LED LAMPS ORIGINAL EQUIPMENT MANUFACTURER PERFORMANCE ASSESSMENT

2021 Report

February 2022

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ASSESSING PRODUCTS IN THE MARKET

VERIFICATION TESTING

The ENERGY STAR Third Party Certification Program (3PC) is designed to provide a consistent structure for ENERGY STAR product certification and subsequent off-the-shelf ("verification") testing. Under 3PC, all ENERGY STAR products are third-party certified and after introduced to the market may be subject to verification testing, administered by each of the EPA-recognized certification bodies. Each year, 10% of all ENERGY STAR certified LED lamps are verified. Up to half of the tested products are selected through an Agency-led nomination process, and the other half of tested products are selected from the ENERGY STAR Qualified Products List (QPL)[1] by the certification body (CB). EPA's selection list is comprised of products nominated by ENERGY STAR stakeholders, such as utilities and industry, and by EPA. Some factors that may increase the likelihood of product nominations include prior product failures by the same manufacturer; products that are broadly rebated; manufacturers with limited verification testing data; and products from sources with repeated program compliance issues. Once a final product list for testing is compiled, responsible brand owner partners are informed by the CBs, products are procured, and testing begins.

LED lamps subject to verification testing under 3PC undergo some variation of the same tests required for purposes of ENERGY STAR product certification (see Table 1), except that products are tested at 0 hours, 3,000 hours and 6,000 hours.

Table 1: Tests Required for ENERGY STAR Certification and Verification

Photometric Performance	Lumen Maintenance and Rated Life	Operational and Electrical Performance
Luminous Efficacy	3000-Hour Lumen Maintenance	Power Factor
Light Output	6000-Hour Lumen Maintenance	Start Time
Elevated Light Output Ratio	Rated Life	Run-Up Time
Center Beam Intensity	Rapid Cycle Stress Test	Transient Protection
Correlated Color Temperature (CCT)		
Color Rendering Index (CRI)		

LED lamps first became eligible for ENERGY STAR certification in 2013 and began verification testing in 2015. **1,498 LED lamps have completed ENERGY STAR verification testing as of December 31, 2020**. Table 2 provides a breakdown of number of products tested by year. **481 products were tested in 2020**, representing a 64% increase over the number of products tested in 2019 and a 423% increase over the number tested in the first year of LED lamps testing.

[1] http://www.energystar.gov/products

Table 2: LED Lamps Products Tested 2015 – 2020

Year Testing Completed	# Products Tested
2015	92
2016	153
2017	195
2018	284
2019	293
2020	481
All Years (Cumulative)	**1498**

PRODUCT DISQUALIFICATION

During verification testing, LED lamp performance is assessed at three stages of testing: 0 hours, 3,000 hours and 6,000 hours. A product failure can occur at any of these stages. EPA addresses failed products and their association with the ENERGY STAR mark pursuant to the ENERGY STAR disqualification procedures. If a product fails, then EPA sends notification that it intends to disqualify the product from ENERGY STAR to the brand owner of the tested product and all other labelers who sold that base product under another brand ("affected private labelers"). Those parties may or may not include the original equipment manufacturer (OEM), depending upon whether the OEM labels and sells its own branded version of the bulb, or only sells the product to other labelers for market distribution. All parties notified are provided the opportunity to dispute the pending disqualification. If applicable, EPA conducts a technical review of all information the partner(s) submits in order to make a final determination on the product's status.

For any product that warrants disqualification from the ENERGY STAR Program, EPA requires a corporate certification detailing product control measures undertaken to manage the sale, distribution, and marketing of the disqualified model, such that the ENERGY STAR name and label is no longer associated with the product. LED lamps that are disqualified appear on the Lighting Products Disqualified from the ENERGY STAR Program list on the ENERGY STAR Program Integrity webpage.

EARLY INTERIM CERTIFICATION FAILURES

Lifetime testing for LED lamps seeking ENERGY STAR certification requires a duration of 6,000 hours (approximately nine months). Recognizing the length of time required to bring this product to market, EPA offers Early Interim (provisional) Certification for products that meet minimum light output requirements after life testing has reached the 3,000-hour mark and all other relevant performance requirements. Full Certification depends on successful completion of the full 6,000-hour lumen maintenance life test.

Early certified products represent a small fraction of the nearly 23,000 LED lamps that have been certified. Because early certified LED lamps are certified consistent with specification allowances, products that fail long-term performance are removed from the QPL (and not listed as "disqualified"). EPA requires the same actions to control the sale, distribution, and marketing of LED lamps for early certification failures as for disqualified products. Table 3 breaks down by year the number of early certified lamps that failed to meet program requirements upon completion of lifetime testing. No early interim failures have occurred in the past four years.

Table 3: Early Interim Certification Failures (2012-2020)

Year	Number of Incidents
2012	13
2013	2
2014	2
2015	8
2016	11
2017	0
2018	0
2019	0
2020	0
All Years (Cumulative)	**36**

THE ROLE OF OEMS

In the United States, LED lamps are sold under a variety of brand names. These branded products, or private labels, are manufactured by an OEM who sells its products to the private label brand owner. In some cases, an OEM will sell the product under its own brand name, as well as selling it to other private labelers. Other times, a brand owner and an OEM will enter an exclusive relationship whereby the OEM sells a product to one labeler only. Most commonly, an OEM sells the same model to multiple private labelers and each private labeler sells the model under its own brand name. This underscores the broad impact of an OEM product's quality as it moves through the market and the significance of calculating and tracking OEM VT performance.

ANNUAL DISQUALIFICATION RATES

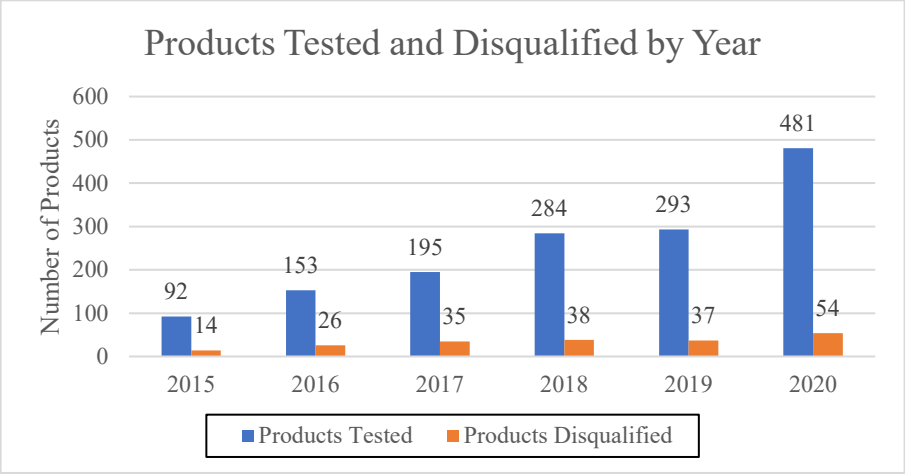
PRODUCT CATEGORY DISQUALIFICATION RATE

The disqualification rate for LED lamps in 2020 was 11%. This was the lowest disqualification rate for this product category since verification testing of LED lamps began in 2015 and resulted in a decrease to the program's cumulative disqualification rate, from 18% at the conclusion of 2019 testing to 14% presently. This improvement in passing rates occurred while the number of products tested increased by 64% between 2019 and 2020, expanding testing data to include nearly 200 additional products. Table 4 provides a breakdown by year of the number of products tested and corresponding disqualification rates. Figure 1 presents the number of products tested annually and the corresponding number of products disqualified. This figure illustrates the relatively stable trend of product disqualifications relative to significant increases in products tested.

Table 4: Summary Performance Results of All LED Lamps Products Tested 2015 – 2020

Year Testing Completed	# Products Tested	# Products Disqualified	Disqualification Rate
2015	92	14	15%
2016	153	26	17%
2017	195	35	18%
2018	284	38	13%
2019	293	37	13%
2020	481	54	11%
All Years (Cumulative)	**1498**	**211**[2]	**14%**

Figure 1: Products Tested and Disqualified by Year



EXPANDING THE ASSESSMENT OF OEMS

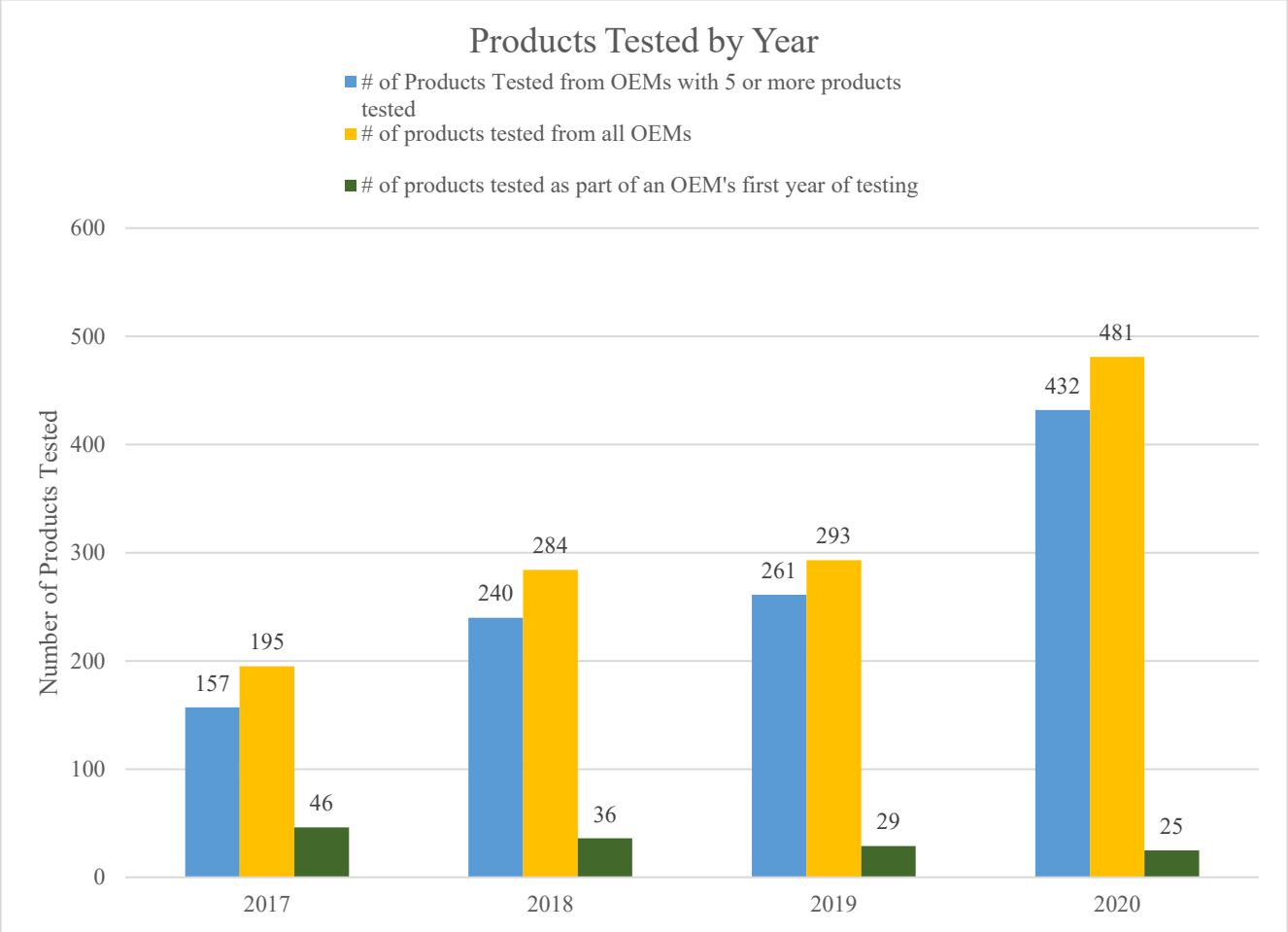
In 2017, EPA began to compare individual OEM disqualification rates to gain a better understanding of quality variability among OEMs. To ensure that comparisons of OEM disqualification rates are not distorted by the number of products an OEM has had tested (for example, disqualification of one of two tested products yields a 50% disqualification rate for a minor examination of the party's product), EPA compares only those OEMs that have had five or more products tested to date (a "significantly tested OEM"). Annual disqualification rates for the LED bulb product category include all products that have completed testing, not solely significantly tested OEMs.

Between 2015 and 2020, a total of 162 LED bulb OEMs had products that completed verification testing. Of those 162 OEMs, 53 have had five or more LED lamps tested, representing 87% of all LED lamps tested to date. In 2020, EPA increased the number of significantly tested OEMs from 42 at the conclusion of 2019 to 53. In addition to that, EPA increased the number of LED bulb OEMs who had not yet been subject to verification testing. The significance of the increase in OEMs tested is that it provides a better understanding of quality

[2] The cumulative number of disqualified products is greater than the sum of annual results because it included models disqualified in 2020 scheduled for testing completion in 2021.

among a broader universe of sources, as well as comparisons across the industry. Figure 2 reflects EPA's efforts to test all OEMs producing ENERGY STAR LED bulbs and to increase statistically significant information to compare OEM performance.[3] EPA expects the number of OEMs tested for the first time to continue to decrease as the only remaining OEMs in that category will be recent entries to the program.

Figure 2: Products Tested by Year



INDIVIDUAL OEM DISQUALIFICATION RATES

The cumulative disqualification rate for verification testing conducted on 1498 LED bulbs from 2015-2020 is 14%. Individual disqualification rates for the 53 significantly tested OEMs during that period range from 0% to 67% (see Figure 3). Of those OEMs, 14 had zero disqualifications, and roughly half (25) performed below the average rate. The 14 OEMs with perfect testing records had between 5 and 33 products tested through lifetime. Of the 16 OEMs with 20 or more products tested from 2015-2020, disqualification rates indicated higher performance, ranging from 0% to 38%. Notably, the two OEMs with the greatest number of products tested (220 and 142), both have overall disqualification rates below 10% (see Figure 3, OEMs "AU" and "S"). The poorest

[3] Figures 4 and 5 reflect the increase from 2019 to 2020 in the number of significantly tested OEMs, reflecting EPA's efforts to broaden the universe of OEMs for comparison.

performing OEM during this period has a disqualification rate 10% higher than the next poorest performer (see Figure 3, OEMs “X” and “C”).

Product disqualification rates varied widely among the OEMs with 5 or more products tested in 2020, ranging from 0% to 60% (see Figure 4). In many ways, individual OEM performance improved. Eight of 24 significantly tested OEMs in 2020 had zero disqualifications, representing more zero disqualification OEMs than any other year, and including one OEM that had 22 products tested in 2020. Fourteen of the 24 of the significantly tested OEMs (58%) had either 1 or 0 disqualifications in 2020. Of those OEMs that performed worse than the program average, only 1 had more than 3 disqualifications in 2020. As a comparison, in 2019, seven of the 13 significantly tested OEMs had zero disqualifications (roughly the same), and 9 performed better than the 2019 overall product disqualification rate of 13% (versus 14 in 2020).

Figure 3: Cumulative (2015-2020) Disqualification Rates, by OEM (5 or more products tested 2015-2020)

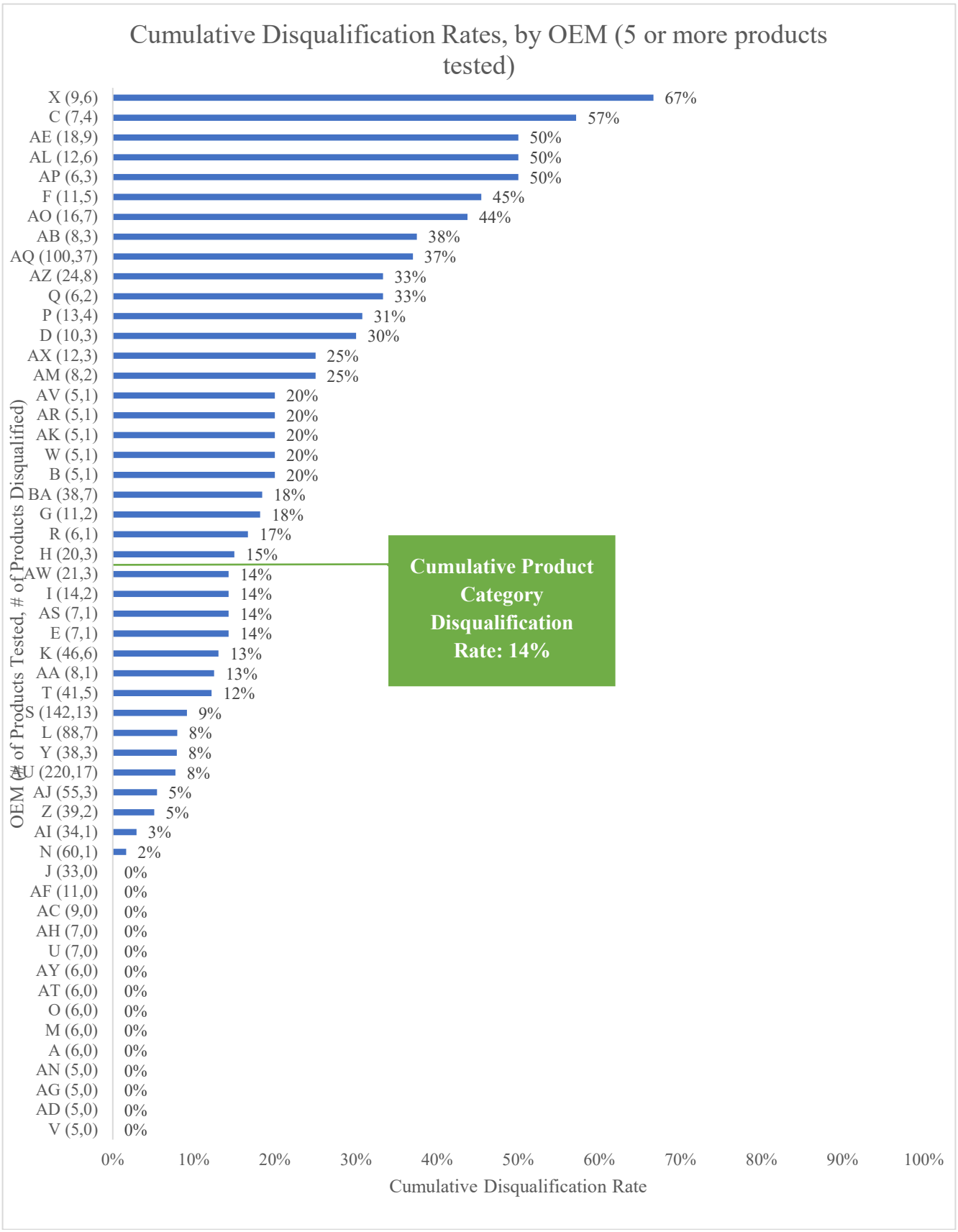


Figure 4: 2020 Disqualification Rates, by OEM (5 or more products tested in 2020)

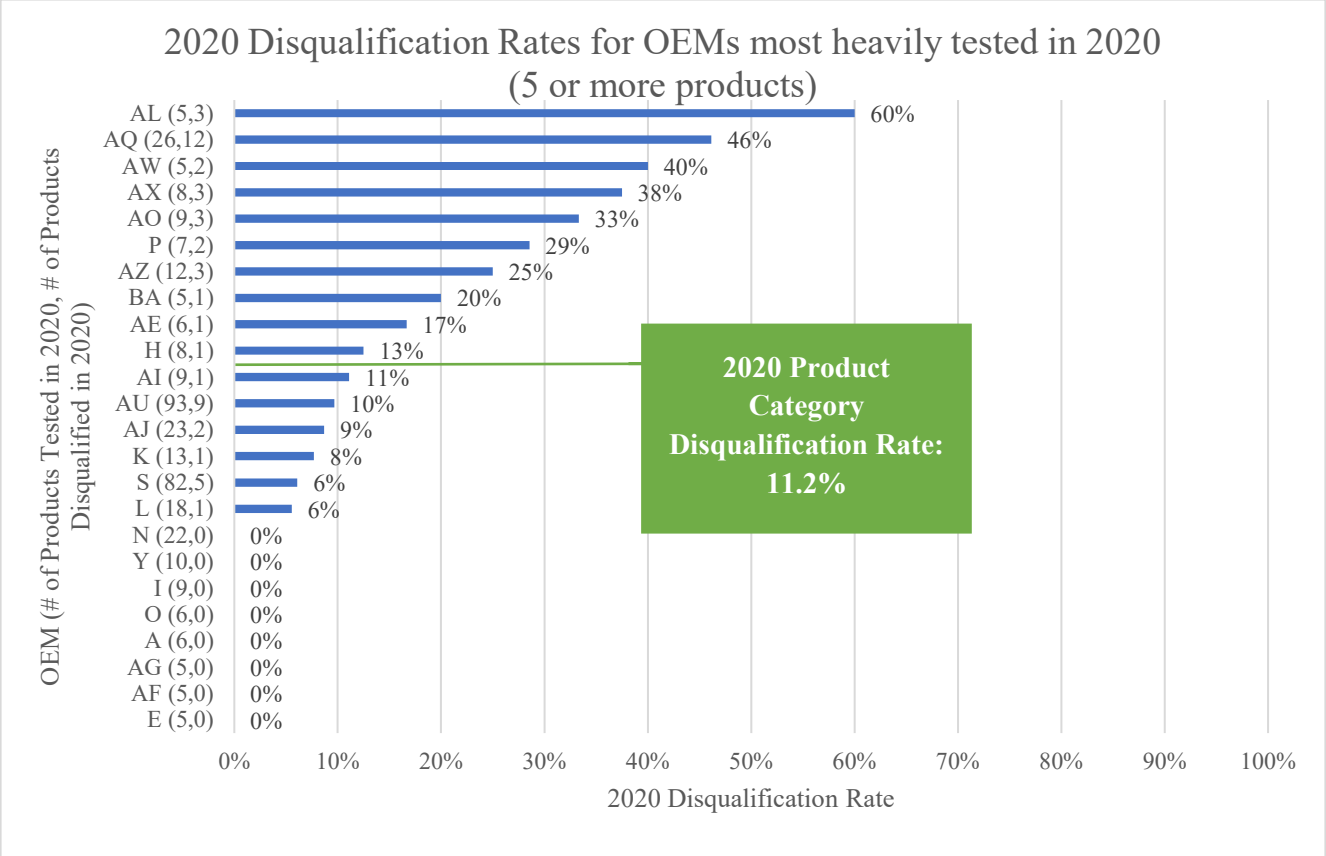
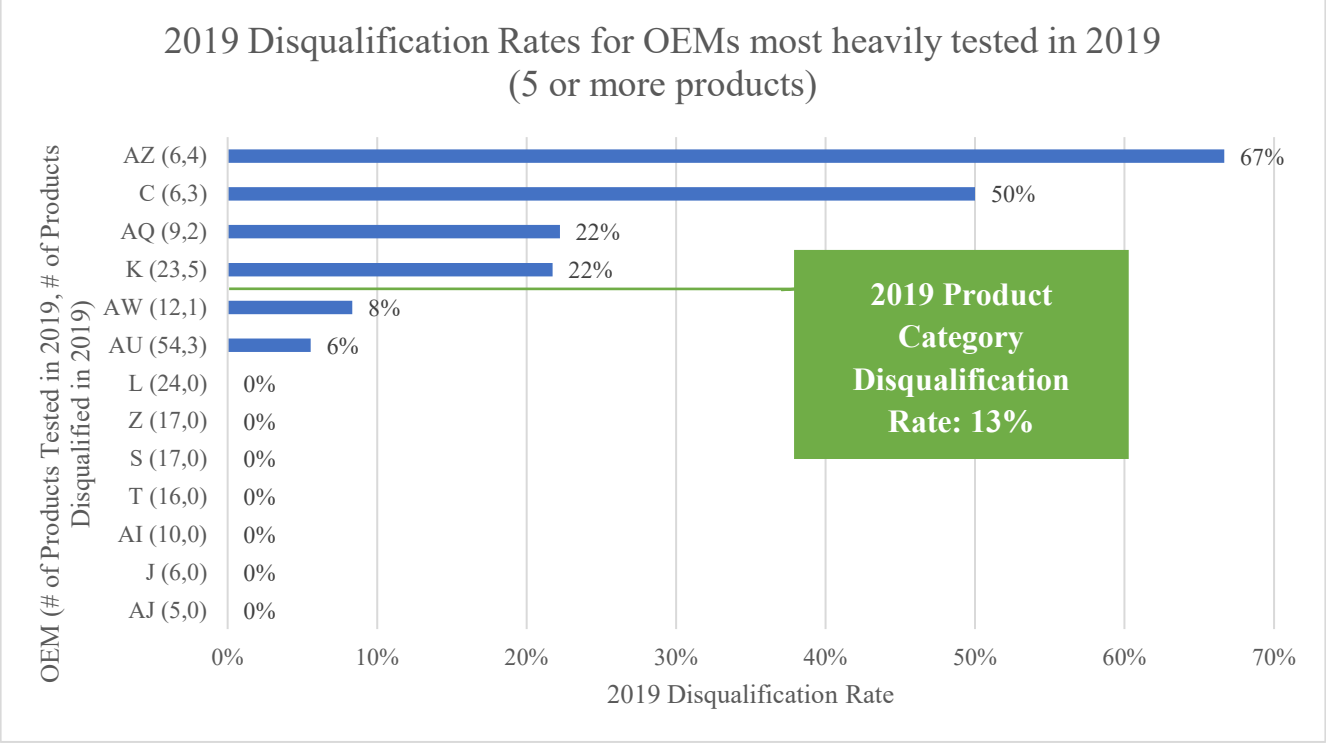


Figure 5: 2019 Disqualification Rates, by OEM (5 or more products tested in 2019)



OEM LEADERSHIP

In 2018, ENERGY STAR issued a special recognition award to Feit Electric for outstanding verification testing results as an LED bulb supplier for years 2015-2017. During that time, Feit Electric had a perfect testing record (zero disqualifications), and among those OEMs with perfect records, had the greatest number of products tested. This special recognition is intended to be a one-time annual award that recognizes an OEM presenting consistently high manufacturing quality among the products examined in verification testing.

In 2019, a special recognition award was issued to Xiamen Longstar Lighting for its 2018 verification testing results. Xiamen Longstar Lighting had a perfect testing record (zero disqualifications), and among those OEMs with perfect records, had the greatest number of products tested.

In 2020, special recognition was issued to Shanghai Dangoo Electronics Co., Ltd. for a perfect testing record established through significant testing.

This year's special recognition goes to GE Lighting, a Savant Company for its 2020 testing record (greatest number of products tested among OEMs with zero disqualifications) and an exceptional cumulative testing record.

HEIGHTENED OVERSIGHT

In 2013, EPA began to track and more openly communicate annual disqualification rates associated with each OEM for CFLs. In addition, EPA instituted heightened oversight practices, a series of program elements that provide greater oversight of those OEMs with a demonstrated history of below-average performance to prompt increased quality control. Poor performing OEMs, and private labelers associated with them, became subject to increased verification testing. Models from sources with failure rates greater than the overall product category average (based on five or more tested products) were considered for verification testing nominations, and private labelers were required, as part of corrective measures, to establish and submit additional quality control assurances covering all models that they carry from that source.

As a result of these heightened oversight efforts, the product category disqualification rate fell by a third from 2013 to 2016. Four of the five worst performing OEMs with CFLs tested during the CFL Testing Program did not certify any CFLs to the new Lamps Version 1.0 Specification. By eliminating poor performing sources from the ENERGY STAR CFL market, EPA intended to decrease the likelihood of their participation in the ENERGY STAR LED bulb market. Based on its demonstrated value in assessing and affecting the CFL market, EPA began applying that approach to individual LED bulb OEMs.

FUTURE DIRECTION

In 2021, based on analysis of all verification data, EPA announced a reduction to verification testing requirements for LED bulbs. For the first time since 3PC verification testing began in 2015, five percent rather than ten percent of bulbs would be subject to testing. EPA made that decision in recognition of the extent to which this category of products had been tested, the improvements observed in product quality among OEMs and labelers, and the cost of testing relative to the market value of the product. Since that time, EPA has received the 2020 testing data included in this assessment and is able to demonstrate continued and meaningful improvement in product quality. EPA intends to focus its resources on monitoring and providing greater scrutiny

and oversight of OEMs with poor performance in the last two years. EPA will continue to issue to all LED bulb OEMs letters that identify their annual verification testing performance. EPA encourages brand owners to seek verification testing data, including those letters issued by EPA to OEMs.

APPENDIX

TEST DATA FOR LED LAMP OEMS 2014-2020

OEM Letter Key	2019 Tested	2019 Disqualified	2020 Tested	2020 Disqualified	Cumulative Tested	Cumulative Disqualified	Cumulative Disqualification Rate
A	0	0	6	0	6	0	0.0%
B	1	1	2	0	5	1	20.0%
C	6	3	0	0	7	4	57.1%
D	2	1	0	0	10	3	30.0%
E	1	1	5	0	7	1	14.3%
F	1	1	2	1	11	5	45.5%
G	0	0	1	0	11	2	18.2%
H	2	1	8	1	20	3	15.0%
I	0	0	9	0	14	2	14.3%
J	6	0	4	0	33	0	0.0%
K	23	5	13	1	46	6	13.0%
L	24	0	18	1	88	7	8.0%
M	2	0	0	0	6	0	0.0%
N	0	0	22	0	60	1	1.7%
O	0	0	6	0	6	0	0.0%
P	2	0	7	2	13	4	30.8%
Q	1	1	2	0	6	2	33.3%
R	3	0	2	0	6	1	16.7%
S	17	0	82	5	142	13	9.2%
T	16	0	3	0	41	5	12.2%
U	3	0	3	0	7	0	0.0%
V	1	0	1	0	5	0	0.0%
W	0	0	0	0	5	1	20.0%
X	3	3	0	0	9	6	66.7%
Y	4	1	10	0	38	3	7.9%
Z	17	0	4	0	39	2	5.1%
AA	0	0	0	0	8	1	12.5%
AB	0	0	2	0	8	3	37.5%
AC	0	0	0	0	9	0	0.0%
AD	0	0	0	0	5	0	0.0%
AE	2	2	6	1	18	9	50.0%
AF	4	0	5	0	11	0	0.0%
AG	0	0	5	0	5	0	0.0%
AH	3	0	0	0	7	0	0.0%
AI	10	0	9	1	34	1	2.9%
AJ	5	0	23	2	55	3	5.5%
AK	0	0	0	0	5	1	20.0%
AL	2	0	5	3	12	6	50.0%

AM	2	0	2	0	8	2	25.0%
AN	2	0	0	0	5	0	0.0%
AO	4	2	9	3	16	7	43.8%
AP	0	0	0	0	6	3	50.0%
AQ	9	2	26	12	100	37	37.0%
AR	0	0	4	1	5	1	20.0%
AS	0	0	2	0	7	1	14.3%
AT	2	0	0	0	6	0	0.0%
AU	54	3	93	9	220	17	7.7%
AV	1	0	1	1	5	1	20.0%
AW	12	1	5	2	21	3	14.3%
AX	4	0	8	3	12	3	25.0%
AY	1	0	0	0	6	0	0.0%
AZ	6	4	12	3	24	8	33.3%
BA	3	0	5	1	38	7	18.4%