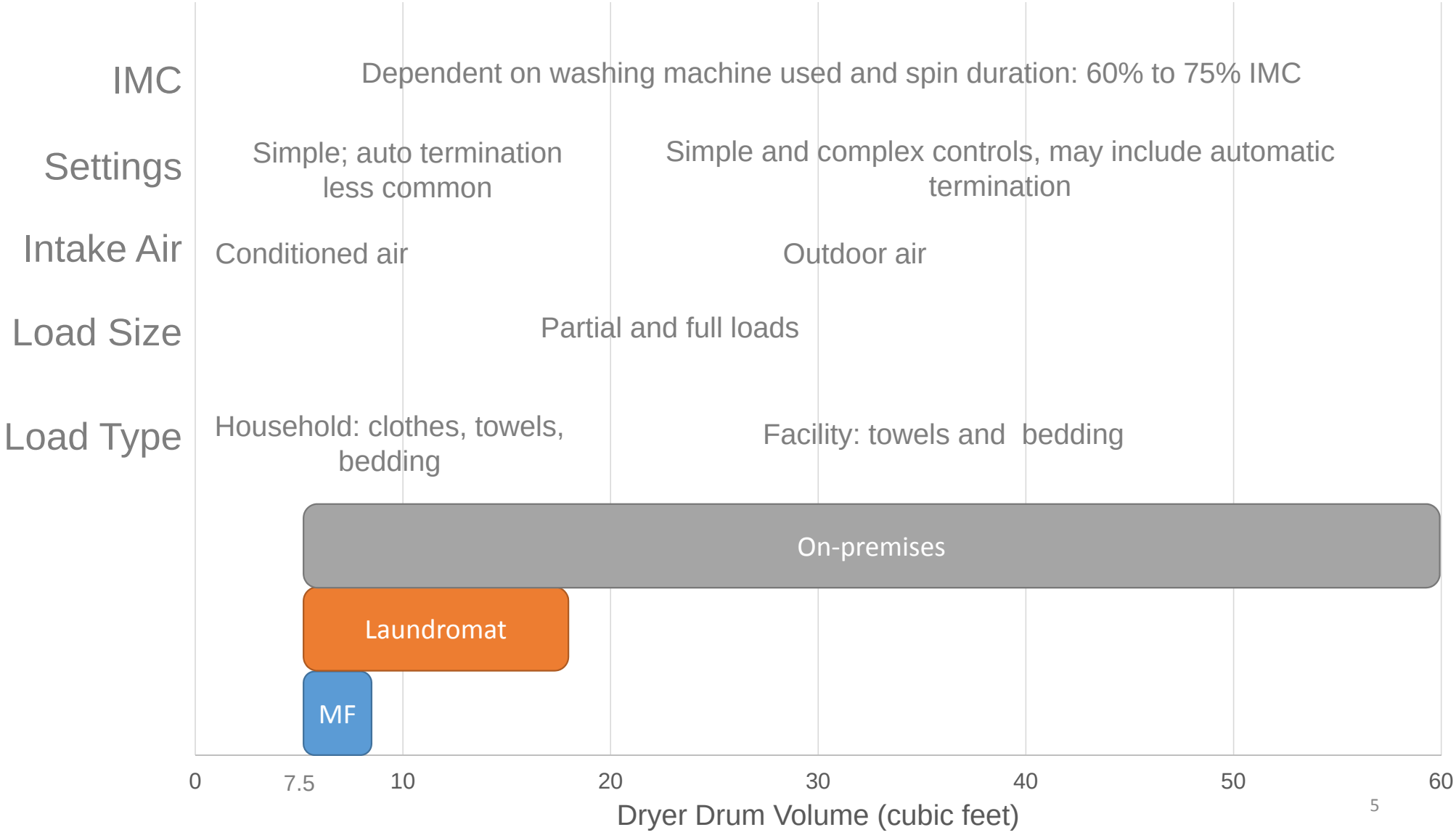
35% of the total stock
35% of carbon emissions
Gas and electric fuel
Vended controls

7.5 ft^3 (18 lb.) to 17.5 ft^3 (55 lb.)

On-premises

5% of the total stock
45% of carbon emissions
Gas and electric fuel
Hotel, motel, health club, etc.

7.5 ft^3 (18 lb.) to 65 ft^3 (200 lb.)


IMC
Dependent on washing machine used and spin duration: 60% to 75% IMC
Settings
Simple; auto termination less common
Simple and complex controls, may include automatic termination
Intake Air
Conditioned air
Outdoor air
Load Size
Partial and full loads
Load Type
Household: clothes, towels, bedding
Facility: towels and bedding
On-premises
Laundromat
MF
0
7.5
10
20
30
40
50
60
Dryer Drum Volume (cubic feet)

Commercial dryers (< 65 ft^3)use a significant amount of energy

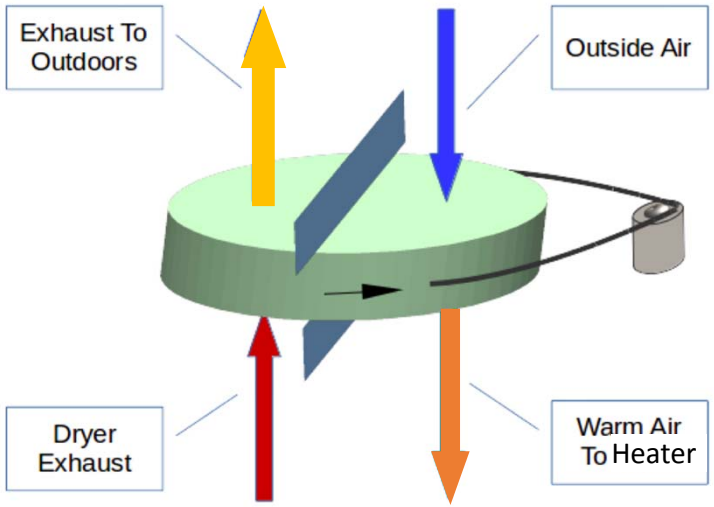
Unit	Estimated Use of CA Stock
Electricity (kWh per year)	900 million
Gas (therms per year)	260 million
Utility bills (dollars)	$440 million
Carbon dioxide emissions (metric tons CO_2e/yr)	1.8 million
Rosenfelds (power plant equivalent)*	Two-thirds of a 500 MW coal-fired power plant

*using 3 million metric tons of CO_2e conversion as defined by Koomey et al. (2010)

Dryers of similar size can have dramatically different efficiency levels

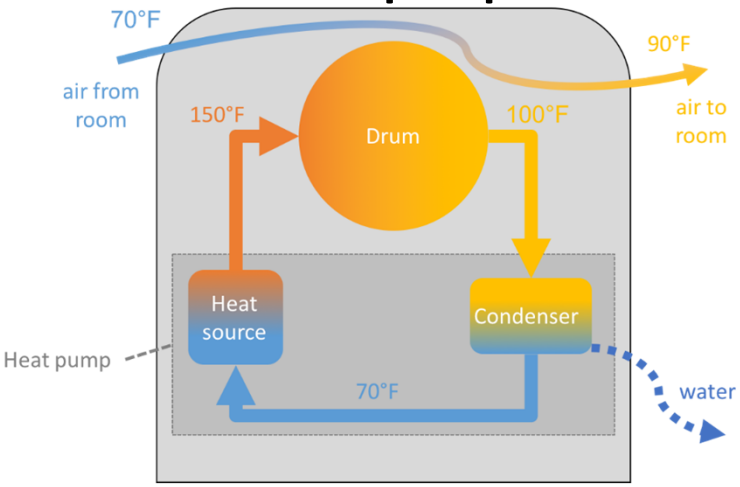
	Efficiency (Site Energy Factor (EF)) (lbs. of bone dry textiles/site kWh)	Power Factor [a] (expressed as a percent)	Standby (watts)	Average Program Time (minutes)	2015 Price (U.S. Dollars)
Dryer 4 (30 lbs. and 11.7 ft^3 drum volume, vended controls)	EF: 1.36	64%	11.9 W	56	$3,422
Dryer 6 (35 lbs. and 10.2 ft^3 drum volume, vended controls)	EF: 2.15	93%	3.3 W	34	$3,145

Heat exchanger



Gas and electric
8% to 40% savings

Heat pump

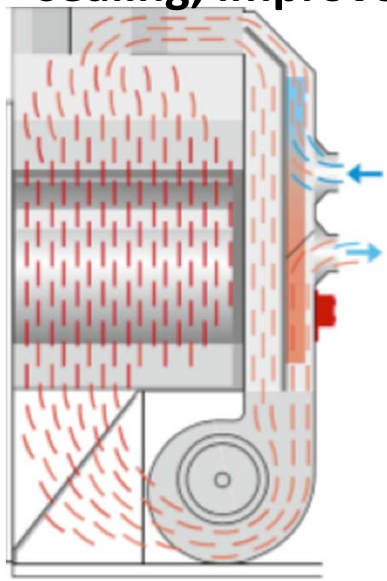


Electric only
13% to 60% savings

Burner/fan modulation

Gas and electric
3% to 25% savings

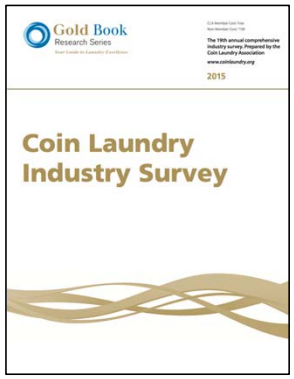
Other: air recirculation, automatic termination, insulation, air sealing, improved motors, etc.



Gas and Electric
15% to 20% savings

Opportunities exist for incorporating more efficient technology in coin-op and OPL facilities

Businesses care about dryer efficiency…



"What do you feel are the biggest problems you face in the laundry business?"

Answer: High cost utilities (65%)

Utilities are 25 to 35% of gross revenue

- Lighting, HVAC, water measures are not enough to meet aggressive energy reduction goals set by many national/international hotel brands with sustainability plans.
- Utility costs of shared spaces in apartment buildings is passed onto occupants or managing entity.

…but the quantitative information available is sparse and difficult to compare

"Axial air flow pattern ensures maximum air utilization for labor and energy savings."

"Even more profitability by numerous options of [technologies] (Reversing Drum Action, Residual Moisture Control, Heat Exchanger, Fresh Air Intake etc.)"

"[over-dry prevention technology] lowers energy, utility, and linen replacement costs."

"Best performance, high productivity: up to 10% faster and 15% more energy efficient"

Overview of residential test procedures

	ANSI/AHAM HLD 2010	IEC	DOE 2015	Utility Test Protocol
Purpose	Performance + Efficiency	Performance + Efficiency	Efficiency	Efficiency
Test series	Reference to 3 or 1, flexible	5 runs per test series, multiple series	1 run on two dryers	5 runs per test series
Load material	IEC-specified cotton	IEC-specified cotton or IEC-specified synthetic	DOE test cloths	Real-world clothing, DOE test cloths
Textile allowed age	Age-weighted load, 80 total runs	Age-weighted load, 80 total runs	25 total runs	25 total runs
Termination method	Technician termination and automatic termination	Automatic termination, language on timed unclear	Technician termination and automatic termination	Automatic termination[a]
IMC	70%	40% to 70%	57.5%	57.5% and 62%
RMC	5%	0% to 8%	2%	2% and 4%
Settings	High/max heat	Range	High/max heat	Range
Program time measured?	Automatic termination ONLY	Yes	No	Yes

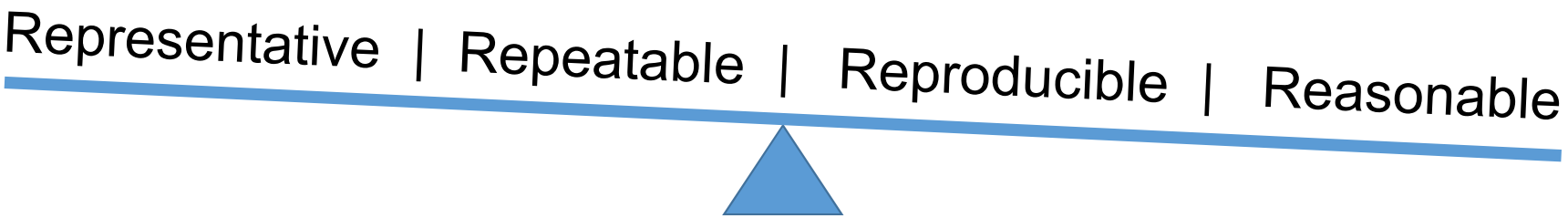
[a]This test protocol was designed for more efficient dryers, so it is assumed that all will have automatic termination capability.

Challenges to applying residential test procedure to commercial dryers

- AHAM and Alliance Laundry Systems docketed comments (2013):
  - Commercial dryers dry heavier loads than residential
  - Cycle time is shorter
  - Timed drying generally used (AHAM)
  - Come in “stacked” versions with dryer over dryer
  - Larger and wider range of drum volumes (20 to 200 lbs.)
- Different load types (home versus facility type loads)
- Air intake–unconditioned air for laundromat and on-premises
- Installed in a broad range of facilities
  - Differing levels of business optimization
  - Operated by people with different levels of training

Test Procedure Objectives

- Representative:
  - Highly indicative of performance in “real world” applications
  - Reflective of consumer behavior or behaviors (test conditions specified “as used”)
  - Inclusive of “system level” effects
  - Incorporating “all modes” of operation, including primary, secondary, and parasitic
  - Results presented in a “disaggregated” basis for all stakeholder use
  - Consideration given to “interactive effects”, such as power factor
- Repeatable:
  - When test is performed multiple times at the same lab, highly consistent results are obtained
- Reproducible:
  - When tests are performed by multiple accredited labs, highly consistent results are obtained
- Reasonable:
  - Tests costs are not overly burdensome, and are justified in meeting the other objectives



Summary of research methods

- Literature review
  - Test procedures, energy efficiency reports, government rulemakings, laundry industry market information, web marketing materials
  - Residential and commercial review
- Expert interviews
  - Engineer experts familiar with the use of equipment because they have been in a number of facilities installing efficiency retrofits
- Site visits
  - OPL (Hotel), laundromat, multifamily
- Lab testing
  - Preliminary testing to evaluate the most important variables for efficiency of commercial dryers
  - Applying the proposed test procedure on 8 dryers in 2016 and 2 additional dryers in 2017

Test Procedure Scope Summary (version 2.6)

- Commercial dryers up to 65 ft^3 (approx. 200 lb.) capacity
- Residential-platform, large-chassis-style (tumblers), washer dryer combination units, dual-pocket tumble dryers
- Gas and electric models only (no steam)
- Covers ~85% energy use of commercial dryers in California

Dryer Installation Requirements

Humidity-controlled and temperature-controlled chamber
65 °F ± 1.5 °F ambient
50% ± 5% relative humidity

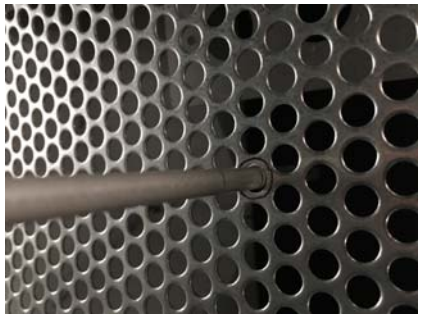
Exhaust simulator (modeled after AHAM)

Various instrumentation distances to ensure reproducibility
Exhaust obstruction (shown), temperature sensor location, etc.

Other requirements: drum cleaning to remove residue, service requirements for gas pressure and BTU content range, electrical voltage and frequency requirement, preconditioning prior to start to steady state temperature

Test Load preparation

- IEC 60456:2010 (Fifth Edition) and AHAM/ANSI HLD-1-2010
- Articles tightly specified
- Available from U.S. distributors
- Equal weight from three articles
- Load size based on rated drum capacity with measurement confirmation
- Filling factor 2.5 lbs. per cubic foot (full) and 1.25 lbs. per cubic foot
- Age-weighted load regularly normalized, 80 runs allowed



Rod measurement method for large dryers, small use DOE method

Precondition the textiles, bone dry, and moisten for testing

- Preconditioning
  - Water hardness for washing
  - Electrical conductivity for rinsing
- Bone dry load to confirm weight meets tolerance
- Wet the textiles to required initial moisture content or IMC: 60%, 75%
- Normalization occurs every 9 to 12 runs

Measurement tolerances specified in detail

- Relative humidity
- Temperature
- Weight
- Electrical energy
- Gas flow rate
- Gas energy content
- Gas pressure
- Time
- Distance

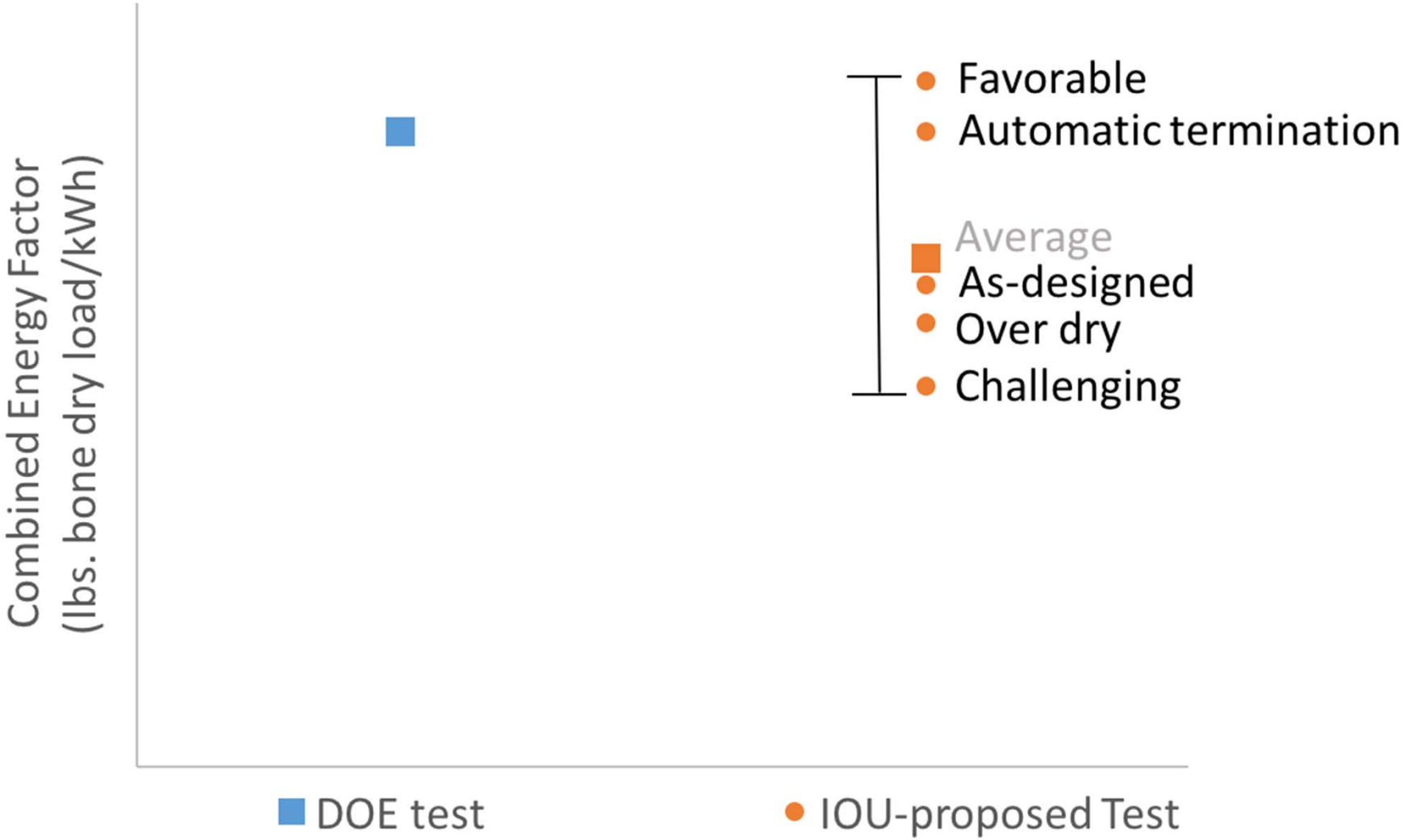
Error analysis of DOE equipment tolerances revealed opportunities for cost and error reduction:

⬆ accuracy of scale for weighing textiles –slightly increased cost

⬇ accuracy of electrical energy meter for gas dryer– significant decreased cost

Test run sequence

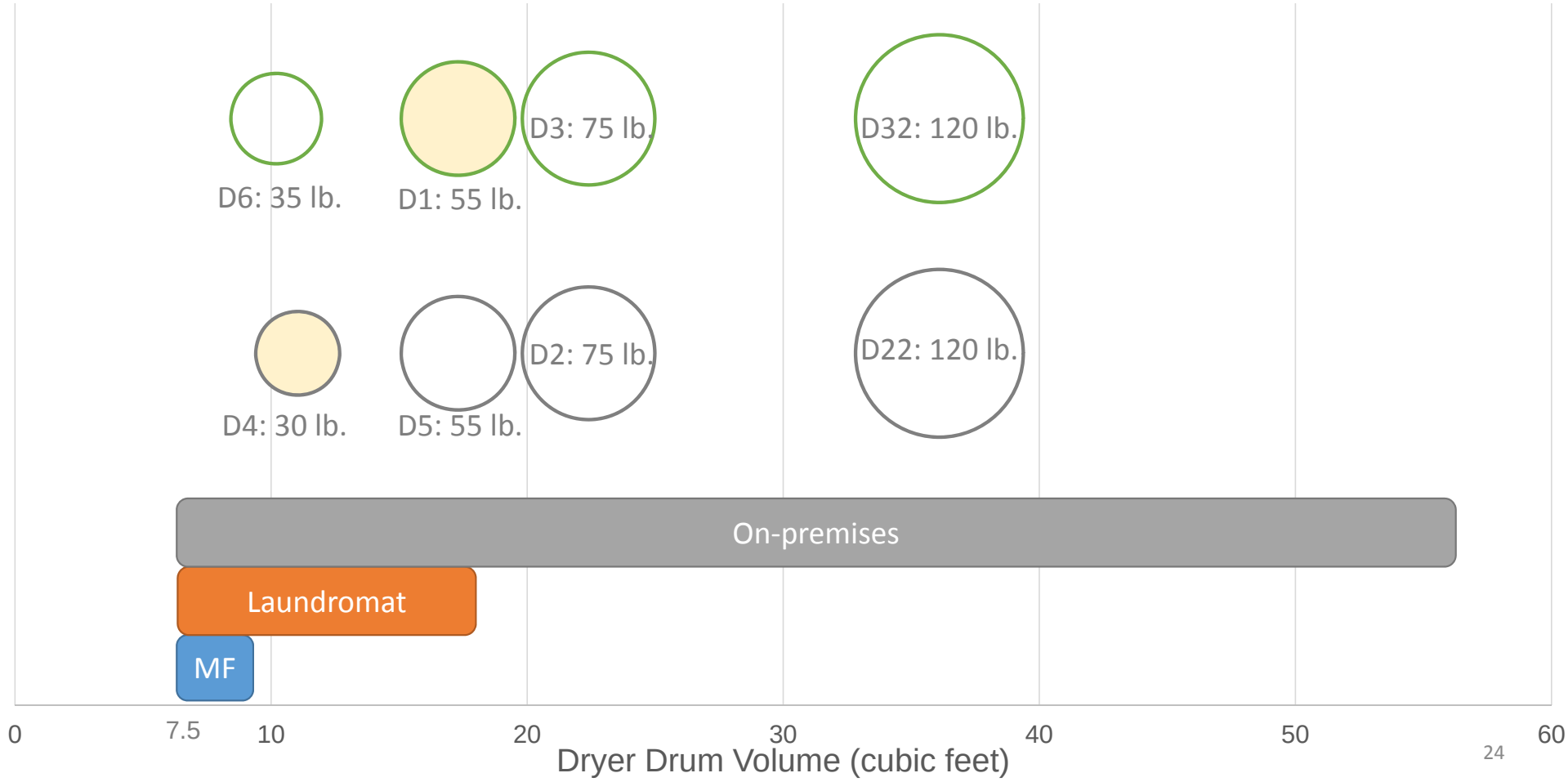
- Textiles come out of washer, and confirm IMC by weighing on scale
- Set controls for time required to get to required RMC or engage automatic termination, depending on test
- Measure gas and electric energy use
- Monitor chamber temperature and humidity to ensure remains within tolerance
- When dryer self-terminates, textiles are removed and weighed again to confirm remaining moisture content (RMC)
- Program time is measured and reported


Combined Energy Factor
(lbs. bone dry load/kWh)
Favorable
Automatic termination
Average
As-designed
Over dry
Challenging
DOE test
IOU-proposed Test

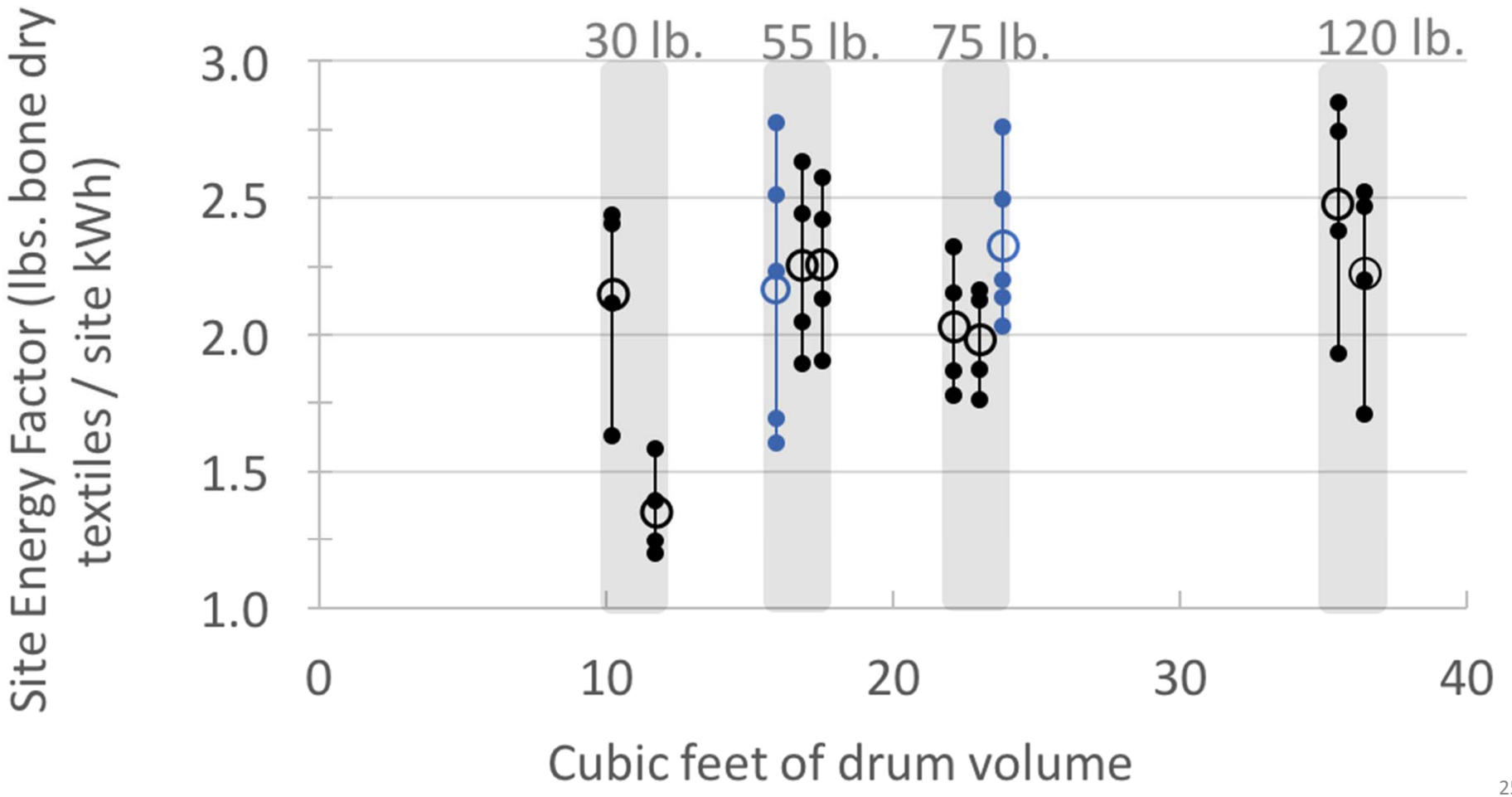
Test series overview: 5 to 6 tests

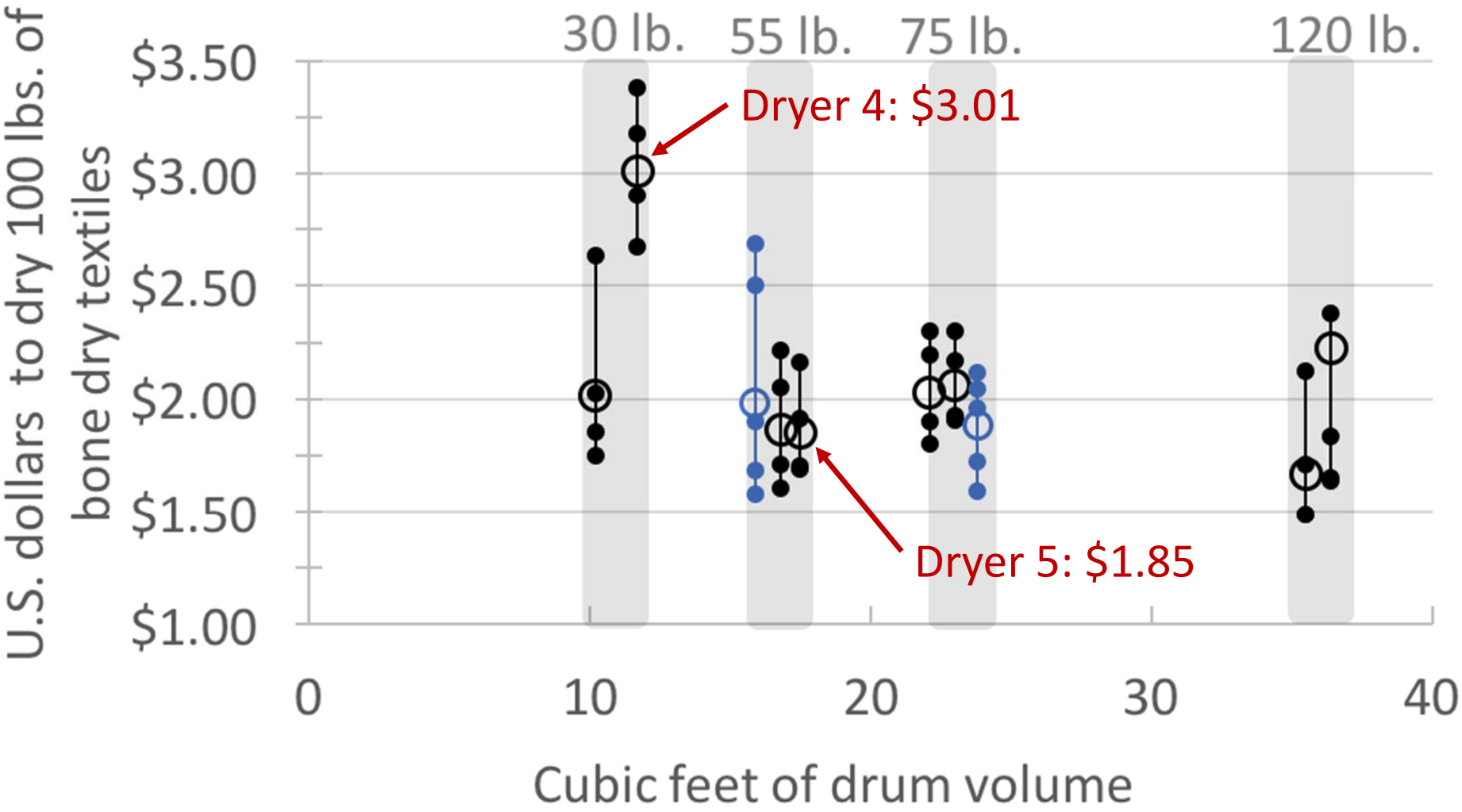
Run	Run sequence	Load size	IMC	RMC	Settings
A	Shortest timed	Full-sized	60%	1.5% - 4%	Timed, high heat
B				4% - 8%	
C	Over dry timed	Full-sized	60%	≤ 4%	
D	Challenging timed	Partial	75%	2% - 7%	
E	Favorable timed	Full-sized	60%	4% - 7%	Timed, low heat w/ cool down
F	Automatic termination	Partial	60%	≤ 4%	Automatic termination, medium heat

Dryers tested in 2016 included standard and “efficient” models



Summary of 2016 and 2017 test results




30 lb.
55 lb.
75 lb.
120 lb.
Dryer 4: $3.01
Dryer 5: $1.85
U.S. dollars to dry 100 lbs. of bone dry textiles
$3.50
$3.00
$2.50
$2.00
$1.50
$1.00
0
10
20
30
40
Cubic feet of drum volume

Institution type	Total number of lbs. of textiles per year	Approximate annual operational cost of Dryer 4, $3.01 per 100 lbs. of dry textiles	Approximate annual operational cost of Dryer 5, $1.85 per 100 lbs. of dry textiles	Annual Cost difference	Dryer lifetime cost difference
Universities and Colleges	128,100	$3,900	$2,400	$1,500	$22,500
Hotels and Motels	321,100	$9,700	$5,900	$3,800	$57,000
Nursing Homes	653,400	$19,700	$12,100	$7,600	$114,000

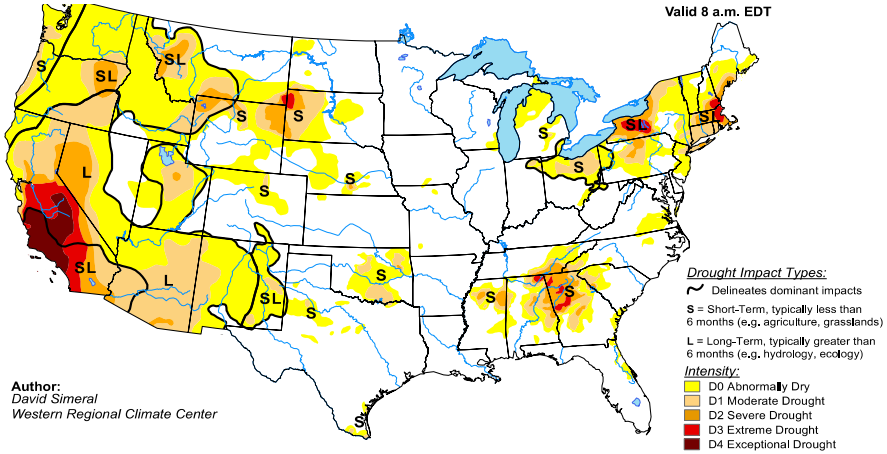
Site energy | Source impacts | Cost

kWh

BTU

CO_2

$



Test procedure defines Site Energy Factor and Cost-benefit Factor

Site Energy Factor:
(similar to U.S. DOE)

$$EF = \frac{W_{bone}}{\left(G_{cycle} + E_{cycle} + E_{low}\right)}$$

Cost-benefit Factor

$$CBF = \frac{W_{bone}}{(\propto G_{cycle} + \beta E_{cycle} + \beta E_{low})}$$

Test procedure defines two constants to weight the relative societal/environmental cost of gas and electricity: α for gas and β for electricity; stays silent on the values or terms of these constants

Example units for $\propto$ and β could be $\frac{CO_2}{kWh}$ for source impacts and $\frac{\$}{kWh}$ for economic cost

Test procedure proposes one way to combine the energy efficiency and cycle time data to simplify for policymaking

$$Average\ EF = \frac{1}{5}[EF_{AB} + EF_C + EF_D + EF_E + EF_F]$$

$$Average\ CBF = \frac{1}{5}[CBF_{AB} + CBF_C + CBF_D + +CBF_E + CBF_F)]$$

$$Average\ T_{cycle} = \frac{1}{5}\left[T_{cycle(AB)} + T_{cycle(C)} + T_{cycle(D)} + T_{cycle(E)} + T_{cycle(F)}\right]$$

June 2017 test protocol updates (version 2.6)

- Calculation revisions to enable discrete gas and electric values
- Measurement and set up specifications for the largest tumble dryers
- Refinement of automatic termination test (Run F) setting selection
- Detailed guidance on two-pocket dryers and washer-dryer combination units to clarify how they should be tested

Dual-pocket tumble dryers

Washer-dryer combination units

Test procedure benefits

- Appropriate for the commercial market (load size, timed dry, ambient temperature, etc.)
- More representative than DOE to ensure savings are achieved once dryers installed
- Gives a broad picture of energy efficiency performance to be used by purchasers
  - Includes tests for common use scenarios as well as bracketing the range
- Harmonizes, where possible, with existing procedures in use by industry (IEC load)
- Less burdensome than the DOE washer test procedure
- First step to California saving:
  - $90 million in utility bills
  - 180 million kWh
  - 50 million therms
  - 360,000 metric tons of CO_2e

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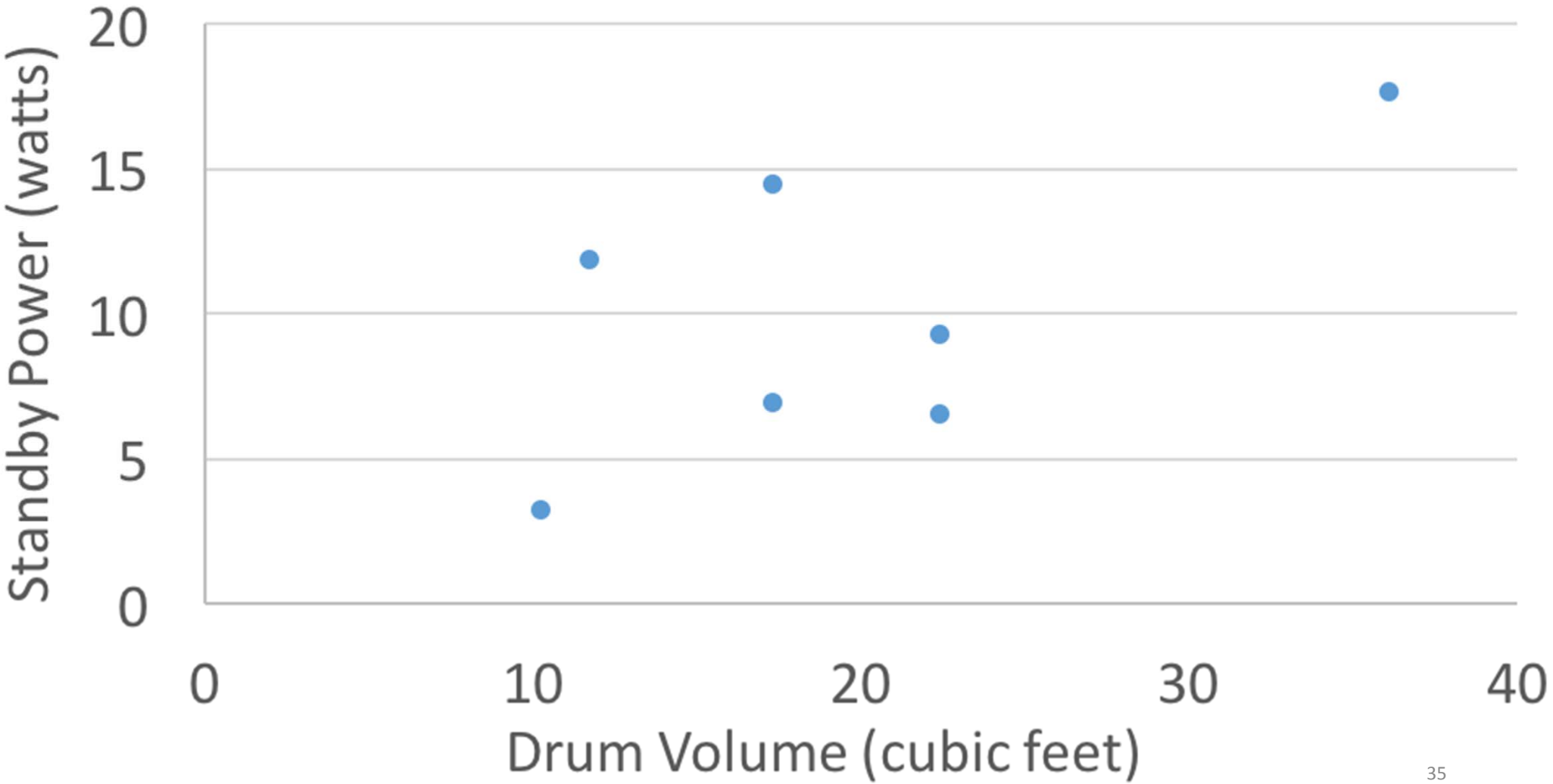
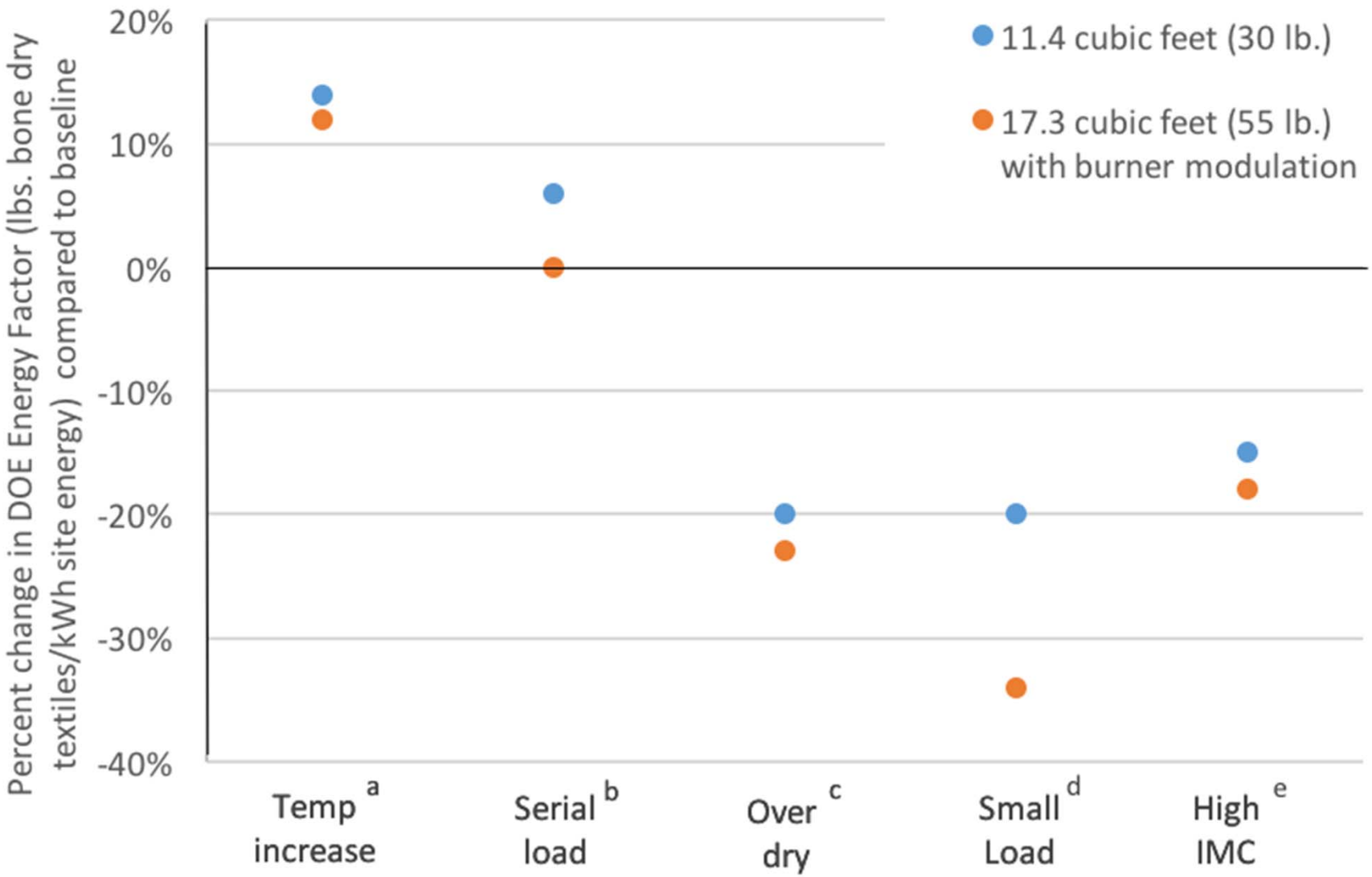
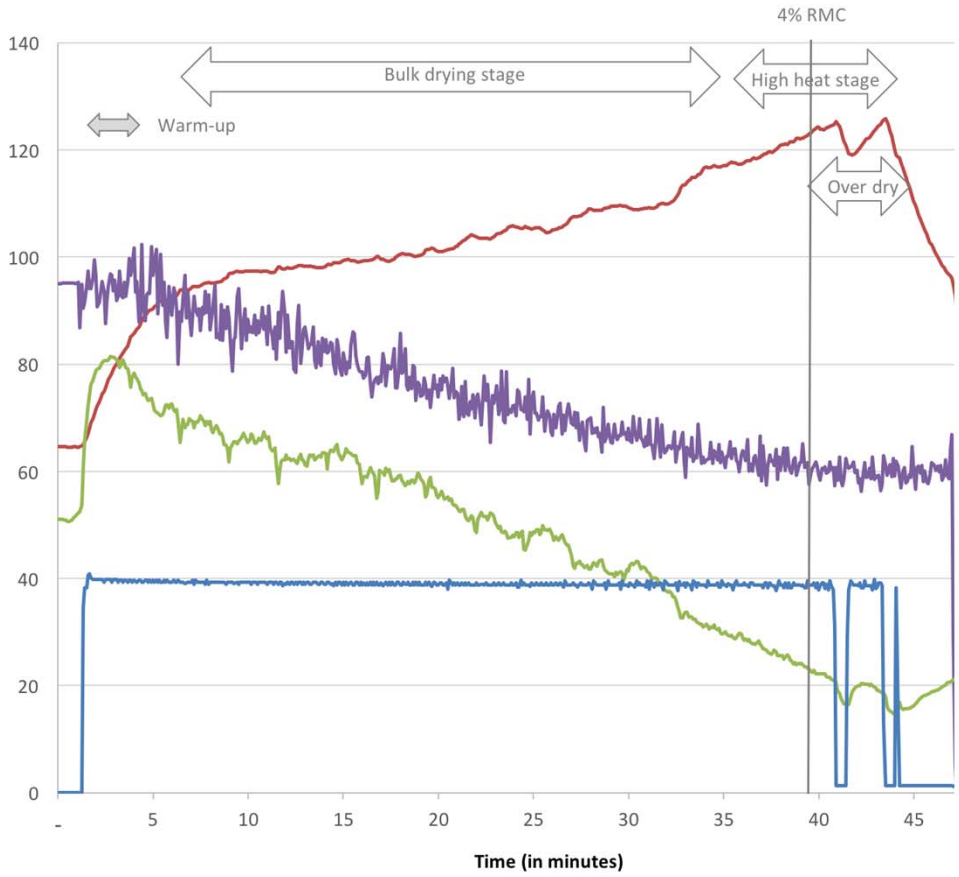
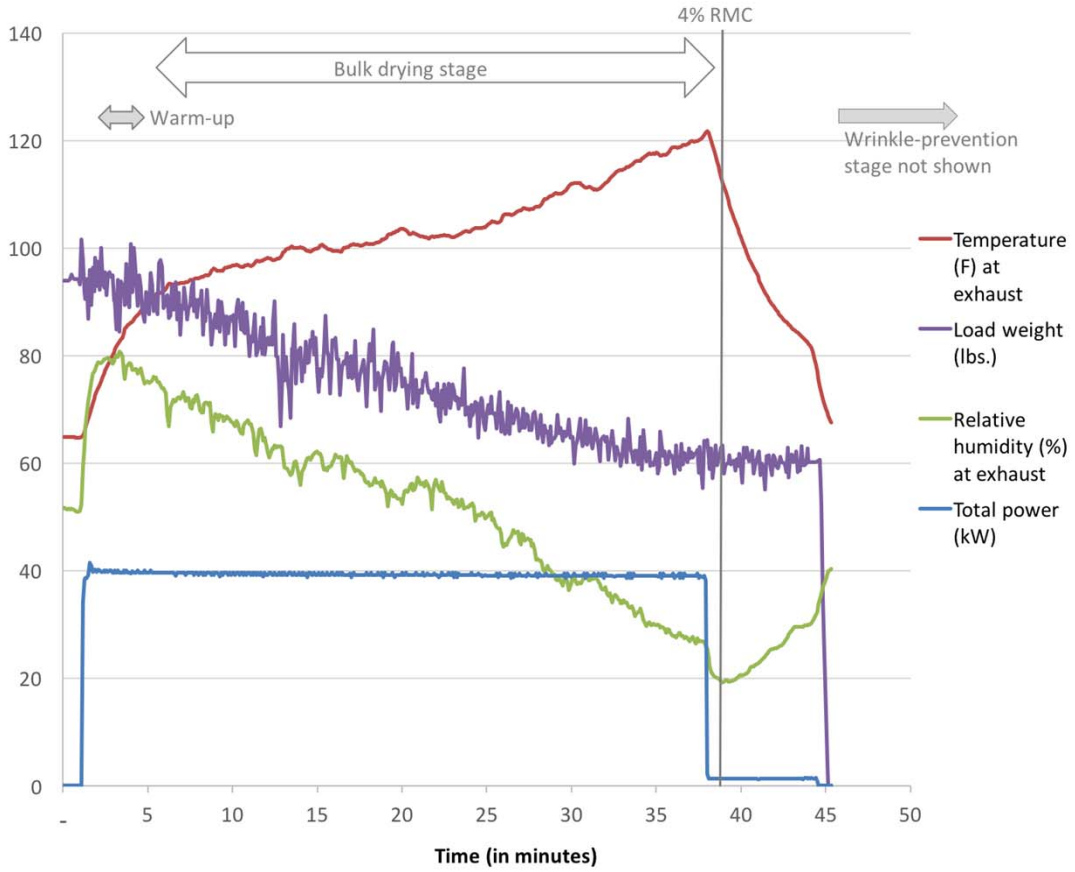
Additional material


Standby Power (watts)
20
15
10
5
0
0
10
20
30
40
Drum Volume (cubic feet)


Percent change in DOE Energy Factor (lbs. bone dry textiles/kWh site energy) compared to baseline
20%
10%
0%
-10%
-20%
-30%
-40%
11.4 cubic feet (30 lb.)
17.3 cubic feet (55 lb.) with burner modulation
Temp increase [a]
Serial load [b]
Over dry [c]
Small Load [d]
High IMC [e]

Controls can reduce energy by 10% in over dry scenario





2017 Findings

	ANSI/AHAM HLD 2010	IEC	DOE 2015	Utility Test Protocol	IOU-proposed Commercial
Purpose	Performance + Efficiency	Performance + Efficiency	Efficiency	Efficiency	Efficiency
Test series	Reference to 3 or 1, flexible	5 runs per test series	1 run on two dryers	5 runs per test series	5 to 6 runs per test series
Load material	IEC-specified cotton	IEC-specified cotton	DOE test cloths	Real-world clothing, DOE test cloths	IEC-specified cotton
Textile allowed age	Age-weighted load, 80 total runs	Age-weighted load, 80 total runs	25 total runs	25 total runs	Age-weighted load, 80 total runs
Termination method	Technician termination and automatic termination	Automatic termination, language on timed unclear	Technician termination and automatic termination	Automatic termination	Timed and automatic termination
IMC	70%	40% to 70%	57.5%	57.5% and 62%	60% and 75%
RMC	5%	0% to 8%	2%	2% and 4%	1.5% to 8%
Settings	High/max heat	Range	High/max heat	Range	Range
Program time measured?	Automatic termination ONLY	Yes	No	Yes	Yes