| DOCKETED | |
|---|---|
| **Docket Number:** | 17-AAER-12 |
| **Project Title:** | Low-Power Mode |
| **TN #:** | 248670 |
| **Document Title:** | California Investor Owned Utilities Comments - Updated Data Collection Procedure Proposal and Round Robin Test Results |
| **Description:** | N/A |
| **Filer:** | System |
| **Organization:** | California Investor Owned Utilities |
| **Submitter Role:** | Public |
| **Submission Date:** | 2/3/2023 3:27:01 PM |
| **Docketed Date:** | 2/3/2023 |

*Comment Received From: California Investor Owned Utilities*
*Submitted On: 2/3/2023*
*Docket Number: 17-AAER-12*

## Updated Data Collection Procedure Proposal and Round Robin Test Results

*Additional submitted attachment is included below.*

# Low-Power Modes

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

Updated Data Collection Procedure
Proposal and Round Robin Test Results
**Low Power Mode**
**17-AAEER-12**

February 3, 2023

Prepared for:

Pacific Gas and Electric Company®

SDGE™

SOUTHERN CALIFORNIA EDISON®
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This report was prepared by the California Statewide Investor-Owned Utilities Codes and Standards Program and funded by the California utility customers under the auspices of the California Public Utilities Commission.

# Acknowledgments

The Statewide CASE Team thanks our OEM collaborators for their valuable contributions that significantly improved this work. We also acknowledge the efforts of Michael Daukoru and Billy Burmeister of the PG&E Applied Technology Services laboratory, who led testing and provided valuable input throughout the development of this proposal. We thank the following experts for their reviews and feedback on various iterations:

- John Clinger, ICF
- Abigail Daken, U.S. Environmental Protection Agency
- Pierre Delforge, Natural Resources Defense Council (now with Harvest Thermal)
- Noah Horowitz, Natural Resources Defense Council (now with ClimateWorks Foundation)
- Bruce Nordman, Lawrence Livermore National Laboratory

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# 1. Introduction

The Codes and Standards Enhancement (CASE) initiative presents recommendations to support California Energy Commission's (the Energy Commission or CEC) efforts to update California's Appliance Efficiency Regulations (Title 20). Three California Investor-Owned Utilities (IOUs) – Pacific Gas and Electric Company (PG&E), Southern California Edison (SCE), and San Diego Gas and Electric (SDG&E) – sponsored this effort (herein referred to as the Statewide CASE Team). The program strives to prepare and submit proposals that will result in cost-effective enhancements improving the energy and water efficiency of products sold in California. The information presented herein responds to the Energy Commission's request for a low-power modes (LPM) data collection procedure (DCP) proposal. Specifically, this submission includes this document, which contains results from round-robin testing of the Statewide CASE Team's DCP proposal and a list of products for which it yields reproducible data, and the updated DCP proposal (version (v) 3) as an accompanying document.

The CEC is leading efforts to develop a DCP as a foundational activity for the LPM Roadmap (Figure 1). The Statewide CASE Team developed a DCP proposal that measures whole-product power draw and meets CEC's objectives outlined in their January 2019 webinar, which are to:

- Create a common test procedure for a wide variety of products,
- Break products into groups with separate setup or measurement instructions only when necessary,
- Define reproducible test setups that represent real-world usage,
- Measure power draw in an "inactive" condition in which the product is not performing a primary function,
- Capture power draw of supporting[1] functions in the inactive condition, and
- Allow stakeholders to collect and submit comparable data.[2]

The Statewide CASE Team proposal builds on the International Electrotechnical Commission (IEC) test procedure, IEC 62301:2011.[3] IEC 62301 provides some guidance for conducting power measurements in low-power operating modes but has two significant limitations that prevent it from meeting CEC's objectives. First, IEC 62301 lacks setup instructions that apply to many of the newest functions that electricity-using products may offer, such as network connectivity, voice activation, and environmental monitoring. Second, IEC 62301 measures power in discrete operating modes, rather than in a real-world inactive condition that may consist of multiple modes. The Statewide CASE Team's DCP proposal provides instructions for the setup and measurement of products in the inactive condition, addressing the limitations of IEC 62301 and providing a method to reproducibly test products under real-world conditions.

[1] The Statewide CASE Team previously used the term "secondary functions." The team updated the term to "supporting functions" in this submission, as described in Section 2.
[2] CEC Low-Power Mode Roadmap Webinar Presentation, January 24, 2019. https://efiling.energy.ca.gov/GetDocument.aspx?tn=226376&DocumentContentId=57150.
[3] Standard available at https://www.iecee.org/dyn/www/f?p=106:49:0::::FSP_STD_ID:6789.

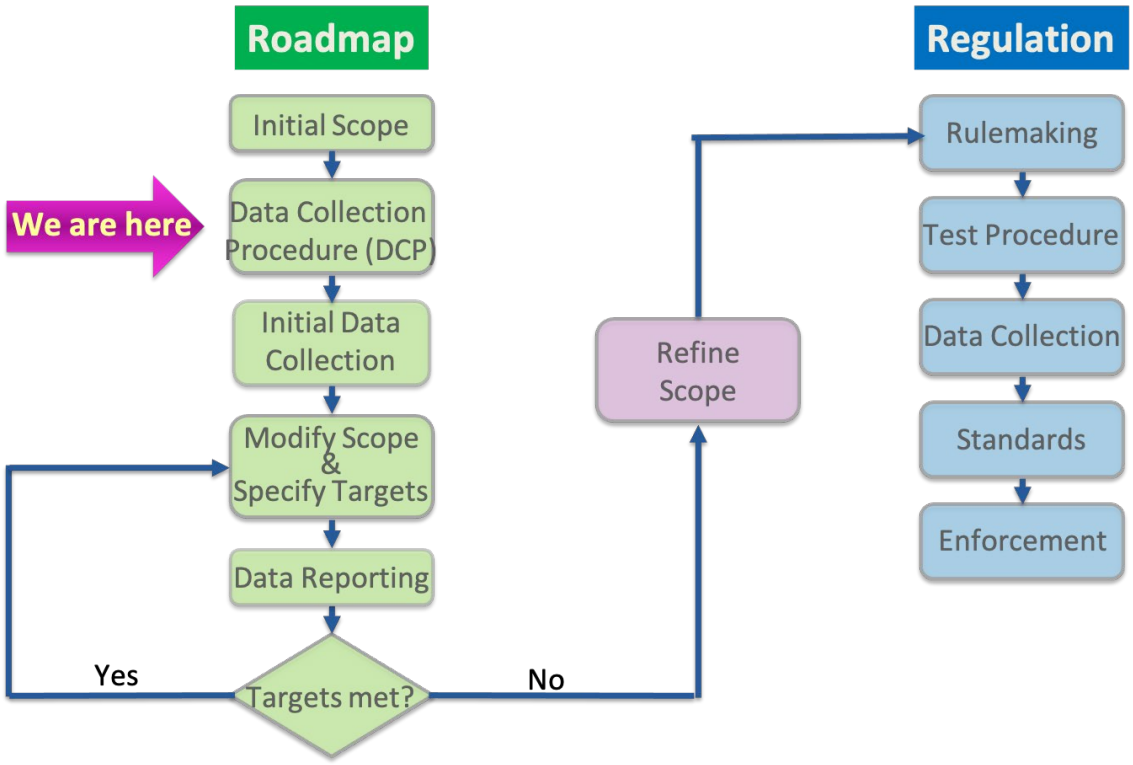


**Figure 1. CEC LPM Roadmap plan.**
Source: CEC[4]

The Statewide CASE Team's DCP proposal was developed iteratively from 2019 to 2020 at PG&E's Applied Technology Services (ATS) laboratory (Figure 2). The team used 44 products to test preliminary draft instructions. Once the team had a well-developed set of instructions, it performed internal round-robin testing during which an ATS engineer that did not participate in DCP proposal development tested several products using the same instrumentation used in DCP development. These internal tests were successful. In May 2021, the team submitted a DCP proposal (DCP proposal v1) for measuring inactive condition power that included instructions for instrumentation, product setup, and measurement of the product's average power when not performing its primary function.[5] On August 25, 2021, the CEC held a public workshop to gather feedback on the Statewide CASE Team's DCP proposal and requested written comments. In response to stakeholder feedback, the team modified the DCP proposal (DCP proposal v2), then conducted round-robin testing at two International Organization for Standardization (ISO) 17025-accredited third-party labs to identify products for which the DCP proposal yields reproducible measurements.

The round-robin testing used a sample size of 29 products to vet as many DCP proposal instruction blocks (numbered paragraphs in the DCP proposal) and supporting functions as possible. The third-party labs tested products purchased in early 2022 rather than those previously tested during DCP proposal development. Test results identified aspects of the original DCP proposal that needed

[4] CEC Staff Presentation for Low-Power Mode Roadmap Workshop, August 25, 2021. https://efiling.energy.ca.gov/GetDocument.aspx?tn=239448&DocumentContentId=72910
[5] CA IOU Cover Letter and Data Collection Procedure, May 14, 2021. https://efiling.energy.ca.gov/GetDocument.aspx?tn=237807&DocumentContentId=71046

further clarification and additional instructions to yield reproducible results. As a result, the Statewide CASE Team submits this updated DCP proposal, DCP proposal v3, for the CEC's consideration.

The DCP proposal yielded reproducible measurements for 20 of the 29 products in the round-robin study. The team then conducted an analysis to identify additional products that the DCP proposal would generate reproducible measurements, as described in Section 4. Section 4 contains a list of "vetted" products that the CEC may consider for data collection in the first round of the LPM Roadmap, and identifies products that are not reproducible with the current version of the DCP proposal. The team will continue to investigate DCP proposal refinements to include these product categories in later cycles of the LPM Roadmap.

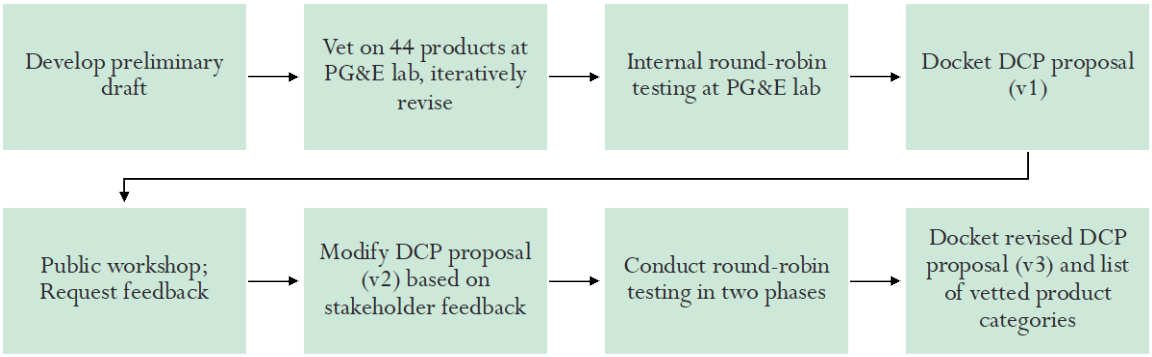


**Figure 2. Overview of steps in the CASE Team's development of its DCP proposal.**
Source: Statewide CASE Team

# 2. Terminology Updates

The Statewide CASE Team received valuable feedback from other stakeholders before and during round-robin testing activities. The team incorporated much of their feedback, described in further detail below. This section discusses stakeholder feedback on terminology and changes made to this document and the updated DCP proposal.

The name of the test condition, "DCP inactive state," continues to confuse stakeholders. "State" is often used to describe an operating mode of a component within a product, such as a processor. The team has replaced the term "state" with "condition" to eliminate this issue. Multiple stakeholders have expressed concern regarding the term "inactive," which implies the product's lack of functionality, primary or supporting. Stakeholders suggested alternatives: "default baseline power" and "alternative low-power state." The team does not have a strong preference for the alternative terms and uses the term "DCP inactive condition" in this submission.

Stakeholders suggested alternatives for the terms "primary function" and "secondary function." The team determined the alternative suggestions "main" and "major" for the term "primary" convey a similar meaning and retain the term "primary function." The team clarified in the DCP proposal that a product can have more than one primary function.

A stakeholder suggested the alternative term "supporting function" for "secondary function" to acknowledge its role in providing the user with the product's expected services. The team agrees with this change and uses the suggested term in this submission.

Moreover, stakeholders highlighted the need for clear definitions of primary and supporting functions, which are crucial for determining product setup and testing conditions. The team added examples to clarify these definitions; DCP proposal v3, Appendix A lists vetted product categories and their typical primary functions. Although the list is not exhaustive, these examples will help testers and stakeholders determine primary functions of products. Appendix B lists and defines functions that are typically supporting functions and operate when the product is in DCP inactive condition. It also gives examples of products with primary functions that, across products in the LPM scope, are more frequently supporting functions.

The Statewide CASE Team notes that the aforementioned terminology issues may warrant discussion among the collective stakeholder group to develop meaningful terminology, and seeks feedback on the changes above.

# 3. Round-Robin Testing: Process and Results

## 3.1 Pre-Round-Robin DCP Proposal Modifications

Prior to round-robin testing, the Statewide CASE Team modified the DCP proposal based on stakeholder feedback received after the August 2021 public workshop. These modifications included:

- Requiring a fixed, three-hour test length. The original proposal required the tester to determine a sufficient test duration that captures the unit under test's (UUT's) inactive condition behavior,
- Reducing the warmup time from 24 hours to the greater of (a) the amount of time (up to 12 hours) needed to observe UUT power behavior in DCP inactive condition, or (b) the manufacturer's recommended provisioning time,
- Adding clarification and guidance for identifying primary and supporting functions in new Appendices A and B,
- Including light meter specifications and instructions for controlling products responsive to ambient light,
- Clarifying instructions that originally confused other stakeholders.

The first phase of round-robin testing used this modified DCP proposal v2 (Figure 2).

## 3.2 Overview of the Round-Robin Testing Process

The Statewide CASE Team began round-robin testing in late 2021 to test reproducibility of the DCP proposal. The team selected UL Solutions in Freemont, California, and Intertek in Cortland, New York to carry out the testing. The labs are ISO 17025-accredited and conduct ENERGY STAR and other electronics compliance testing.

The round-robin testing aimed to evaluate the DCP by comparing power measurements made by the two labs, which used only the guidance of the DCP proposal v2 and the accompanying Data

Reporting Tool (DRT). To reduce testing timelines, the Statewide CASE team procured two samples of each tested product and sent one sample to each lab. Except for the game consoles, which were in limited supply at the time of purchase, the team purchased the two samples of each product from the same retailer and stock-keeping unit (SKU).

To determine whether the DCP proposal yielded the same result at the two labs, the Statewide CASE Team imposed the following reproducibility criterion. If average power (across the three-hour inactive test window) was greater than one watt (W), the difference in the two labs' measurements must be less than or equal to five percent. If average power was less than one watt, the difference must be less than or equal to 0.05 W. If power measurements met the criterion for the inactive condition and off mode tests, the team concluded the proposal yielded reproducible results for that product.

## 3.3 Round-Robin Test Strategy and Process

The Statewide CASE Team designed round-robin testing to identify products for which the DCP proposal yields reproducible data. The team intended to prove the reproducibility of a broad set of products and functions in the LPM scope within a reasonable time. The team's testing strategy included:

- **Vetting as many DCP instruction blocks as possible.** The DCP proposal applies to a wide range of products and contains instruction blocks that apply only to specific product types. The team selected products for round-robin testing that together would test the majority of the instruction blocks in the DCP proposal v2.
- **Vetting as many supporting functions as possible.** A key element of the DCP proposal is identifying product functions and, given its functions, setting up and testing the product appropriately. The team selected products for testing that covered the following supporting functions:
    - network connections (Wi-Fi, Ethernet, Bluetooth, Zigbee, Wi-Fi Direct, proprietary radio frequency (RF) protocol)
    - HDMI and USB connections
    - displays (fixed pixel, fixed pixel with automatic brightness control (ABC), dot matrix, segment, touch screen)
    - voice interfaces
    - remote controls (infrared (IR) remote, app)
    - sensing (e.g., occupancy, ambient sound, light, contact)
    - cameras
- **Focusing on residential-type electronic and other loads.** While developing the DCP proposal, the Statewide CASE Team tested residential-type electronic and other loads. A considerable energy savings potential exists for residential loads. Always-on loads

comprise about 23% of electricity use in Northern California homes. [6] The team continued to focus its testing on residential-type products in the round-robin project.

- **Placing more focus on products with high savings potential or complex setups.** The Statewide CASE team focused round-robin efforts on products that present the most savings potential in our preliminary estimates. Because previous round-robin testing at ATS (using the same instruments but a different engineer) yielded similar measurements, the team expected that measurements on products with simple setups would likely be reproducible. The team therefore selected products with more complex setups for round-robin testing. However, seemingly simple products can reveal complications during setup, as discussed below.

The round-robin testing process included:

- **Conducting testing in two phases.** A phased approach allowed the Statewide CASE Team to edit the DCP proposal after testing the first set of products. After the first testing phase, the team clarified instructions that the labs or manufacturers found confusing, and added instructions that were found to be missing. In addition, the team streamlined the testing to reduce confusion and test burden. Sections 3.4 and 3.6 describe the modifications.

- **Seeking manufacturer feedback regarding products included in the round-robin testing.** The Statewide CASE Team reached out to the manufacturers of each product tested. Manufacturers participated to varying degrees based on interest and availability by providing feedback on the DCP proposal v2, reviewing the product summaries and test results, and, in some cases, conducting verification testing.

Table 1 shows the products selected for round-robin testing. To expedite testing, the Statewide CASE Team elected to test different samples at the two third-party labs (testing A and B samples at Lab A and Lab B, respectively) rather than the traditional method of testing the same sample at different labs. The team expected inter-sample differences in power draw measurements (meaning the difference in measured power of samples A and B of a given product) to be small. To minimize inter-sample differences, the team purchased A and B samples from the same retailer and SKU for most products tested in the study. Game consoles were the exception. Due to limited product availability at the time of procurement, the team was forced to purchase game console samples from lesser-known retailers and could not obtain A and B samples from the same SKU.

The team allowed labs to conduct tests with minimal guidance to determine whether third-party labs interpreted the DCP proposal instructions similarly. When differences in instruction interpretation arose, the team clarified its intent with the labs and later revised the DCP proposal to clarify or add instructions where necessary.

When the measurements at the two labs did not meet our reproducibility criterion, the team worked to troubleshoot the causes of the differences, clarified setups with the labs, and then asked the labs to retest the samples. Most of the differences were caused by the labs' interpretation of the primary and supporting functions, how to connect which network connections, and which

[6] Natural Resources Defense Council (NRDC), 2015. Home Idle Load: Devices Wasting Huge Amounts of Electricity When Not in Active Use. https://www.nrdc.org/sites/default/files/home-idle-load-IP.pdf

additional products to connect to the UUT. After troubleshooting, the testing yielded reproducible data for 20 of 29 products, as discussed below.

**Table 1. Product types (and the number of products) tested in two round-robin phases.**

| |
|---|
| **Phase 1** |
| Local area network (LAN) equipment (5) |
| Smart speakers (4) |
| Smart speaker + wireless extender (1) |
| Home security camera & systems (3) |
| Lighting controls (1) |
| **Phase 2** |
| Game consoles (3) |
| Smart displays (3) |
| Connected doorbells (3) |
| Computer speakers (2) |
| Printers (2) |
| Coffee makers (2) |

## 3.4 DCP Proposal and Testing Modifications between Round-Robin Phases

A phased approach to round-robin testing allowed the Statewide CASE Team to modify the DCP proposal based on knowledge acquired from the first phase test results and stakeholder feedback. Modifications to the DCP proposal before the second phase included:

- **Streamlining the tests, requiring at most three tests per UUT.** The Statewide CASE Team designed the original DCP proposal to be a comprehensive data collection tool that tested products under different setup conditions to understand their sensitivity to those conditions (e.g., power delivery method to UUT, connected network technologies, DCP inactive condition initiation method, and power management settings). The team concluded that the suite of tests required by the original DCP proposal was too complicated. The labs required help to determine which tests to carry out and the proper setup of the UUT for each test. Moreover, feedback from an OEM stakeholder indicated that the responsibility of identifying which tests to run on a UUT should not fall on the tester. Therefore, the team streamlined the DCP proposal to collect only the data needed to evaluate products' compliance with future LPM Roadmap targets. This change reduced the number of tests required to a maximum of three per UUT: one inactive condition test if the UUT does not respond to ambient light, two inactive condition tests (under bright (daytime) and dark (nighttime) room illuminance conditions) if the UUT inactive condition power depends on ambient light levels, and an off-mode test if the UUT has an off mode.
- **Improving function reporting accuracy.** The team found that the third-party labs had difficulty identifying primary and supporting functions. To improve reporting accuracy, the team updated the DCP proposal to allow the manufacturer or organization ordering the test the option of providing product functions. If provided with product functions, the lab will verify rather than identify the functions. The second round-robin

phase used this procedure, and the team provided labs with primary and supporting functions for each tested product.

- **Adding dark room requirements for products with a scaled response to ambient light.** The original DCP proposal did not include dark room requirements for products that scale power to ambient light, such as displays with automatic brightness control (ABC). The team added dark room and illumination requirements from the ENERGY STAR test method for displays to address this shortcoming.[7]
- **Adding ambient sound level requirements for products that respond to voice or other sounds**. The team received feedback that ambient sound in the test environment may impact products with voice interfaces; thus, the DCP proposal should include a maximum allowable ambient sound requirement. The team added a maximum ambient sound requirement of 50 dB and sound pressure level meter requirements following the ANSI/CTA-2084-A test method for audio and video products.[8]
- **Editing language to clarify instructions**. Based on feedback from the third-party labs and stakeholders, the team again edited language to clarify the DCP proposal instructions.

For the second testing phase, the team selected products to vet instruction blocks and supporting functions not addressed in phase one, including products that use ambient light to scale power, low-voltage AC and DC power, and automatic power down (APD).

## 3.5 Round-Robin Results

Table 2 shows an overview of the round-robin results; the Appendix includes the complete results. Note that the team presents anonymized data to focus the discussion on the DCP proposal's ability to yield reproducible results rather than on the energy consumption of specific products. The Appendix also includes product characteristics: product category, primary function(s), and supporting function(s). Labs were designated A and B, with the product samples initially shipped to each also designated A and B to allow identification of testing results and issues with particular product samples.

The round-robin tests yielded reproducible measurements for 20 of 29 products, including small network equipment (SNE), smart speakers, lighting controls, game consoles, computer speakers, printers, and coffee makers. For most (18) of the products that yielded reproducible data, power draw of samples A and B, measured by labs A and B respectively, met the team's reproducibility requirement. Two products met the reproducibility requirement in a slightly different manner due to sample damage or inter-sample variability:

- Connected lighting kit. Damage occurred to sample B during testing. A third lab tested sample A and reproduced Lab A's data.
- Game console. A and B samples of one of the tested game consoles showed an inactive power difference of about 15%. Suspecting that some of the difference was due to inter-

[7] ENERGY STAR Program Requirements Product Specification for Displays Test Method Rev. November – 2021. https://www.energystar.gov/sites/default/files/asset/document/Displays%20Version%208.0%20Program%20Requirements%20Rev.%20Nov-2021.pdf

[8] Test procedure available at: https://shop.cta.tech/products/ansi-cta-2084-a-test-methods-for-determining-a-v-product-energy-efficiency

sample variability, the team asked the labs to swap samples. The resulting inactive power measurements of Samples A and B were within 1.0% and 0.6%, respectively (Appendix).

Measurements were not reproducible for the home security products, smart displays, and connected doorbells. The wireless extender with integrated smart speaker samples did not yield reproducible data from their first tests. During troubleshooting, both samples tested were reset to default settings and were unable to establish network connections. The team was unable to make these units function again and therefore did not complete testing on this product.

**Table 2. Summary of round-robin reproducibility results.**

| Product Category | Total samples tested | Met reproducibility criteria? | |
|---|---|---|---|
| | | Yes | No |
| SNE - Router | 3 | 3 | 0 |
| SNE - Wi-Fi Mesh | 2 | 2 | 0 |
| Wi-Fi extender with integrated smart speaker | 1 | 0 | 1 * |
| Smart speaker | 4 | 4 | 0 |
| Home security camera or system | 3 | 0 | 3 |
| Connected lighting kit | 1 | 1 ** | 0 |
| Game console | 3 | 3 *** | 0 |
| Smart display | 3 | 0 | 3 |
| Doorbell | 3 | 1 | 2 |
| Computer speakers | 2 | 2 | 0 |
| Printer | 2 | 2 | 0 |
| Coffee maker | 2 | 2 | 0 |
| **Notes:** | | | |
| Green highlighting indicates that all products in the product category yielded reproducible measurements.<br>* Products became nonfunctional (would not connect to network) for unknown reasons before the completion of troubleshooting.<br>** B sample was damaged during testing. Lab A and a third lab obtained reproducible measurements on the A sample.<br>*** Reproducibility was shown on each sample rather than by a comparison of samples A and B. | | | |

The team finds that the DCP proposal yields reproducible results for products with supporting functions requiring relatively simple setup conditions, including products that include sensors, voice interfaces, displays without ABC, and network connections. The current DCP proposal does not yield reproducible measurements for products with displays that use ABC, or cameras impacted

by ambient light. The team learned that many supporting functions may require additional setup instructions, evident only when the product is inspected or tested. Therefore, reproducibility results can be extrapolated only to products with similar functionality to those in the round-robin effort. See the discussion in Section 4.

In summary, the Statewide CASE Team finds that the current version of the DCP proposal is a strong horizontal foundation that can be applied to a group of residential-type products identified in Section 4. The DCP proposal requires additional development to include more products.

## 3.6 Post-Round-Robin DCP Modifications

As with phase one, phase two testing revealed clarifications needed in the DCP proposal. The team made the following modifications after the second phase of round-robin testing.

- **Modified setup instructions for products with multiple peripheral options**.[9] The original DCP proposal required the tester to attach all peripherals included with the UUT. These peripherals must stay attached and functioning during the test. The team noted in phase two testing that for some products that ship with multiple peripherals, simultaneously connecting all the peripherals might not be possible. To address this situation, the team instructed the tester to use the first peripheral configuration described in the manufacturer's instructions.
- **Added instructions to update the app and record the version**. The original DCP proposal instructed testers to update software or firmware if a new version was available. The updated proposal also requires the tester to update any apps used during UUT setup to the latest version, if applicable.
- **Added instructions to disable automatic updates**. Some products began downloading or installing updates during round-robin tests, impacting reproducibility. The team added instructions to disable software, firmware, app, store, and other automatic updates if possible to limit reproducibility issues.
- **Specified that the tester must charge all UUT rechargeable batteries before testing.** The original DCP proposal required UUTs with rechargeable batteries to be fully charged prior to the start of a test. In phase two, the team identified reproducibility issues stemming from peripherals that were charging during testing. The team added explicit instructions to fully charge UUT batteries, including those in peripherals, before testing.
- **Included instructions for UUTs that do not have default power management settings.** The majority of products had defaults selected for power management settings. The team added this instruction for UUTs that do not have default settings: the tester shall determine and test the setting that yields the highest power draw for the UUT.
- **Created an exception for UUTs with the primary function of providing power to another product.** Plug strips, outlets, and similar products pose a reproducibility challenge. The original DCP proposal required the tester to set up the UUT to perform its primary function by populating one or more outlets or ports to power the

[9] A peripheral is a product component that attaches to the central product component to provide one or more functions. For example, a game console controller is a peripheral that attaches to the central component, the console, to provide a user interface.

attached product(s). However, some products, especially electronics, impact the UUT's power draw by drawing measurable power during the DCP inactive condition test. The team created an exception for UUTs whose primary function is powering another product. The tester will not populate the UUT's power ports or outlets that provide power as its primary function.

- **Removed unproven instruction blocks.** The team removed instruction blocks that were not tested or applied to products that did not yield reproducible measurements during round-robin testing. The team did not test any PoE-powered products and therefore removed PoE-specific instrumentation and setup instruction blocks. The team also removed instructions for testing displays that scale screen brightness to ambient light because the tested smart displays did not yield reproducible measurements. The team plans to continue to develop instructions to yield reproducible measurements of PoE-powered and products that scale screen brightness to ambient light for inclusion in the LPM Roadmap's future cycles.
- **Reduced the inactive condition test duration from three hours to one hour.** The Statewide CASE Team analyzed round-robin data to determine if the test length could be reduced while still capturing the UUT's full inactive power draw behavior and yielding reproducible measurements. The team found that most UUTs showed similar power draw over the first hour of the test and the full three hours of the test. For most UUTs, average power over the first hour of the test was less than one percent different than the three-hour average power. All UUTs that yielded reproducible measurements with the three-hour test would also yield reproducible measurements if the test was only one hour long. Reducing the test length will reduce test burden without negatively impacting results.
- **Edited instructions for clarity**. Based on feedback from the third-party labs and stakeholders, the Statewide CASE Team edited the DCP proposal language to improve understandability.

The modifications discussed above and in Sections 3.1 and 3.4 are included in the Statewide CASE Team's updated DCP proposal, v3, which accompanies this report.

# 4. Scope of DCP Proposal v3

The broadness of the LPM Roadmap's initial scope limited the team's ability to test all in-scope product types to verify that the DCP proposal yields reproducible measurements. Therefore, the team developed an evaluation strategy to identify and infer reproducibility for products similar to those that yielded reproducible data in round-robin testing.

Round-robin testing showed that the DCP proposal yields reproducible data for the products highlighted in Table 2. These are referred to as "directly" vetted products since direct measurements showed that the DCP proposal yielded reproducible measurements. The team examined additional products in the LPM Roadmap's scope to determine those for which reproducibility can be inferred without testing. These "indirectly" vetted products are ones that:

- Use instrumentation, UUT setup, and measurement instruction blocks tested on directly vetted products during round-robin testing, and
- Implement supporting functions possessed by directly vetted products.

An essential takeaway from the round-robin testing is that some products may require additional setup instructions or clarifications to yield reproducible data, which is difficult to anticipate before inspection or testing of the product. Thus, the team was conservative in classifying the indirectly vetted products, including only relatively simple products in functionality and understandability.

The team successfully vetted all the instruction blocks in the DCP proposal except the following:

- Instrumentation and UUT setup for power over ethernet (PoE) products,
- Ambient light requirements for products that have a scaled response to ambient light, i.e., displays with ABC.

Although it tested all instruction blocks for products with cameras, the team did not generate reproducible data for security systems and doorbells. Consequently, the DCP proposal should only test PoE products, products containing cameras, or APD displays once further refinements yield reproducible measurements.

Directly and indirectly vetted products are presented in Table 3. The list does not contain product categories yet to be considered in DCP proposal development and round-robin testing, including commercial- and industrial-specific products, most heating, ventilation, and air conditioning (HVAC) products (except for plug-in, portable types), medical and health care equipment, light sources, major appliances, and major building infrastructure or systems products. The DCP proposal has not yet generated reproducible measurements for these types of products.

**Table 3. Products that yield reproducible data with the DCP proposal v3, including directly vetted products (in bold type) and indirectly vetted products (in** plain type**).**

| End Use | General product category | Product category |
|---|---|---|
| HVAC | Space Conditioning | Portable heaters |
| | Ventilation | Residential standalone fans |
| | Controls | Programmable and connected thermostats and humidity controls |
| | Other | Air purifiers |
| Lighting | Controls | **Light switches** |
| | | Wireless adapters |
| | | Occupancy sensors |
| | | Environmental & light level sensors |
| Electronics | Multimedia | **Game consoles** |
| | | Speakers (including **smart speakers**) |
| | | Streaming media players |
| | | Receivers |
| | | Turntables |
| | | Home-theater-in-a-box systems |
| | | Soundbars |
| | | MP3 speaker docks |
| | | Audio amplifiers |

| End Use | General product category | Product category |
|---|---|---|
| | | Video projectors |
| | Computers & peripherals | **Computer speakers** |
| | | External hard drives |
| | | Docking stations |
| | Imaging equipment | **Printers** |
| | | Multi-function devices |
| | Network equipment | **LAN equipment** |
| Household devices | Small kitchen appliances | **Coffee makers** |
| | | Coffee grinders |
| | | Blenders |
| | | Electric grills |
| | | Toaster ovens and toasters |
| | | Air fryers |
| | | Pressure cookers, rice cookers, slow cookers, and multicookers |
| | | Food processors |
| | Electric housewares | Vacuum cleaners |
| | | Sewing machines |
| Infrastructure | Power | Power strips, outlets, plugs |
| | Building automation & control devices | Smoke & carbon monoxide detectors |
| | | Energy monitoring systems |
| Miscellaneous | Business equipment | Shredders |
| | | Pencil sharpeners |
| | Personal care | Hair stylers, trimmers, clippers |
| | | Hair dryers |
| | | Epilators |
| | Outdoor equipment | Outdoor water features |
| | | Irrigation controllers |
| | Bathroom devices | Heated towel racks |
| | | Faucets |
| | | Showerheads |
| | | Toilets |
| | Hobby, entertainment, leisure | Exercise equipment |
| | | Water pumps less than one horsepower, excluding dedicated pool and spa pumps |
| | | Heated or motorized furniture |
| | | Musical instruments and production equipment |

The team recognizes that some individual products within the product categories listed above cannot be tested with the DCP proposal because they do not have a DCP inactive condition. These products are powered with on/off switches and do not possess supporting functions like sensors, displays, or network connections. To illustrate this situation, consider two paper shredders. Shredder A has an on/off switch. When switched on, the motor runs continuously. The user must

switch the shredder off to stop the motor. Shredder B has an on/off switch, but the motor does not run unless the shredder senses paper in the unit. The motor automatically powers down once shredding is complete. Shredder A does not have supporting functions or a DCP inactive condition. The paper sensor is Shredder B's supporting function. In the DCP inactive condition, the machine is on, but the motor is not running. The DCP proposal can test Shredder B but not Shredder A.

In summary, the DCP proposal v3 applies to the product categories listed in Table 3. If the CEC adopts the DCP proposal and moves to the data collection phase, the Statewide CASE Team would recommend a scope for the first cycle of the LPM Roadmap that includes a subset of the products listed in Table 3. The Statewide CASE Team plans to continue expanding the scope of products that can be tested with the DCP proposal for inclusion in future cycles of CEC's LPM Roadmap. Products of interest include those that posed reproducibility challenges during this study (security cameras and systems, doorbells, smart displays), as well as other products with high energy savings potential. The team will also evaluate new products and functions as they come to market, such as sleep trackers.

# 5. Conclusions

The Statewide CASE Team has developed a data collection procedure to measure power draw and allow testers to characterize the functionality of products when inactive. This test method is well-suited for CEC's "horizontal" approach to the LPM Roadmap because the instructions are not product category specific. The team recommends this DCP version to conduct whole-product testing for the first CEC's LPM Roadmap cycle.

Round-robin testing demonstrated that the proposed DCP provides reproducible results for many product categories assessed (Table 3). The list includes products that yielded reproducible data in round-robin testing as well as similar products that possess the same supporting functions and use the same DCP instruction blocks as tested products.

For the first LPM Roadmap cycle, the team recommends that CEC focus on a subset of vetted product categories. The team will continue to refine the proposed DCP to expand the list of vetted product categories for future LPM Roadmap cycles and increased energy savings potential.

# Appendix

**Table 4: Detailed Round-Robin Test Results**

| Product Category | Primary Function | Supporting Functions* | Ambient light test condition | $t_{APD}$ (min) | Inactive Condition Power | | | Off Mode Power | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Lab A (W) | Lab B (W) | Diff | Lab A (W) | Lab B (W) | Diff |
| SNE - Router | Passing user-generated IP traffic | Networking (**Ethernet: 10/100/1000, Wi-Fi: 802.11ax**), USB 3.0 (2 ports) | n/a | n/a | 11.3 | 11.2 | 0.89% | n/a | n/a | n/a |
| SNE - Router | Passing user-generated IP traffic | Networking (**Ethernet: 10/100/1000; Wi-Fi: 802.11ax**), USB 3.0 (2 ports) | n/a | n/a | 7.46 | 7.66 | 2.6% | n/a | n/a | n/a |
| SNE - Router | Passing user-generated IP traffic | Networking (**Ethernet: 10/100/1000, Wi-Fi: 802.11ax**) | n/a | n/a | 10.7 | 10.2 | 5.0% | n/a | n/a | n/a |
| SNE - Wi-Fi Mesh | Passing user-generated IP traffic | Networking (**Ethernet: 10/100/1000, Wi-Fi: 802.11ax**) | n/a | n/a | 8.19 | 8.18 | 0.12% | n/a | n/a | n/a |
| SNE - Wi-Fi Mesh | Passing user-generated IP traffic | Networking (**Ethernet: 10/100/1000, Wi-Fi: 802.11ac**) | n/a | n/a | 13.86 | 13.76 | 0.72% | 0.07 | 0.06 | 0.01 W |
| Wi-Fi extender + Smart speaker | Passing user-generated IP traffic, playing audio content | Networking (Ethernet: 10/100/1000, **Wi-Fi: 802.11ac**), **Voice interface**, Remote control (app) | n/a | n/a | 7.19 | 8.10 | 12%** | 0.07 | 0.07 | 0.00 W |

| Product Category | Primary Function | Supporting Functions* | Ambient light test condition | $t_{APD}$ (min) | Inactive Condition Power | | | Off Mode Power | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Lab A (W) | Lab B (W) | Diff | Lab A (W) | Lab B (W) | Diff |
| Smart speaker | Playing audio content | Networking (**Wi-Fi: 802.11ac**, Zigbee, Bluetooth), **Voice interface**, Remote control (app) | n/a | n/a | 1.66 | 1.72 | 3.6% | n/a | n/a | n/a |
| Smart speaker | Playing audio content | Networking (**Wi-Fi: 802.11ac**, Bluetooth), **Voice interface**, Remote control (app) | n/a | n/a | 1.58 | 1.53 | 3.2% | n/a | n/a | n/a |
| Smart speaker | Playing audio content | Networking (**Wi-Fi: 802.11ac**, Bluetooth), **Voice interface**, Remote control (app) | n/a | n/a | 0.62 | 0.64 | 0.02 W | n/a | n/a | n/a |
| Smart speaker | Playing audio content | Networking (Ethernet: 10/100/1000, **Wi-Fi: 802.11ac**), **Voice interface**, Remote control (app) | n/a | n/a | 2.71 | 2.65 | 2.2% | n/a | n/a | n/a |
| Home security camera | Alerting an event, such as a break-in or unsafe condition. Supporting real-time monitoring. | Networking (**Wi-Fi: 802.11ac**), Remote control (app), Sensing (**motion, ambient light**) | Dark | n/a | 1.92 | 1.72 | 11% | 0.61 | missed measurement | not determined |
| | | | Bright | | 1.90 | 1.94 | 2.1% | | | |

| Product Category | Primary Function | Supporting Functions* | Ambient light test condition | $t_{APD}$ (min) | Inactive Condition Power | | | Off Mode Power | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Lab A (W) | Lab B (W) | Diff | Lab A (W) | Lab B (W) | Diff |
| Home security system | Alerting an event, such as a break-in or unsafe condition. Supporting real-time monitoring. | Networking (Ethernet: 10/100/1000, **Wi-Fi: 802.11n**), USB 2.0 (1 port), Remote control (app), **Sensing (motion, contact)** | n/a | n/a | 2.90 | 6.14 | 72% | n/a | n/a | n/a |
| Home security system | Alerting an event, such as a break-in or unsafe condition. Supporting real-time monitoring. | Networking (**Wi-Fi: 802.11ac**, Bluetooth 5), Remote control (app), **Sensing (motion, ambient light)** | Dark | n/a | 4.09 | 3.92 | 4.2% | n/a | n/a | n/a |
| | | | Bright | | 3.57 | 5.43 | 41% | | | |
| Connected lighting kit | Providing or controlling illumination | Networking (**Ethernet: 10/100/1000, Proprietary wireless**), Remote control (app) | n/a | n/a | 1.30 | 1.31** | 0.08% | n/a | n/a | n/a |
| Game console | Playing video games or streaming audio and/or video content | Networking (Ethernet: 10/100/1000, **Wi-Fi: 802.11ac**), **HDMI** (1 port), USB 3.1 (3 ports) | n/a | 60 | 0.35 | 0.30 | 0.05 W | 0.35 | 0.30 | 0.05 W |
| Game console | Playing video games or streaming audio and/or video content | Networking (Ethernet: 10/100/1000, **Wi-Fi: 802.11ax**, Bluetooth 5), **HDMI** (1 port), USB 3.2 (3 ports), USB 2.0 (1 port) | n/a | 60 | Sample A: 3.61 Sample B: 3.09 | Sample A: 3.59 Sample B: 3.05 | Sample A: 1.0% Sample B: 0.6% | Sample A: 0.26 Sample B: 0.26 | Sample A: 0.26 Sample B: 0.26 | Sample A: 0W Sample B: 0W |

| Product Category | Primary Function | Supporting Functions* | Ambient light test condition | $t_{APD}$ (min) | Inactive Condition Power | | | Off Mode Power | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Lab A (W) | Lab B (W) | Diff | Lab A (W) | Lab B (W) | Diff |
| Game console | Playing video games or streaming audio and/or video content | Networking (**Wi-Fi: 802.11ac**, Bluetooth 4), HDMI (1 port), USB 3.0 (3 ports), Fixed pixel display (6.2" diagonal, 1280x720, touch screen) | n/a | Lab A: 12 Lab B: 13 | 0.11 | 0.15 | 0.04 W | 0.20 | 0.20 | 0.00 W |
| Smart display | Playing audio and/or video content | Networking (**Wi-Fi: 802.11ac**, Bluetooth), USB (1 port), **Fixed pixel display** (8" diagonal, 1280x800, touch screen), **Voice interface**, Remote control (app), **Sensing** (ambient light), Camera (13 MP) | 12 lux | 10 | 2.73 | 2.21 | 21% | missed measurement | 0.04 | not determined |
| | | | 300 lux | | 3.26 | 2.95 | 10% | | | |
| Smart display | Playing audio and/or video content | Networking (**Wi-Fi: 802.11ac**, Zigbee, Bluetooth 5), **Fixed pixel display** (7" diagonal, 1024x600, touch screen), **Voice interface**, Remote control (app), **Sensing** (motion, ambient light) | 12 lux | < 1 | 2.54 | 3.70 | 37% | n/a | n/a | n/a |
| | | | 300 lux | | 2.97 | 2.57 | 14% | | | |
| Smart display | Playing audio and/or video content | Networking (**Wi-Fi: 802.11ac**, Bluetooth 5), **Fixed pixel display** (10" | 12 lux | 20 | 2.34 | 2.48 | 5.8% | n/a | n/a | n/a |

| Product Category | Primary Function | Supporting Functions* | Ambient light test condition | $t_{APD}$ (min) | Inactive Condition Power | | | Off Mode Power | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Lab A (W) | Lab B (W) | Diff | Lab A (W) | Lab B (W) | Diff |
| | | diagonal, 1280x800, touch screen), **Voice interface**, Remote control (app), **Sensing** (motion, ambient light), Camera (13 MP) | 300 lux | | 2.41 | 2.79 | 15% | | | |
| Doorbell | Alerting presence of person of object at door | Networking (**Wi-Fi: 802.11n**), Remote control (app), **Sensing** (motion, ambient light), Camera (2.1 MP) | Dark | < 1 | 3.11 | 4.58 | 38% | n/a | n/a | n/a |
| | | | Bright | | 2.26 | 3.52 | 44% | | | |
| Doorbell | Alerting presence of person of object at door | Networking (**Wi-Fi: 802.11n**), Remote control (app), **Sensing** (motion, ambient light), Camera (2.4 MP) | Dark | < 1 | 2.13 | 2.10 | 1.4% | n/a | n/a | n/a |
| | | | Bright | < 1 | 2.70 | 2.70 | 0.0% | n/a | n/a | n/a |
| Doorbell | Alerting presence of person of object at door | Networking (**Wi-Fi: 802.11ac**), Remote control (app), **Sensing** (motion, ambient light), Camera (4 MP) | Dark | < 1 | 2.60 | 2.66 | 2.3% | n/a | n/a | n/a |
| | | | Bright | | 2.80 | 2.16 | 26% | | | |
| Computer speakers | Playing audio output from a computer | USB (**Power**, 1 port) | n/a | 0 | 0.094 | 0.095 | 0.001 W | n/a | n/a | n/a |
| Computer speakers | Playing audio output from a computer | USB (**Power**, 1 port) | n/a | 0 | 0.43 | 0.46 | 0.03 W | n/a | n/a | n/a |

| Product Category | Primary Function | Supporting Functions* | Ambient light test condition | $t_{APD}$ (min) | Inactive Condition Power | | | Off Mode Power | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Lab A (W) | Lab B (W) | Diff | Lab A (W) | Lab B (W) | Diff |
| Printer | Copying, scanning, printing, or faxing an image or document | Networking (Ethernet: 10/100/1000, **Wi-Fi: 802.11n,** Wi-Fi Direct), USB 2.0 (2 ports), **Fixed pixel display** (2.7" diagonal, resolution unknown, touch screen), Remote control (app) | n/a | 2 | 2.07 | 2.12 | 2.4% | 0.04 | 0.04 | 0.00 W |
| Printer | Copying, scanning, printing, or faxing an image or document | Networking (**Wi-Fi: 802.11n**), USB 2.0 (1 port), **Dot matrix display**, Remote control (app) | n/a | Lab A: 10 Lab B: 3 | 1.18 | 1.24 | 5.0% | 0.15 | 0.15 | 0.00 W |
| Coffee maker | Making or heating coffee or water | **Segment display** | n/a | 240 | 0.16 | 0.15 | 0.01 W | n/a | n/a | n/a |
| Coffee maker | Making or heating coffee or water | **Segment display** | n/a | 60 | 0.94 | 0.95 | 0.01 W | n/a | n/a | n/a |

**Notes:**

Green shading indicates tests met reproducibility criteria. Yellow and red shading indicates test measurement differences of 5%-10% and greater than 10%, respectively.

* Supporting functions in **bold type** are active when UUT is in its test condition.

** Products became unfunctional (would not connect to network) for unknown reason before troubleshooting completed.

*** B sample was damaged during test. A third lab tested the A sample with this result.