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L•PRIZE®

U.S. Department of Energy

Manufacturing and Installation Phase Submission Instructions and Evaluation Plan

Connected Systems Track

This document provides submission instructions and detailed information to L-Prize Prototype Phase competitors for how their Connected System will be evaluated by the L-Prize Team to verify performance and capabilities as part of the judging process. Competitors should use this information in combination with the L-Prize Official Rules to ensure that their submission includes the necessary documentation, equipment, and capabilities for successful evaluation and judging by the U.S. Department of Energy L-Prize Team.

Please refer to section IV.4 and Appendix D of the Official Rules for a complete list of documentation that should be included in a submission. For any questions about this document or the submission process, please email lprize@nrel.gov.

Connected Systems Track – Prototype Phase Submission Instructions and Evaluation Plan

Definitions

- Expert Review Panel (ERP) – A team of experts who will score submissions and make determinations of whether minimum requirements are achieved, with support from Test Operators.
- Lighting zone – A building area served by a group of luminaires that execute common control strategies.
- SMS – System Management Software. This is the software and user interface that is used to configure the Connected System and retrieve monitored data from the test luminaires.
- SUT – System Under Test. This is the competitor's Connected System that will be physically evaluated and tested.
- Test Operators – Staff from Pacific Northwest National Laboratory that will conduct testing of the submitted Connected System.
- Competitor Representatives – One or two staff representing the competitor who will configure the system, train the Test Operators to use the SMS, and assist with any debugging of issues that are experienced during testing.

Documentation Submission

All documentation shall be submitted on HeroX.

Number of Systems to Submit

In addition to documentation, Connected Systems track competitors shall provide **three** complete working connected systems: one to be installed and tested; one to be disassembled; and one to have as a backup. All **three** systems shall include all components necessary to operate **four** luminaires simultaneously, including but not limited to: gateways, switches, power supplies, servers, tablets, cabling, wiring, etc., as applicable, with exception to sensing/communication modules and OpenADR VEN devices where fewer numbers are required. Specifically, **ten** separate sensing/communication modules in total shall be submitted, comprised of **four** modules to be installed in the luminaires, and **six** for backup or disassembly. If the OpenADR VEN is a separate component of the Connected System, then only **two** VENs shall be submitted: **one** for installation, and **one** for backup or disassembly. If the OpenADR VEN is built into a Connected System component, then **three** component VENs shall be submitted, and security certificates shall be submitted for **two** of the three.

Connected Systems track competitors shall provide **five** test luminaires for use in evaluating their Connected System. **Four** of these luminaires will be used during evaluation, and **one** will be for backup. The test luminaires shall have the necessary functionality to implement all PASS/FAIL

tests described in this document. The test luminaires shall be 2' x 2' troffers and all mounting hardware necessary for installation in a suspended ceiling shall be provided. The LED drivers in the test luminaires shall be D4i certified and comprehensive driver data sheets that contain (at a minimum) dimming curve details (e.g., DALI linear or logarithmic) and energy reporting accuracy details (e.g., accuracy claims, standard or other test method used to form accuracy claims) shall be provided. The test luminaires shall include a Zhaga Book 20 compliant sensor port and associated wiring in which to install the competitor's sensing/communication module. The rated light output of each test luminaire shall be >1,500 lumens. Any rated power and CCT is acceptable. If the power cord is hardwired to the enclosure, a strain relief/cord grip that prevents damage to the cord shall be used. A quick disconnect shall be used between the LED driver and the power cord (incoming power) to ensure that the LED drivers could be replaced in a safe and easy (plug and play) manner.

DOE will retain ownership of the submitted systems following the completion of the evaluation.

Shipping Information

Connected Systems should be carefully packaged to prevent damage during shipping. Freight shipping on pallet(s) is strongly encouraged. Test luminaires and connected system components should be marked as fragile and shrink-wrapped to pallet(s) to hold shipments together and reduce potential for damage. Shipping should be coordinated with, and tracking information provided to:

Anne Manning
anathea.manning@pnnl.gov
Tel: 503-417-7559
Cell: 503-927-6165

An itemized packing list shall be attached to the pallet(s) and sent to Anne Manning in advance. Boxes shall be labeled such that each box is clearly identifiable with the items listed on the packing list.

Connected Systems should be shipped to the following address:

CLTB/Anne Manning
c/o Hollywood Lights
5251 SE McLoughlin Blvd
Portland, OR 97202
Tel: 503-232-9001

Connected Systems shall be shipped **on or before August 5, 2025**. Tracking documentation shall verify this ship date for the entry to be eligible for evaluation.

Electrical Requirements

All connected system components that require AC electrical power shall be submitted with an attached pre-installed 18/3 300V (at a minimum) UL-certified 10-foot cord and NEMA 5-15P plug for connecting to a typical 120 VAC NEMA 5-15R receptacle. Any component that requires DC power shall be submitted with a power supply that converts 120 V AC to the required DC source.

The Manual Control Strategy requirement shall be met via wireless or low-voltage connection to and communication with luminaires. Line-voltage devices that connect to luminaires via AC mains voltage and break or alter the mains voltage as a means of control are not permitted. The competitor shall supply the user-interface device or mobile device application that facilitates manual control. If a mobile device application is used, the competitor shall supply the mobile device and application.

OpenADR Security Certificates and 3.0 Certification

Each Connected System competitor shall provide electronic OpenADR security certificates that allow connection to an OpenADR Virtual Top Node (VTN) such that the OpenADR capabilities of the system can be fully evaluated. The no cost "test" certificates available from https://kyrio.com/openadr/ are acceptable; production certificates are also acceptable, but not required. Certificates shall be submitted in .zip format through the HeroX submission process along with other documentation.

The Virtual End Nodes (VENs) used by competitors shall also comply with the OpenADR 3.0 specification, and proof of certification shall be demonstrated by listing on the OpenADR certified products website.

Testing and Evaluation Overview

For each Connected System requirement described in Appendix B of the Official Rules, Table 1 describes the test methods, comprised of Documentation Review and/or Physical Evaluation that will be used to determine whether a) the mandatory minimum requirements are met and b) any optional points are earned. Detailed test protocols and PASS/FAIL criteria are provided in the following section. Mandatory minimum requirements shall be met before optional points can be earned.

Table 1: Test Methods

Requirement	Documentation Review, Physical Evaluation, or Both	Approach
Standards-Based Luminaire or System Controller	Physical Evaluation	The Test Operators will verify that the Connected System can communicate with and control luminaires with D4i-compliant drivers. Submissions shall pass all pass/fail criteria described in Section III of this document.
Technical Interoperability	Documentation Review	The ERP will review the submitted documentation and verify compliance with at least one industry standard specification for network connectivity.
Application Interoperability	Documentation Review and Physical Evaluation	The ERP will review the submitted documentation to check that it meets the minimum requirements and any optional points to be earned. The Test Operators will send the Connected System valid API requests and scan the BACnet interface to verify correct system response. The BACnet interface will only be scanned if the competitor claims the optional points for the BACnet interface. Submissions shall pass all pass/fail criteria described in Section IV.a and IV.b of this document. Additional points may be earned if the submissions pass all pass/fail criteria described in Section IV.c and/or Section IV.d of this document.
Energy Reporting	Documentation Review and Physical Evaluation	The ERP will review the submitted documentation and verify that it describes the reporting interval, reporting method, associated data model, and ability to store data. The Test Operators will operate the Connected System for 1 hour and verify that the energy reports meet all requirements. Energy reports shall have sufficient resolution such that a 1-hour test period results in a change in the reported energy use. Submissions shall pass all pass/fail criteria described in Section V of this document.
Lighting Control Strategies	Physical Evaluation	The Test Operators will interact with the Connected System to verify that the task tuning, scheduling, occupancy sensing, and daylight harvesting control strategies meet all requirements. Submissions shall pass all pass/fail criteria described in Section VI of this document.

Requirement	Documentation Review, Physical Evaluation, or Both	Approach
Addressability	Documentation Review and Physical Evaluation	The ERP will review the submitted documentation and configuration interface and verify the Lighting Control Narrative described in Section II of this document was successfully implemented. Submissions shall pass all pass/fail criteria described in Section VII of this document.
Cybersecurity	Documentation review	The ERP will review the submitted documentation to verify that a letter or certificate of compliance is provided for the system from the list of acceptable cybersecurity certifications and services. The ERP may also review certification registries and request additional information as required from the competitor to verify that the requirement is met.
System Resilience	Physical Evaluation	The Test Operators will create disruptions to the Connected System and verify that its resiliency meets all requirements. Submissions shall pass all pass/fail criteria described in Section VIII.a of this document. Additional points may be earned if submissions pass all pass/fail criteria described in Section VIII.b of this document.
Fault Detection and Diagnostics	Documentation Review and Physical Evaluation	The ERP will review the submitted documentation and verify it includes datasheets, installation, and configuration manuals needed for the Test Operators to demonstrate the requirement and any optional points to be earned. The Test Operators will create specific mandatory-detection and optional-detection faults and verify detection and reporting. Submissions shall pass all pass/fail criteria described in Section IX.a of this document. Additional points may be earned if submissions pass all pass/fail criteria described in Section IX.b and Section IX.c of this document.
Standards-based Luminaire Level Lighting Control	Documentation Review	The ERP will verify the sensing/communication module is compliant with D4i or ANSI C137.4 by reviewing a) the certified products list at https://www.dali-alliance.org/products or b) submitted test results that demonstrate compliance with the standards. If test results are submitted, they shall be from either a DALI Alliance certified Test House or conducted by the competitor using the equipment and test sequences specified by the DALI Alliance. Test results shall demonstrate compliance with IEC 62386 Parts 101, 103, and DALI Part 351.

Requirement	Documentation Review, Physical Evaluation, or Both	Approach
Grid-Services Capable	Documentation Review and Physical Evaluation	The ERP will review the submitted documentation and verify that it describes OpenADR grid signals capabilities and configuration options. The Test Operators will create compliant OpenADR 3.0 (if applicable) test signals and verify correct system response. Submissions shall pass all pass/fail criteria described in Section X.a of this document. Additional points may be earned if submissions pass all pass/fail criteria described in Section X.b and Section X.c of this document.
Life Cycle and Sustainability Innovation	Documentation Review and Physical Evaluation	The ERP will review the submitted narrative and any supporting documentation. If the claimed innovation can be viewed, the ERP may observe the innovation (e.g., during the installation or configuration of the system). If the claimed innovation can be physically evaluated, the Test Operators may test or implement the innovation (e.g., during physical evaluation of the operational system). The ERP will then score the Life Cycle and Sustainability innovations as described in Appendix B of the Official Rules.
Labeling and Markings	Documentation Review and Physical Evaluation	The ERP will examine the connected system major components to check for the presence of labels or markings that lead or direct to a manufacturers website. The ERP will then review the website to check that the website provides all of the information described in the Supplemental Guidance section of the Labeling and Markings Requirement in Appendix B of the Official Rules.
Technical Innovation – Ease of Installation and Use	Documentation Review and Physical Evaluation	The ERP will review the submitted narrative. If the claimed innovation can be viewed, the ERP may observe the innovation (e.g., during the installation or configuration of the system). If the claimed innovation can be physically evaluated, the Test Operators may test or implement the innovation (e.g., during physical evaluation of the operational system). The ERP will then score the ease of installation and use innovations as described in Appendix B of the Official Rules.
Technical Innovation – Compatibility and Interoperability	Documentation Review and Physical Evaluation	The ERP will review the submitted narrative. If the claimed innovation can be physically evaluated, the Test Operators may test or implement the innovations. The ERP will then score the compatibility and interoperability innovations as described in Appendix B of the Official Rules.
Technical Innovation – Scalability	Documentation Review and Physical Evaluation	The ERP will review the submitted narrative. If the claimed innovation can be physically evaluated, the Test Operators may test or implement the innovations. The ERP will then score the scalability innovations as described in Appendix B of the Official Rules.

Requirement	Documentation Review, Physical Evaluation, or Both	Approach
Technical Innovation – Affordability and Value Proposition	Documentation Review and Physical Evaluation	The ERP will review the submitted narrative. If the claimed innovation can be viewed or physically evaluated, the Test Operators may test or implement the innovations. The ERP will then score the affordability and value proposition innovations as described in Appendix B of the Official Rules.
Technical Innovation – Health and Wellbeing	Documentation Review and Physical Evaluation	The ERP will review the submitted narrative. If the claimed innovation can be physically evaluated, the Test Operators may test or implement the innovations. The ERP will then score the health and wellbeing innovations as described in Appendix B of the Official Rules.
U.S. Content	Documentation Review and Physical Evaluation	The ERP will review the submitted narrative and any supporting documentation to verify that the narrative includes the minimum information described in Materials to Submit section of the requirement in Appendix B of the Official Rules. The ERP and/or DOE may physically visit locations where U.S. content or manufacturing is claimed to verify it. If the connected system does not have or claim any U.S. content, then a narrative is not required. The ERP will then score the U.S. content as described in Appendix B of the Official Rules.
Production and Deployment Plan	Documentation Review and Physical Evaluation	The ERP will review the submitted Production and Deployment Plan to verify that the plan includes the minimum information described in the Supplemental Guidance section of the requirement in Appendix B of the Official Rules. The ERP and/or DOE may physically visit manufacturing or assembly sites to verify what is described in the plan. The ERP will then score the Production and Deployment Plan as described in Appendix B of the Official Rules.

Requirement	Documentation Review, Physical Evaluation, or Both	Approach
U.S. Installation	Documentation Review and Physical Evaluation	The ERP will review the site installation document to verify that the document includes the minimum information described in the Material to Submit section of the requirement in Appendix B of the Official Rules. The ERP and/or DOE will visit the site to check that the installation and site matches what is described in the installation document and that all minimum requirements for the site are met. The ERP and/or DOE may implement or require demonstration of the capabilities listed in the minimum requirement for U.S. Installation (e.g., addressability, lighting control strategies, energy reporting, etc.). If HVAC integration has been implemented at the site, the ERP and/or DOE may require competitors to demonstrate or verify its operation. The ERP will then determine whether the U.S. Installation meets the minimum requirement and whether any HVAC integration points will be earned as described in Appendix B of the Official Rules.
Commercial Availability	Documentation Review	The ERP will review the submitted documentation to verify that spec sheets, marketing materials, installation guides, and other relevant system documentation are provided to indicate full commercial availability. The ERP will verify that safety certification documentation (e.g., authorization to mark) is provided for each connected system component. The ERP will then determine whether the system meets the requirement for commercial availability as described in Appendix B of the Official Rules.

Pre-Testing

Each competitor shall complete OpenADR and API connectivity pre-testing prior to submitting their system to DOE for testing. This pre-testing is intended to reduce configuration and debugging time during actual testing. Test operators will schedule time with each competitor that completes an Intent to Submit Form to conduct the pre-testing.

1. OpenADR pre-testing: This pre-test is to ensure that the OpenADR VEN in the SUT can register and communicate signals with the Test Operator OpenADR VTN. The Test Operator will provide the VTN URL and the competitor shall submit Connected System configuration information (e.g., market context information, etc.) prior to the scheduled pre-testing period. The Test Operators will host a VTN and the competitor shall register their VEN with the PNNL VTN during the pre-testing period. Successful connection (i.e., the VEN has registered with the VEN) shall be documented in the form of an OpenADR report OR screenshot(s) showing an “Online”or “Connected” status (or equivalent, as determined by the Test Operators). Once connection is established, the Test Operators will send an OpenADR Simple signal to the

competitor VEN. Successful transmission and reception of the Simple signal shall be documented in the form of an OpenADR report OR screenshot(s) showing a "Received" status (or equivalent, as determined by the Test Operators).

2. API pre-testing: This pre-test is to ensure that the API endpoints in the SUT can be queried and return data. Competitors shall submit a single Postman collection file and a single Postman environment file with all the available variables and endpoints **prior** to the scheduled pre-testing period. Competitors shall have an up-and-running instance of their Connected System ready to be queried at the beginning of the scheduled pre-testing period. Test Operators will use the submitted Postman environments to execute 3 or more API queries during the pre-testing period. Successful API queries shall be documented by saving text outputs and/or screenshots.

Detailed Testing and Evaluation Method

This section details how each requirement will be tested and evaluated by the L-Prize Expert Reviewer Panel. In addition to this section, competitors should reference Appendix B of the Official Rules for supplemental guidance and links to referenced documents.

I. Test setup

a. Test Operators will install **four** of the **five** submitted 2'x2' test luminaires in a suspended ceiling at the Pacific Northwest National Laboratory (PNNL) evaluation site in Portland, OR.
b. If not pre-installed, Test Operators will install the sensing/communication modules into the Zhaga Book 20 port of the test luminaires.
c. Test Operators will connect the test luminaires to AC electrical power via the attached NEMA 5-15P plug.
d. Test Operators will use a laboratory circuit-level power metering system to log electrical data every minute.
e. Competitors shall send one or two Competitor Representatives to the PNNL laboratory evaluation site in Portland, Oregon to configure the Connected System. Test Operators will coordinate with competitors to schedule visitation dates. Competitor Representatives shall configure the Connected System to enable the lighting control strategies described by the Lighting Control Narrative shown in Section II of this document, and all other functionality to be evaluated. Competitor Representatives shall configure the system under the supervision of Test Operators and then train the Test Operators to use the SMS for all testing described in this document. Competitor Representatives shall have two 8-hour days total to complete the configuration and training of Test Operators. If bugs or unforeseen problems are encountered during testing, Competitor Representatives shall have one additional 8-hour day to assist with any debugging and remediation that is required.

II. Lighting control narrative

a. The Lighting System shall be configured to create two lighting zones (A and B) such that each zone contains 2 luminaires.
b. Basic lighting control: Zone A
    i. Luminaires in Zone A shall NOT be task tuned. All relative power specifications (e.g., 100%) for Zone A luminaires shall be relative to the luminaire rated power.

ii. Scheduled Control Strategy: All luminaires in Zone A shall be configured to implement a scheduled control strategy. All luminaires in Zone A shall be scheduled to operate in a SCHEDULED–ON state (100%) at a set time and operate in a SCHEDULED–OFF (0%) state at 10 minutes after that time. **Note**: the times will be specified based on the actual time of testing.

iii. Daylight Harvesting Control Strategy: Each luminaire in Zone A shall be configured to implement a daylight harvesting control strategy. Luminaires in Zone A shall be configured to respond to daylight in ONE of the following ways: a) each luminaire responds to its own daylight sensor b) each luminaire responds to the daylight sensor in an identified "master" luminaire in Zone A, or c) each luminaire responds to some algorithmic processing of the daylight sensor readings from ALL luminaires in Zone A. Daylight sensor sensitivity shall be set to maximum sensitivity to daylight. If a luminaire in Zone A is operating in a SCHEDULED–ON state, and daylight is detected, then that luminaire shall transition to a DAYLIGHT–DIMMED state (less than or equal to 50%) within 2 minutes. If a luminaire in Zone A is operating in a SCHEDULED–ON state, and no daylight is detected, then the luminaire shall continue to operate in the SCHEDULED–ON state, as specified by the Scheduled Control Strategy. If a luminaire in Zone A is operating in a DAYLIGHT–DIMMED state, and no daylight is detected, then that luminaire shall transition to a SCHEDULED–ON state within 2 minutes. If a luminaire in Zone A is operating in the SCHEDULED-OFF state, then it shall not respond to daylight.

c. Basic lighting control: Zone B

i. Task Tuning Control Strategy: All luminaires in Zone B shall be task-tuned to 80% of their rated power. All relative power specifications (e.g., 100%) for Zone B luminaires shall be relative to this task-tuned power. For example, a specification of ON (100%) shall be understood to indicate 100% of the task-tuned power, which is equivalent to 80% of luminaire rated power. Similarly, a specification of ON (70%) shall be understood to indicate 70% of the task-tuned power, which is equivalent to 80% * 70% = 56% of luminaire rated power.

ii. Occupancy Control Strategy: All luminaires in Zone B shall be configured to implement an occupancy control strategy. When no occupant motion or presence is detected by ANY luminaire in Zone B, ALL luminaires in Zone B shall operate in an OCCUPANCY–OFF state (0%). Upon detection of occupant motion or presence by ANY luminaire in Zone B, ALL luminaires in Zone B shall transition to an OCCUPANCY–ON state (100%) within 2 seconds. When occupant motion or presence is no longer detected, ALL luminaires shall transition back to the OCCUPANCY–OFF state within 60 seconds.

iii. Manual Control Strategy: All luminaires in Zone B shall be configured to respond to a manual control. The manual control shall provide ON/OFF functionality, as well as light output RELATIVE UP/DOWN (percentage points) or light output RELATIVE SETPOINT (%) functionality via a user-interface device or mobile device application that is intended for occupant use. The choice of RELATIVE UP/DOWN or RELATIVE SETPOINT shall be documented in the submission materials. Use of the manual control ON/OFF capability shall not disable the Occupancy Control Strategy. Following use of the manual control ON input, all luminaires in Zone B, regardless of their current state, shall operate in an OCCUPANCY-ON state – and stay there until use of the manual control OFF input or until occupant motion or presence is no longer detected. Following use of the manual control OFF input, all

luminaires in Zone B, regardless of their current state, shall operate in an OCCUPANCY-OFF state – and stay there until use of the manual control ON input or until occupant motion or presence is detected. Use of the manual control light output RELATIVE UP/DOWN (percentage points) and/or RELATIVE SETPOINT (%) inputs shall override the OCCUPANCY-ON light level until the next time luminaires transition to the OCCUPANCY–OFF state, either via the occupancy control strategy OR use of the manual control OFF input. All RELATIVE UP/DOWN (percentage points) and/or RELATIVE SETPOINT (%) setpoint adjustments shall be relative to the task-tuned power (i.e., 80% of luminaire rated power, per II-c-ii). For example, if the current setpoint for luminaires in Zone B is 80% of luminaire rated power, and a "DOWN 10 (percentage points)" input is received from the manual control, then the new OCCUPANCY-ON setpoint for luminaires in Zone B shall be 70% of luminaire rated power. Similarly, if the current setpoint for luminaires in Zone B is 80% of luminaire rated power, and a "RELATIVE SETPOINT 70%" input is received from the manual control, then the new OCCUPANCY-ON setpoint for luminaires in Zone B shall be 70% of the task-tuned power, which is equivalent to 80% * 70% = 56% of luminaire rated power. Luminaires that are operating in an OCCUPANCY-OFF state shall not respond to the RELATIVE UP/DOWN or RELATIVE SETPOINT inputs.

d. Grid services control: ALL luminaires (i.e., in Zone A and Zone B)
   i. Mandatory: All luminaires shall be configured to respond to OpenADR "SIMPLE" events. Luminaires that are in a SCHEDULED-OFF or OCCUPANCY-OFF state shall not adjust their power draw during an OpenADR "SIMPLE" event. If an OpenADR "SIMPLE" event contains a payload of 0, all luminaires that are in a SCHEDULED-ON or OCCUPANCY-ON state shall not adjust their power draw. If an OpenADR "SIMPLE" event contains a payload of 1, all luminaires that are in a SCHEDULED-ON or OCCUPANCY-ON state shall reduce their power draw by 30% RELATIVE to their current level for the duration of the event. For example, if luminaire power is currently set to 80% of luminaire rated power, then the luminaire shall reduce its power draw down to 80% * (100% – 30%) = 56% of luminaire rated power. Following the completion of any OpenADR "SIMPLE" event, all luminaires that are in a SCHEDULED-ON or OCCUPANCY-ON state shall adjust their power draw back to the level specified by their zone-based lighting control narrative. **Note**: Luminaires shall continue to execute their zone-based lighting control strategies throughout the duration of the OpenADR "SIMPLE" event.
   ii. Optional: All luminaires shall be configured to respond to OpenADR "PRICE" events. Luminaires that are in a SCHEDULED-OFF or OCCUPANCY-OFF state shall not adjust their power draw during an OpenADR "PRICE" event. If an OpenADR "PRICE" event contains a payload less than or equal to $0.04/kWh, all luminaires that are in a SCHEDULED-ON or OCCUPANCY-ON state shall not adjust their power draw. If an OpenADR "PRICE" event contains a payload greater than 0.04 $/kWh and less than or equal to 0.05 $/kWh, all luminaires that are in a SCHEDULED-ON or OCCUPANCY-ON state shall reduce their power draw by 30%, RELATIVE to their current level, for the duration of the event. For example, if luminaire power is currently set to 80% of luminaire rated power, then the luminaire shall reduce its power draw down to 80% * (100% – 30%) = 56% of luminaire rated power. If an OpenADR "PRICE" event contains a payload greater than 0.05 $/kWh, all luminaires that are in a SCHEDULED-ON or OCCUPANCY-ON state shall reduce their power draw by 50% RELATIVE to their current level, for the duration of the event. For

example, if luminaire power is currently set to 80% of luminaire rated power, then the luminaire shall reduce its power draw from 80% down to 80% * (100% – 50%) = 40% of luminaire rated power. Following the completion of any OpenADR "PRICE" event, all luminaires that are in a SCHEDULED-ON or OCCUPANCY-ON state shall adjust their power draw back to the level specified by their zone-based lighting control narrative. **Note**: Luminaires shall continue to execute their zone-based lighting control strategies throughout the duration of the OpenADR "PRICE" event.

e. The reporting interval for energy use data shall be set to its minimum value.

III. Standards-based Luminaire or System Controller

a. The SMS shall be accessed by an authorized user when functioning as intended and in communication with the luminaires in the SUT.
b. If the SMS shows the current status (e.g., online/offline/error) and energy use of EACH luminaire in the SUT, then the SUT shall be deemed to PASS this test; if not, it shall be deemed to FAIL this test.
c. If the authorized user can manually override existing luminaire settings, turn luminaires ON/OFF, and adjust luminaire light/power levels, then the SUT shall be deemed to PASS this test; if not, it shall be deemed to FAIL this test.

IV. Application Interoperability

a. The submitted API documentation and OpenAPI specification (OAS) document shall be reviewed. If the SUT only requires RESTful API requests and does not require invoking any other protocol (e.g., WebSockets, Cap'n Proto, etc.) in order to retrieve the data, and ALL of the following are available in the submitted documentation and deemed complete, then the SUT shall deemed to PASS this test; if not it shall be deemed to FAIL this test.
    i. Authentication guide
    ii. Resource guidance including all API endpoints
    iii. Error codes
    iv. Debugging guidance
b. The REST APIs shall be queried via the Postman software application to retrieve the following data types. If ALL REST API queries provide the requested data in the body of a JSON formatted response, as specified by the API documentation, then the SUT shall be deemed to PASS this test; if not, it shall be deemed to FAIL this test.
    i. Individual luminaire binary occupancy status (i.e., occupancy detected, occupancy not detected)
    ii. Individual luminaire cumulative energy use
    iii. Lighting zone characteristics: luminaires within the zone, control strategies, room name, space type, and any other related metadata
    iv. Lighting zone A and zone B binary occupancy status (i.e., occupancy detected, occupancy not detected)
    v. Lighting zone A and zone B cumulative energy use
    vi. Automated fault detection and diagnostics (FDD) properties
c. Optional: Ten points will be awarded if the system can pass the following tests.

i. The BACnet certified products list shall be reviewed. If the SUT or a component of the SUT is included in the list, and claims support for the BACnet IP datalink layer and one of the BACnet Controller–General Purpose Device Profiles i.e., Building Controller (B-BC), Advanced Application Controller (B-AAC), Application Specific Controller (B-ASC), or Smart Sensor (B-SS), then the SUT shall be deemed to PASS this test; if not, it shall be deemed to fail this test.

ii. The submitted documentation shall be reviewed. If the documentation includes a BACnet Protocol Implementation Conformance Statement (PICS) and a complete BACnet Objects table that is a) formatted as described in the Official Rules Appendix B and b) includes a lighting zone cumulative energy use Object and a lighting zone occupancy status Object, the SUT shall be deemed to PASS this test; if not, it shall be deemed to fail this test.

iii. The test operators shall utilize a BACnet test software to scan the SUT BACnet interface for lighting zone energy use Objects. If the SUT returns time series data describing cumulative (not interval) energy use (in kWh or Wh) for every lighting zone in the system, then the SUT shall be deemed to PASS this test; if not, it shall be deemed to FAIL this test.

iv. The test operators shall utilize a BACnet test software to scan the SUT BACnet interface for lighting zone occupancy status Objects. If the SUT returns time series data describing binary lighting zone occupancy status (i.e., occupancy detected, occupancy not detected), the SUT shall be deemed to PASS this test; if not, it shall be deemed to fail this test.

d. Optional: Five additional points will be awarded if the system can pass the following tests.

i. The submitted documentation shall be reviewed. If the documentation includes a BACnet Protocol Implementation Conformance Statement (PICS) and a complete BACnet Objects table that is a) formatted as described in the Official Rules Appendix B and b) includes a HVAC zone occupancy status Object, the SUT shall be deemed to PASS this test; if not, it shall be deemed to fail this test.

ii. The submitted documentation shall be reviewed. If the submitted documentation describes how to define occupancy status for a user-defined number of HVAC zones using customizable Boolean operations on lighting zone occupancy status, the SUT shall be deemed to PASS this test; if not, it shall be deemed to fail this test.

iii. The test operators shall follow the instructions in the provided documentation for how to define HVAC zone occupancy status using Boolean operations on lighting zone occupancy status to create customized HVAC zone statuses for multiple HVAC zones. The test operators shall utilize a BACnet test software to scan the SUT BACnet interface for lighting zone and HVAC Objects. If the SUT returns time series Lighting Zone and HVAC zone occupancy status, and the HVAC zone occupancy status for each created HVAC zone is related to specific Lighting Zone occupancy status according to the configured Boolean operations, the SUT shall be deemed to PASS this test; if not, it shall be deemed to fail this test.

V. Energy Reporting

a. The energy reporting documentation shall be reviewed. If documentation for ALL the following is available and deemed complete, then the SUT shall be deemed to PASS this test. If not, it shall be deemed to FAIL this test.

i. Shortest time interval at which each luminaire reports cumulative (not interval) energy use data

ii. Minimum resolution of the reported cumulative (not interval) energy use data (e.g., 0.1 kWh, 10 Wh, etc.)

iii. REST API method for retrieving the cumulative (not interval) energy use data
iv. Data model for the cumulative (not interval) energy use data

b. The SUT shall be operated for 1 hour and the cumulative (not interval) energy use data of all luminaires in the SUT shall be retrieved for that operation time using REST API queries described in the SUT documentation and provided in Postman environment files.
c. If the API response body contains JSON-formatted time series energy use data describing cumulative (not interval) energy use (in kWh or Wh) for every luminaire in the system, then the SUT shall be deemed to PASS this test; if not, it shall be deemed to FAIL this test.
d. If the API response body contains JSON-formatted time series energy use data describing cumulative (not interval) energy use (in kWh or Wh) for each lighting zone in the system, then the SUT shall be deemed to PASS this test; if not, it shall be deemed to FAIL this test.
e. If the time interval between two consecutive cumulative (not interval) energy data points is equal to the set interval and is <=15 minutes, then the SUT shall be deemed to PASS this test; if not, it shall be deemed to FAIL this test.
f. If all cumulative (not interval) energy data points show monotonically increasing behavior, then the SUT shall be deemed to PASS this test; if not, it shall be deemed to FAIL this test.

VI. Lighting Control Strategies

a. A 30-minute test period (e.g., start time, end time) shall be defined for the SUT by the Test Operators. All five lighting control strategies shall be evaluated during this test period.
b. The Zone A luminaires shall be reconfigured by adjusting their scheduled turn ON and OFF times. The Zone A luminaires shall be configured to turn ON (100%) at a designated start time within the designated 30-minute test period, and then OFF (0%) at a designated end time during the designated 30-minute test period. The designated end time shall be 10 minutes after start time. For example, SUT scheduled ON at 3:10pm and OFF at 3:20pm in a test period from 3-3:30pm.
c. Following completion of the test period, data for all **four** luminaires shall be retrieved from the laboratory circuit-level power metering system for a time span that covers the test period.
d. Scheduling control strategy: If the laboratory power metering data reveals that 1) ALL Zone A luminaires draw the SCHEDULED–ON power (+/- 5 percentage points) specified by the Lighting Control Narrative in Section II of this document following the designated start time, AND 2) ALL Zone A luminaires draw the SCHEDULED–OFF power (+/- 5 percentage points) specified by the Lighting Control Narrative in Section II of this document following the designated end time, then the SUT shall be deemed to PASS this test; if not, it shall be deemed to FAIL this test.
e. Task tuning control strategy: If the laboratory power metering data reveals that all Zone A and Zone B luminaires draw the ON power (+/- 5 percentage points) specified by the Lighting Control Narrative in Section II of this document, then the SUT shall be deemed to PASS this test; if not, it shall be deemed to FAIL this test. For example, if the Lighting Control Narrative specifies that luminaires in a lighting zone shall be task-tuned to 80% of luminaire rated power, then the allowed metering range for a PASS determination is 75-85% of luminaire rated power.

f. Occupancy control strategy: a human subject shall enter the occupancy detection region for ONE of the luminaires in Zone B while luminaires are OFF, linger for 10 seconds, and then walk outside of the occupancy detection regions of ALL luminaires in Zone B. If the laboratory power metering data reveals that 1) ALL Zone B luminaires draw the OCCUPANCY–ON power (+/- 5 percentage points) specified by the Lighting Control Narrative in Section II of this document following occupant entry AND 2) ALL Zone B luminaires draw the OCCUPANCY–OFF power (+/- 5 percentage points) specified by the Lighting Control Narrative in Section II of this document following occupant departure, then the SUT shall be deemed to PASS this test; if not, it shall be deemed to FAIL this test.

g. Daylight harvesting control strategy: A flashlight shall be pointed at the daylight sensor of ONE Zone A luminaire to emulate daylight, turned on for a period of 2 minutes, and then turned off. If ZONE A has a "master" daylight sensor, then the flashlight shall be pointed at that sensor. If ZONE A does not have a "master" daylight sensor, then the flashlight shall be pointed at a randomly selected Zone A luminaire. If the laboratory power metering data reveals that 1) the Zone A luminaire where the flashlight was directed reduces its power to the level specified by the Lighting Control Narrative (+/- 5 percentage points) within 2 minutes of flashlight turn-on, AND 2) the Zone A luminaire where the flashlight was directed raises its power to the level specified by the Lighting Control Narrative (+/- 5 percentage points) within 2 minutes of flashlight turn-off, then the SUT shall be deemed to PASS this test; if not, it shall be deemed to FAIL this test.

h. Manual control strategy: Occupant motion or presence shall be removed from the detection region of all luminaires in Zone B, and sufficient time allowed to elapse until all luminaires in Zone B are in an OCCUPANCY-OFF state. The ON input available via user-interface device or mobile device application that is intended to give occupants manual control of Zone B luminaires shall be used to signal an intent to transition all Zone B luminaires from the OCCUPANCY–OFF state to the OCCUPANCY–ON state. If the laboratory power metering data reveals that ALL Zone B luminaires draw the OCCUPANCY–ON power (+/- 5 percentage points) specified by the Lighting Control Narrative in Section II of this document following use of the manual control ON input, then the SUT shall be deemed to PASS this test; if not, it shall be deemed to FAIL this test.

VII. Addressability

a. The configuration documentation and related user interface(s) shall be reviewed to verify the ability to assign unique addresses and control strategies to individual luminaires without respect to wiring.

b. If the documentation and user interface verify the ability to assign unique addresses and control strategies to individual luminaires, and the Lighting Control Narrative described in Section II of this document is successfully implemented **(as determined by PASSING all requirements in section VI of this document),** then the SUT shall be deemed to PASS this test. If not, it shall be deemed to FAIL this test.

VIII. System Resilience

a. Mandatory

i. Internet connection to the system shall be removed by unplugging it. The Lighting Control Strategy tests described in section VI of this document shall be performed. If the SUT PASSES ALL tests described in section VI of this document, then it shall be deemed to PASS this test; if not, it shall be deemed to FAIL this test.

ii. Electrical power to all system equipment (e.g., luminaires, gateways) shall be removed by unplugging them. Following the passage of 48 hours from the time of unplugging, electrical power to all system elements shall be restored by plugging them back in. A reset time of 10 minutes shall be allowed to occur for the system to reboot and restore settings. Following the completion of the reset time, the Lighting Control Strategy tests described in section VI of this document shall be performed. If the SUT PASSES ALL tests described in section VI of this document, then it shall be deemed to PASS this test; if not, it shall be deemed to FAIL this test.

b. Optional: Fifteen points will be awarded if the SUT can PASS the following test.

i. Electrical power to the equipment one level higher in the networked system hierarchy than the luminaire (e.g., room controller, gateway, server) shall be removed by unplugging it. The Lighting Control Strategy tests described in section VI of this document shall be performed. If the SUT PASSES ALL tests described in section VI of this document, then it shall be deemed to PASS this test; if not, it shall be deemed to FAIL this test.

IX. Fault Detection and Diagnostics

a. Mandatory
   i. Loss of Network Communication Fault: If the SUT has a gateway, electrical power to the gateway shall be removed by unplugging it. If the SUT does not have a gateway, then this test does not apply. If the SUT reports this fault through an automatic notification in a way that is distinct from the Device/Equipment Fault, then the SUT shall be deemed to PASS this test; if not, it shall be deemed to FAIL this test. An automatic notification may include an automatic notification through the System Management Software (SMS), an email, or a text message.
   ii. Device/Equipment Fault: the sensing/communication module from a single luminaire shall be removed. If the SUT reports this fault through an automatic notification within 60 minutes of the removal of the sensing/communication module, and in a way that is distinct from the Loss of Network Communication Fault, then the SUT shall be deemed to PASS this test; if not, it shall be deemed to FAIL this test.

b. Optional: Eight points will be awarded if the SUT can PASS **ALL** the following three tests.
   i. The LED array/module shall be disconnected from the LED driver in a single luminaire in the SUT. If the SUT reports this fault through an automatic notification in a way that is distinct from the other mandatory and optional faults, and the method used to detect the fault is described in the documentation, then the SUT shall be deemed to PASS this test; if not, it shall be deemed to FAIL this test.
   ii. The documentation that describes the method used to detect a driver failure fault shall be reviewed. If the documentation is clear then the SUT shall be deemed to PASS this test; if not, it shall be deemed to FAIL this test.
   iii. A set of five progressive 1-minute undervoltage conditions (starting at 108 VAC, 96 VAC, 84 VAC, 72 VAC, and ending at 60 VAC) shall be created for ONE of the luminaires in the SUT. If the SUT reports any of the five undervoltage conditions through an automatic notification in a way that is distinct from the other mandatory and optional faults, and the method used to detect the fault is described in the documentation, then the SUT shall be deemed to PASS this test; if not, it shall be deemed to FAIL this test.

c. Optional: Seven additional points will be awarded if the SUT can PASS **ALL** the following three tests:
   i. If the remaining life of LED arrays/modules and LED drivers is reported to the SMS, then the SUT shall be deemed to PASS this test; if not, it shall be deemed to FAIL this test.
   ii. If the SMS reports the cause (i.e., the diagnosis) of ANY of the faults described in section IX.b. of this document, then the SUT shall be deemed to PASS this test; if not, it shall be deemed to FAIL this test.
   iii. If the SMS predicts the future occurrence of ANY of the faults described in section IX.b. of this document based on past occurrence (e.g., by updating the probability of fault occurrence for a specific piece of equipment, by updating the timeframe in which a fault may occur for a specific piece of equipment, by updating the “remaining life” of a specific piece of equipment), then the SUT shall be deemed to PASS this test; if not, it shall be deemed to FAIL this test.

X. Grid Services Capable

a. Mandatory
   i. If the method for configuring the SUT to response to a grid signal is accessible through a user interface AND is described in the submitted documentation, then the SUT is deemed to PASS this test.
   ii. An OpenADR event with a "SIMPLE 1" signal and a duration of 5 minutes shall be sent to the SUT using an OpenADR-compliant VTN. Following completion of this 5-minute test period, data for ALL four luminaires shall be retrieved from the laboratory circuit-level power metering system for a time span that covers the test period. If the laboratory power metering data reveals that ALL luminaires reduce their power draw to the amount (+/- 5 percentage points) specified by the Lighting Control Narrative in Section II of this document, then the SUT shall be deemed to PASS this test; if not, it shall be deemed to FAIL this test.

b. Optional: Eight points will be awarded if the SUT can PASS **ALL** the following three tests.
   i. If the method for configuring the system in response to a OpenADR price signal is accessible through a user interface AND is described in submitted documentation, then the SUT shall be deemed to PASS this test; if not, it shall be deemed to FAIL this test.
   ii. An OpenADR event with an "ELECTRICITY_PRICE" signal of 0.02$/kWh and a duration of 5 minutes shall be sent to the SUT using an OpenADR-compliant VTN. Following completion of this 5-minute test period, data for all four luminaires shall be retrieved from the laboratory circuit-level power metering system for a time span that covers the test period. If the laboratory power metering data reveals that all luminaires do not change their power draw then the SUT shall be deemed to PASS this test; if not, it shall be deemed to FAIL this test.
   iii. An OpenADR event with an "ELECTRICITY_PRICE" signal of 0.06$/kWh and a duration of 5 minutes shall be sent to the SUT using an OpenADR-compliant VTN. Following completion of this 5-minute test period, data for all four luminaires shall be retrieved from the laboratory circuit-level power metering system for a time span that covers the test period. If the laboratory power metering data reveals that all luminaires reduce their power draw to the amount (+/- 5 percentage points) specified by the Lighting Control Narrative in Section II of this document, then the SUT shall be deemed to PASS this test; if not, it shall be deemed to FAIL this test.

c. Optional: Seven additional points will be awarded if the SUT can PASS **ALL** the following three tests:
   i. If the SMS and/or a configuration tool facilitates configuration of luminaire ramp rate (i.e., the rate-of-change of luminaire power as it transitions from one operational state to another, e.g., from 100% to 80%, in units of %change per second), AND the configuration method is described in the submitted documentation, then the SUT shall be deemed to PASS this test; if not, it shall be deemed to FAIL this test.
   ii. If the SMS and/or a configuration tool facilitates the ability to define building spaces (e.g., lighting zones, specific room instances, all room instances of a specific space type) that a) ALWAYS RESPOND to a grid services/demand response event by

implementing the appropriate grid services control, b) CONDITIONALLY RESPOND to a grid services/demand response event by implementing the appropriate grid services control only if a certain lighting system condition is true (e.g., if measured daylight is above a certain threshold), or c) NEVER RESPOND to a grid services/demand response event AND the configuration method is described in the submitted documentation, then the SUT shall be deemed to PASS this test; if not, it shall be deemed to FAIL this test.

iii. If the SMS and/or a configuration tool facilitates the ability to base the conditional response described in Section X.c.ii of this document on daylight and occupancy sensor values, AND the configuration method is described in the submitted documentation, then the SUT shall be deemed to PASS this test; if not, it shall be deemed to FAIL this test.