**Advanced High-Resolution Controls for Dimmable LED Lighting in Offices**

**Specification & Procurement Support Materials – Editable version: Appendix B only\***

****

**Steve Mesh, LC, IESNA**

Lighting Education & Design

San Francisco, California

**Eleanor S. Lee** and **Luis Fernandes, PhD**

Building Technologies and Urban Systems Division

Energy Technologies Area

Lawrence Berkeley National Laboratory

**Prepared for:**

**Amy Jiron**

DOE Building Technologies Program

Commercial Building Integration Program

**June 2016**

*\*See “NYC-Lighting-Controls-Spec-Final.pdf” for full annotated content at* [*https://facades.lbl.gov/nyclivinglab*](https://facades.lbl.gov/nyclivinglab)

**Disclaimer**

This document was prepared as an account of work sponsored by the United States Government. While this document is believed to contain correct information, neither the United States Government nor any agency thereof, nor The Regents of the University of California, nor any of their employees, makes any warranty, express or implied, or assumes any legal responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by its trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof, or The Regents of the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof or The Regents of the University of California.

**Acknowledgment**

This work was supported by the Assistant Secretary for Energy Efficiency and Renewable Energy, Building Technologies Program of the U.S. Department of Energy under Contract No. DE-AC02-05CH11231.

**Overview**

This package of materials is intended to guide you through the specification, procurement, and selection of luminaires and lighting control systems for retrofit applications in office spaces (or spaces with similar uses) with daylight through vertical windows. The specification targets advanced lighting control systems where the resolution of control is highly granular (e.g., on a fixture-by-fixture basis) and the type of control involves dimming the lighting system for daylighting, setpoint tuning and demand response, as well as incorporating conventional occupancy sensing and scheduling functions, plus provision for manual control (manual override).

This package includes two sections:

1. A **Request for Proposals (RFP) Template** that can be filled out to create a project-specific RFP for luminaire and lighting control system vendors.
2. A **Technology Specification Template** that can be tailored to generate owner-driven requirements for technology features and capabilities, metering and integration, maintenance support, and more. The tailored specification should be included in the Scope of Work in Section 3 of the RFP.

**Scope of materials**

These technology specifications and associated materials were developed primarily to address lighting retrofit projects incorporating LED luminaires and advanced lighting control systems.

**Assumptions defining the scope of materials**

These documents and the processes they outline assume that an owner or specifier has little expertise in the design, specification, selection, procurement and installation of energy-efficient luminaires for office areas, as well as advanced lighting control systems. Therefore, one assumption is that an owner will hire project team members as required in order to effectively and efficiently complete this process. See Appendix D for a list of typical project team members and their respective tasks. Depending on the project size, an owner may consolidate some of these tasks in order to reduce the number of people required on the project team. For example, an owner may ask a licensed electrical engineer to perform tasks that might otherwise be done by an independent lighting designer on a much larger project.

Another assumption is that for cost effective retrofit applications, a lighting control system will only be deployed if an owner also retrofits or replaces existing fluorescent luminaires with LED luminaires or retrofit kits. Given the cost and complexity of “weaving in” new control components and control wiring to existing fluorescent luminaires, it’s unlikely that an owner would choose to deploy a lighting control system without also upgrading or changing the fixtures in the process. However, most of the specification language contained herein is applicable to fluorescent luminaires as well as new LED luminaires or retrofit kits. Because there are a variety of factors affecting the purchase and installation of lighting control systems, it’s possible that under certain circumstances it may be as cost effective and efficient to retrofit existing fluorescent luminaires instead of replacing them with new LED luminaires.

Similarly, these materials were developed with an emphasis on issues affecting “retrofit” projects. However, most of the specification language contained herein is equally applicable to new construction, gut rehab (tenant fit-out) or retrofit projects. One important consideration that may govern some of the choices affecting equipment, methods of installation or staging of the work is whether or not the space is “occupied”. For example, it may be considerably more efficient and less intrusive to use luminaires with all required controls components factory-installed if the space is occupied. If the project is new construction, gut rehab or tenant fit-out, this may not be a critical factor.

Typically, advanced lighting control systems are installed with “maximum granularity”. As described in the technology specifications, this means that every luminaire is individually addressable. Depending on the granularity of occupancy sensors and photosensors deployed, using a system with individually addressable luminaires is generally preferred. Not only does it allow unrestricted rezoning based on future changes to the space, but it is also expected to provide the highest degree of energy efficiency as well as maximize comfort for occupants.

The technology specifications contain language addressing both wired and wireless transmission of control signals. Similarly, the language contained herein is protocol-agnostic. This means that a variety of commonly used protocols would satisfy the requirements described in the specification language. Over time, lighting controls manufacturers continue to explore different protocols (such as IP and others), different methods of signal transmission, different topologies and other methods of configuring their systems. These documents are not meant to serve as a survey or summary of these variables, ranked by popularity or by usage in the market (for example). Rather, they are meant to guide the user and to serve as a reminder of the various options that affect the selection of equipment for a specific project.

Lastly, these materials were created based on the assumption that the owner and project team would develop specifications for luminaires and a lighting control system irrespective of who would ultimately install them. It’s possible that an owner might decide to solicit proposals only for “turnkey” solutions, in which vendors would provide the equipment as well as the labor for the installation work. Depending on the locale, existing relationships or standing agreements with electrical contractors, this may or may not be possible. Requesting proposals for “turnkey” solutions may also limit the range of equipment for consideration by the owner. Therefore, the approach suggested in this document is to issue an RFP for the equipment (Section 1), evaluate the proposals from prospective vendors, then solicit bids from potential electrical contractors. Appendix D shows typical tasks for each project team member. This may be used as a basis for soliciting bids from electrical contractors.

**How these materials were developed**

The specification was developed using subject matter expertise combined with experience gained from actual installations.

**How to use these materials**

* This document describes a range of desired performance criteria. Where more than one possibility is listed in the specifications, interpret these as follows, then select the choice that best suits your needs and delete the others:
	+ **Options** represent different methods to achieve the result. There is no predetermination about which option may result in the easiest installation, lowest cost, best quality, etc.
	+ **Tiers** also represent different methods to achieve the result. However, higher-level tiers (e.g., Tier 3 is higher than Tier 2) indicate preferred options based on increased performance, easier installation, lower cost or possibly other factors. Keep in mind that in some situations, it’s possible that higher-tier choices may also result in increased cost and/or complexity of installation (or they may not). The specifier and owner must weigh all of the factors when choosing which options they want for a specific project.
* Content that can be directly copied-and-pasted or transferred into your tailored document is shown in plain (black) text.
* Instructions and content that you should customize, fill in, or supply yourself are shown in *[blue text and in brackets and italics].*
* Descriptive text appearing below a specific item that explains that part of the specification in greater detail is shown in green (and should be deleted in the final version of your tailored document). Note that this document contains both a version with descriptive text to aid in understanding each section and in Appendix B a “clean” version of the specifications (without descriptive text). It may be easier to use the “clean” version as the basis for your own project, then modify as necessary, and refer to the version with descriptive text to learn more about particular issues.
* Any content that is not relevant to your organization or project can be deleted, and additional content can be added.
* Definition of roles:
	+ The word “Owner” refers to the name of the organization soliciting proposals and procuring the equipment.
	+ The word “Proposal” refers to the response of a person, company, or corporation proposing to provide the technology and/or services sought in the RFP.
	+ The word “Proposer” means the person, company, or corporation that submits the RFP.
* These are not legally binding documents, and they do not serve as contracts. Legal and executive reviews are recommended to ensure that appropriate language is included in the documents that you create.

**Section 1: Request for Proposals (RFP) Template**

This section of the package contains a template to guide your creation of a request for proposal (RFP) for office lighting luminaires and lighting control systems. By editing and filling in the template, you will produce a draft RFP for your organization’s lighting retrofit implementation effort.

**Request for Proposals**

**Project:** [*Title of project in which the luminaires and lighting control system will be deployed*]

**To:** Prospective vendors

**From:** [*Point of contact for owner*]

**Date of Issue:** [*Date*]

**Request for Proposals**

Table of Contents

[1. Introduction 9](#_Toc482871438)

[2. Schedule of Events 10](#_Toc482871439)

[3. Scope of Work 11](#_Toc482871440)

[4. Proposal Format Guidelines 12](#_Toc482871441)

[5. Proposal Submission and Eligibility 15](#_Toc482871442)

[6. Evaluation and Selection Criteria 17](#_Toc482871443)

[Appendix A. Existing site characteristics 18](#_Toc482871444)

# 1. Introduction

1.1 Purpose

*[Include a brief* *description of the purpose of this RFP, as follows.]*

*[Name of organization]* is soliciting proposals for qualified companies to provide luminaires as well as a lighting control system. You are invited to submit a proposal in accordance with this Request for Proposals (RFP).

1.2 Background

*[Include a description of the project with background information, including but not limited to the following elements:]*

Project scope: *[Describe the number of sites and floor area included in the scope of the retrofit. If there is any possibility that the deployment of the lighting control system may be expanded in the future, indicate that here, including specific information about possible additional areas or floors that may be addressed.]*

Project objectives: *[Describe the goals of the project. For example, you might specify that the technology selected as a result of this RFP will be expected to:]*

* *Take advantage of (or increase the use of) daylight harvesting control strategies.*
* *Provide public energy dashboards to inform and educate occupants and visitors.*
* *Incorporate enhanced control strategies (such as manual overrides, local dimming, etc.).*
* *Implement Auto Demand Response strategies for electric lighting.*
* *Reduce lighting energy use by \_\_%.*
* *Benefit from all available financial incentives to reduce purchase and installation costs.*
* *Track the impact of the lighting retrofit project, and measure and verify utility cost savings.*
* *Track and manage peak demand associated with lighting energy use.*
* *Report reduction in lighting energy use and greenhouse gas emissions.*
* *Produce reports for operations and maintenance.*
* *Facilitate ease of operation by engineering or other building staff.*

Project budget: *[Include a not-to-exceed budget, or range, as applicable.]*

# 2. Schedule of Events

This RFP will be governed by the following schedule:

|  |  |
| --- | --- |
| **Event** | **Date** |
| **Release of RFP** (including documentation of existing conditions) | *[Date]* |
| *[The RFP should also include estimates of the following deadlines: 1.) luminaire delivery to job site, 2.) lighting control system delivery to job site, 3.) start of installation, 4.) installation completion, 5.) lighting control system commissioning.]* |  |
| **Owner’s or designer’s conference with prospective vendors** (optional) | *[Date]* |
| **Electrical engineer’s conference with prospective vendors** | *[Date]* |
| **Last day to submit written questions**  | *[Date]* |
| **Last day for** *[Owner/designer]* **to respond to questions** | *[Date]* |
| **Proposal due date.** Late proposals will not be accepted. Note that prospective luminaire and lighting control system vendors will not be expected to prepare “final” (“hardline”) drawings of proposed equipment at this time. However, at a minimum, all vendors will be expected to prepare sketches showing all details and information needed by the owner, designer and electrical engineer to assess the proposed equipment and associated wiring requirements. Successful bidders will be required to prepare all necessary “final” drawings during the submittal phase (as described in the Technology Specification section). | *[Date and Time]* |
| **Optional interviews with prospective vendors** | *[Date]* to *[Date]* |
| **Notice of intent to award.** Note that the owner is under no obligation to proceed with the project, and to award a contract for the equipment described in this document for the entire project or any part of the project as described. | *[Date]* |
| **Contract award** | *[Date]* |

# 3. Scope of Work

*[Paste “Technology Specifications” here from Section 2, after carefully reviewing and editing to include all applicable information particular to your project. Alternately, attach the “Technology Specifications” as an appendix and reference them here.]*

# 4. Proposal Format Guidelines

*[Describe the required proposal format and contents, and what information they should provide in their response, in what order, and by what date. See below for suggested proposal format and contents. Include any additional contents you see fit. Indicate how the proposal must be issued (e.g., paper, electronically via PDF, etc.). Note that certain vendors may propose providing both luminaires as well as a lighting control system. Alternately, proposals may be solicited from manufacturer rep agencies or from electrical distributors. In those situations, a single proposal should cover all of the content as suggested below. However, most luminaire vendors do not also fabricate and sell lighting control systems (and vice versa). The owner must decide if they want to solicit only “integrated” proposals, or allow individual vendors to submit proposals for either luminaires or lighting control systems.]*

Proposers are to provide the Owner a thorough proposal according to the following guidelines.

Proposals should use simple language with minimal jargon, and avoid the use of elaborate marketing material beyond that necessary to provide a complete, accurate, and reliable offer. Each Proposal will adhere to the order and content of sections defined below, and each section must be completed in full. Incomplete proposals will not be considered.

1. Cover letter – *[number]* pages, maximum:

Include a cover letter signed by a principal in the company, indicating full contact information (mailing address, telephone number, and e-mail address). The cover letter may also summarize key elements of the proposal, and unique aspects of the proposed equipment.

1. Summary of qualifications for prospective luminaire vendors – *[number]* pages, maximum:

Describe the qualifications of the proposing company, to demonstrate the capability to provide the equipment and services required in this RFP. Information shall include:

* + 1. Company information including name, address, business type, and website
		2. Description of the company, including:
	+ An overview of products that the company provides.
	+ The number of years that the company has provided the equipment requested in the RFP.
	+ The number of completed deployments of the proposed luminaires.
	+ Primary building sectors (office, higher education, hospital, food service, etc.) that the company has worked with in the past.
	+ Any other relevant information about the company.
		1. Provide at least *[number]* references for customers that have deployed similar luminaires as those detailed in the RFP. The Owner reserves the right to contact any of the organizations or individuals listed. Information provided shall include:
	+ Customer name.
	+ Brief description of the products installed, total project square footage and facility types.
	+ Primary point of contact for the customer including name, telephone number, and e-mail address.
1. Summary of qualifications for prospective lighting control system vendors – *[number]* pages, maximum:

Describe the qualifications of the proposing company and project leads, to demonstrate the capability to provide the equipment and services required in this RFP. Information shall include:

* + 1. Company information including name, address, business type, and website
		2. Description of the company, including:
	+ The total number of employees.
	+ Brief bios of key personnel who are expected to interface with the project team throughout design, installation and commissioning, including their years of experience.
	+ An overview of all the products and services that the company provides.
	+ The number of years that the company has provided the equipment and services requested in the RFP.
	+ The number of completed deployments of the proposed lighting control system.
	+ Experience in assisting customers to receive available financial incentives such as utility rebate programs, government incentives and grants, and other options.
	+ Primary building sectors (office, higher education, hospital, food service, etc.) that the company has worked with in the past.
	+ Any other relevant information about the company.
		1. Provide at least *[number]* references for customers that have deployed similar lighting control systems as those detailed in the RFP. The Owner reserves the right to contact any of the organizations or individuals listed. Information provided shall include:
	+ Customer name.
	+ Brief description of the scope of products and services deployed, current status, project start and end dates, total project square footage, number of facilities served and facility types.
	+ Primary point of contact for the customer, including name, telephone number, and e-mail address.
1. Technology features and implementation plan for lighting control systems – *[number]* pages, maximum:

Provide a description of the proposed approach and methodology to satisfy the Scope of Work defined in this RFP. This section shall include:

* + 1. A diagram of the architecture of the proposed lighting control system.
		2. A detailed description of how the proposed technology provides the capabilities listed in Scope of Work in Section 3 of the RFP.
		3. A description of any additional capabilities that may be of interest to the Owner but are not specified in the Scope of Work in Section 3 of the RFP.
		4. Where applicable, screenshots to clearly illustrate key operational, reporting, visualization, or analysis capabilities.
		5. A description of how the proposed technology satisfies the IT requirements listed in the Scope of Work in Section 3 of the RFP.
		6. A description of the training and ongoing technical support and maintenance services that will be provided as outlined in the Scope of Work in Section 3 of the RFP.
		7. A detailed project implementation plan, including all tasks and subtasks, durations, milestones, and deliverables. Refer to Appendix C showing a typical project timeline including specific tasks.
		8. A thorough description of specific responsibilities required of the Owner (e.g., site access, provision of electrical and network diagrams, network access, etc.) in conducting the project. Refer to Appendix C showing a typical project timeline including specific tasks.
1. Cost proposal

The cost proposal shall explain the pricing structure for all hardware, software, integration, commissioning, and any other services required for the project (for both luminaire as well as lighting control system vendors). Include an itemized list of all direct and indirect costs (e.g., personnel, travel, supplies, fringe benefits) associated with the deployment of the proposed equipment. Proposal shall include pricing for the following:

* + 1. Luminaires.
		2. Lighting control system.
		3. Any additional required hardware.
		4. Software set-up fees (e.g., software configuration, programming, license, training, etc.).
		5. Ongoing software usage fees (e.g., data storage and hosting, maintenance, access, technical support and maintenance, or if the system uses a SaaS <software as a service> model, etc.).
		6. Any specified technology features or capabilities that add significantly to project costs.
		7. Any additional optional services or fees.
1. Staffing for lighting control system vendors (and any independent commissioning agents, as required)

Describe the team that will be assigned to the project, with each member’s areas of responsibility. Identify lead personnel and include a résumé for each lead.

1. Protections and assurances

Describe the specific measures and protections that the responding company can provide to the Owner to ensure continuity of services in the event of bankruptcy, transfers of ownership, or other disruptions to business-as-usual operations.

# 5. Proposal Submission and Eligibility

*[Describe the RFP procedures, including your organization’s point of contact for respondent inquires, submission instructions, modification and withdrawal process, confidentiality, and other procedural details.]*

1. Eligibility

*[Include any eligibility requirements or preferences that may apply, considering, for example, foreign vs. domestically owned companies; multi-party joint responses; small businesses; citizenship; and other criteria.]*

1. Preparation

The Proposal content and format must follow the guidelines provided in Section 4, “Proposal Format Guidelines,” in the RFP.

1. Submission and due date

*[Provide a website, e-mail address, and/or mailing address for the proposal submission; identify whether electronic or paper submissions are preferred or required.]*

Proposals are due by *[insert the time and date from the schedule summarized in Section 2 of the RFP]*. Late Proposals will not be accepted.

1. Inquiries

Questions about this RFP must be directed in writing, via e-mail, no later than *[insert the time and date from the schedule summarized in Section 2 of the RFP]****.*** Send to:

*[Provide the name and either e-mail address or telephone number for the desired organizational point of contact.]*

1. Proposal validity

Proposals are to be valid for a minimum of *[number of days]* days to allow sufficient time for evaluation and selection, and any unforeseen delays in the review process.

1. Modification and withdrawal

Any proposal may be modified or withdrawn by written request of the Proposer, provided that the request is received prior to the submission deadline.

1. Right to reject proposals

This RFP does not commit the Owner to award a contract, pay any costs incurred in the preparation of a response to this RFP, or to procure or contract for equipment or services. The Owner reserves the right to accept or reject any or all proposals received as a result of this RFP, to negotiate with any qualified Proposers, or to cancel this RFP in part or in its entirety.

1. Confidential material

All the proposals will become the property of the Owner. Proposers should not include proprietary or confidential information in their response, unless required to clearly convey the proposed work or technology solution. Financial, commercial, or technical information that is considered confidential should be clearly indicated in the proposal.

1. Terms and conditions

*[In partnership with your organization’s legal department or representatives, include specific terms and conditions that will govern the contracting and procurement of the technology and required services, as well as on-site work conducted to complete the project.]*

# 6. Evaluation and Selection Criteria

*[Describe how proposals will be evaluated. You may choose to use a qualitative description, including key criteria, or to include quantitative point and scoring information.]*

# Appendix A. Existing site characteristics

*[Describe in detail, the site characteristics, details on the existing lighting system, task requirements, and other relevant information. Proposers can use this information in combination with the Scope of Work in Section 3 of the RFP to understand key aspects of scope and estimated project costs. You may wish to append spreadsheets, if that is a more convenient format to present the information.]*

**Section 2: Technology Specification Template**

This section of the package contains the template to guide your creation of a specification for office luminaire and lighting control systems. This template is intended to provide a structure and content foundation to facilitate an owner-driven process to define technology capabilities.

By editing, adding to, and deleting from the template, you will produce a custom specification based on your organization’s specific goals and energy management processes. This specification should be included in the Scope of Work in Section 3 of the RFP. See the Overview section of this document for additional information.

**Technology Specification**

**Table of Contents**

[Glossary of Terms 2-21](#_Toc431502395)

[Appendix B: Performance Specifications (*without comments*) 2-22](#_Toc431502397)

[Appendix C: Typical Project Timeline](#_Toc431502398)

[Appendix D: Project Team Members and Typical Tasks](#_Toc431502399)

[Appendix E: Generic Zoning Diagrams for Lighting Control Systems](#_Toc431502400)

For Appendices C-E, see annotated version of this document:

“*NYC-Lighting-Controls-Spec-Final.pdf””*

*at: https://facades.lbl.gov/nyclivinglab*

## Glossary of Terms

**Baseline:** A representation of “standard” or typical energy performance, used for comparative purposes. Baseline may be expressed according to a variety of metrics. In a lighting control system, a baseline may represent pre-install conditions.

**Building Management System (BMS):** A system that is designed to control building operations and indoor climate.

**Communication Protocols:** Standardized rules or languages governing the transmission of information between devices. Common protocols for lighting control include (among others) DALI and 0-10V. BACnet, LonTalk, and Modbus are examples of protocols used by Building Management Systems.

**Controller:** A device that switches a luminaire or group of luminaires on and off, and signals the luminaire(s) to dim up or down based on input from a control system or manual override device such as a wallbox dimmer. Controllers are typically mounted within a luminaire housing. However, some systems use controllers that are centrally located.

**Demand:** The amount of energy use by a particular building or system, i.e., power at a given point in time. Electrical power demand is expressed in kilowatts (kW).

**Demand Response:** Changes in electric usage by customers in response to changes in the price of electricity over time or when system reliability is jeopardized.

**Energy Savings:** Accrued energy savings (or potentially increases) over a certain time frame, relative to the baseline.

**Greenhouse Gas (GHG) Emissions:** The carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O) gases released into the atmosphere as a result of electrical energy consumption at the facility.

**Illuminance:** Incident light falling on a surface, measured in footcandles (English units) or in lux (SI units). Roughly, 1 footcandle (fc.) = 10 lux. Recommended target values for illuminance (for example, as listed in the IES Handbook) are typically for average horizontal maintained values based on the entire task surface or plane.

**Lighting Power Density (LPD):** Electric power required to energize all luminaires at maximum light output, divided by the area. In the U.S., LPD is measured in Watts/square foot (W/sq. ft.).

**Luminaire:** A device used to create artificial light by use of an electric light source. A luminaire consists of a fixture that houses the light source (e.g., LED matrix, fluorescent lamp, etc.), electrical gear required to power the light source (e.g., LED drivers, ballasts, etc.), and any additional components required for mounting and optical control.

**Luminance:** Reflected or transmitted light. The amount of luminance is typically used to determine if a given light source will create glare. Luminance is measured in candelas/meter2 (cd/m2).

**Peak Load:** The maximum load during a specified period of time, usually within 15-minute periods as defined by electric utilities.

## Appendix B: Performance Specifications (*without comments*)

1. Light level target values and energy goals:
2. Task illuminance: at full light output, the lighting system will produce a minimum of 30 average horizontal maintained footcandles on task surfaces (assuming no daylight contribution).
3. Lighting power density (LPD): *[select one]*
	* 1. Tier 1 – Maximum connected lighting load including task lighting shall not exceed 75% of applicable code restrictions. *[Determine which code(s) are applicable to the project; e.g., IECC 2012/ASHRAE 90.1-2010/CA Title 24/etc. Then determine the maximum permissible connected lighting load.]*
		2. Tier 2 – Maximum connected lighting load including task lighting shall not exceed 50% of applicable code restrictions. *[Determine which code(s) are applicable to the project; e.g., IECC 2012/ASHRAE 90.1-2010/CA Title 24/etc. Then determine the maximum permissible connected lighting load.]*
4. Annual lighting energy use: *[select one]*
5. Tier 1 – Energy use from connected lighting load (including task lighting) shall not exceed 2.0 kWh/square foot/year.
6. Tier 2 – Energy use from connected lighting load (including task lighting) shall not exceed 1.5 kWh/square foot/year.
7. Tier 3 – Energy use from connected lighting load (including task lighting) shall not exceed 1.0 kWh/square foot/year.
8. Overhead light fixtures for ambient light:
9. Dimming: *[select one]*
10. Tier 1 – All overhead light fixtures shall be dimmable in a continuous range between 10-100% of full light output.
11. Tier 2 – All overhead light fixtures shall be dimmable in a continuous range between 1-100% of full light output.
	1. Control system components – modify existing lighting scheme to incorporate dimming and any other required control system components as follows: *[select one]*
12. Option 1 – Retrofit existing luminaires to incorporate LED lamps, LED matrices or use complete “retrofit kits”, incorporating dimmable LED drivers as required. Incorporate additional control system components and new optical control media (e.g., lenses or diffusers) as required. Leave existing luminaires housings and primary power feeds in place. Connect new low-voltage network wires as required for communication with the lighting control system.
13. Option 2 – Replace existing luminaires one-for-one with new LED luminaires incorporating dimmable drivers for LEDs, with any required control system components factory-installed. Reuse existing primary power feeds and connect to new luminaires. Connect new low-voltage network wires as required for communication with the lighting control system.
14. Option 3 – Remove existing luminaires and install new LED luminaires with a new layout. Provide new luminaires incorporating dimmable drivers for LEDs, with any required control system components factory-installed, using appropriate spacings/locations to achieve the target illuminance levels. Patch ceiling and/or replace tiles as required. Reroute primary power feeds to new luminaires as required.
	1. Light source color: *[select one]*
15. Tier 1:
	1. Correlated color temperature (CCT) – LEDs shall have a published CCT of 3500K or 4100K. Actual CCT for LEDs as shown on IES LM-79 tests may have a tolerance of ±100K. Therefore they must be in the range of either 3400-3600K (for nominal 3500K) or 4000-4200K (for nominal 4100K).
	2. Coloring rendering index (CRI) – LEDs or LED lamps shall have a published CRI of 80 or greater.
16. Tier 2 – LEDs shall have a base CCT and CRI as described above. However, the CCT may be continuously increased up to 5000K at the user’s discretion (to more closely approximate the cooler color temperature of daylight), either by manually adjusting the color temperature (for example using some form of wallbox device) or by setting the desired CCT in the control system software. Fade rate for any such change in CCT may range from 0-59 seconds, or up to 60 minutes.
	1. Glare and luminance limits – to minimize direct glare from fixtures, restrict luminance as follows for any azimuth angle: *[select one]*
17. Tier 1 – Restrict luminance at any vertical angle at or above 55° from nadir (from 55-90°) to 2000 candelas/square meter (cd/m2).
18. Tier 2 – Restrict luminance at the following vertical angles to:
	* + 1. 850 cd/m2 at 55° from nadir.
			2. 350 cd/m2 at 65° from nadir.
			3. 175 cd/m2 at or above 75° from nadir.
19. Wiring:
20. Wiring to and between luminaires – since all overhead luminaires need to be dimmable, it may be necessary to reroute existing wires or to run additional power wires and/or control wires. Methods of wiring include: *[select one]*
21. Option 1 – Reroute existing power wires and/or run additional power or control wires as necessary from existing or new luminaires locations to a centrally located electrical room(s). Terminate in existing or new distribution panels, depending on the control system.
22. Option 2 – Distribute controllers in the plenum and run power and/or control wires as necessary to luminaires, or to distinct zones. Controllers shall not require “homeruns” back to a centrally located electrical closet(s) for either power or control wiring. Communicate between controllers, from controllers to server, and between controllers to user access points (terminal, switches, etc.) via a new data bus, company local area network (LAN), or wirelessly using radio frequency (RF) or other method of communication.
23. Option 3 – Use existing power wires to luminaires. Luminaires shall be “self-contained”, with on-board components required to switch and dim fixtures, to communicate with the lighting control system (dimming ballasts, dimming drivers, controllers, radios, etc.), and to reconfigure the zoning. The luminaires shall communicate wirelessly with a gateway. If this option is selected, no additional wiring is required to existing (or new) luminaires.
24. Wire colors – luminaire vendors shall use industry-standard wire colors for all line-voltage power feeds as well as low-voltage control connections.
25. Lighting control system for overhead luminaires:
26. Dimming – as previously noted, all overhead luminaires shall be dimmable. Dimming range: *[select one]*
27. Tier 1 – All luminaires shall be continuously dimmable in a range of 10-100% measured light output.
28. Tier 2 – All luminaires shall be continuously dimmable in a range of 1-100% measured light output.
29. Minimum power at lowest light output: *[select one]*
	* 1. Tier 1 – At the lowest light output, input power to the luminaire shall be no greater than 20% of the input power at maximum light output.
		2. Tier 2 – At the lowest light output, input power to the luminaires shall be no greater than 10% of the input power at maximum light output.
30. Control zones for overhead luminaires: *[select one]*
	* 1. Option 1 – Low granularity occupancy zones: create zones corresponding to the coverage pattern of the occupancy sensors to be used (e.g., 500, 1000 or 2000 foot2). *[If occupancy sensors with specific coverage areas (or shapes) are desired, include those specific amounts or shapes in the specification language (and/or attach diagrams showing the coverage area/shape as appendices, or by including manufacturer’s catalog sheets).]*
		2. Option 2 – Medium granularity occupancy zones: create zones that are smaller than the coverage pattern of the occupancy sensors to be used (e.g., 200 foot2). This may be accomplished by masking portions of a ceiling-mounted sensor. Alternately, use occupancy sensors that have smaller coverage patterns than typical ceiling-mounted sensors (e.g., 200 foot2). *[If occupancy sensors with specific coverage areas (or shapes) are desired, include those specific amounts or shapes in the specification language (and/or attach diagrams showing the coverage area/shape as appendices, or by including manufacturer’s catalog sheets).]*
		3. Option 3 – Maximum granularity occupancy zones: create zones that correspond to individual luminaires. *[If occupancy sensors with specific coverage areas (or shapes) are desired, include those specific amounts or shapes in the specification language (and/or attach diagrams showing the coverage area/shape as appendices, or by including manufacturer’s catalog sheets).]*
31. Control strategies – the lighting control system shall be capable of implementing the following lighting control strategies:
32. Daylight harvesting – the availability and amount of daylight shall be determined by the use of photosensors. Luminaires in areas with sufficient daylight shall dim (or potentially turn off) in response to available daylight if those options are selected in the control profile in use at a specific time. Photosensors shall meet the following criteria:
	* + 1. Photosensor type *[select one]*:
33. Closed-loop.
34. Open-loop.
35. Dual-loop.
	* + 1. Signal transmission method *[select one]*.
				1. Analog.
				2. Digital.
			2. Viewing cone – closed-loop photosensors shall be ceiling- or fixture-mounted *[select one]* with a viewing cone limited to an angle of 30-60° *[edit and provide a specific angle]*. Open-loop photosensors shall have a viewing angle that limits its cone of view to *[provide a specific angle; the designer may determine the desired angle based on plans and section drawings]*° and the width of its view parallel to the window wall to *[provide a specific angle; the designer may determine the desired angle based on plans and section drawings]*°.
			3. Spectral filtering – photosensors shall incorporate a photodiode to measure light levels that can be correlated to the desktop illuminance. The photodiode shall be spectrally filtered (color-corrected) to measure light that approximates the human photopic response.
			4. Range – photosensors shall operate within a range of 0-300 footcandles of incident light on the task surface (or greater if the setpoint <target> illuminance level is higher). This may be modified to a more limited range either by physical adjustment at the photosensor, or (preferably) by changing settings in the control system software.
			5. Accuracy – photosensors shall be accurate to within 1% of reading in an operating environment between 15-30°C.
			6. Calibration *[select one]*:
				1. Option 1 – Nighttime calibration. Calibrate the photosensors by adding a “photosensor calibration” event to the schedule in the system’s software. The calibration will be scheduled to take place during nighttime hours (with no available daylight). The control system will turn luminaires on and leave them at full output for 10 minutes to insure that all luminaires are fully warmed up. Then the system will dim luminaires by 10% every 2 minutes (allowing light levels to stabilize with temperature), recording the resulting levels measured by the photosensors. The final dimmed levels shall be 5% and 1% once the photosensors have been calibrated for all levels in 10% increments. Once the calibration is done, the system will use these recorded values to determine the appropriate mix of daylight and electric light to achieve the target illuminance levels during daylight hours when daylight harvesting profiles are active.
				2. Option 2 – Other methods of calibrating the photosensors may be proposed by a lighting control system vendor.
			7. Deadband – a range of values shall be set in the control system software that achieves the following:
				1. Maximum setpoint – upper limit of the target illuminance range. When a combination of daylight and electric light exceeds this setpoint (for a period of time specified in the software), the control system will dim luminaires (or turn them off).
				2. Minimum setpoint – lower limit of the target illuminance range. When a combination of daylight and electric light fall below this setpoint (for a period of time specified in the software), the control system will increase the level of the luminaires (or turn them on if they were previously off).
				3. Time delays & fade rates – time delays and fade rates may be set in the control system software for dimming luminaires up or down. (For example, set variables in the system so that luminaires will not dim up or down until 5 minutes after a change in light level registers at the photosensor.)
36. Occupancy/vacancy sensing – occupancy/vacancy shall be determined by the use of passive infrared (PIR), ultrasonic (US), dual-technology or other types of occupancy sensors (microwave, acoustic, etc.). *[if a specific type of occupancy sensor is desired (some of which are described above in “Control Zones”), indicate that here and delete the others.]*
37. Signal transmission method. Occupancy/vacancy sensors may be “analog” or “digital” *[select one]*.
38. Analog.
39. Digital.
40. Adjustment of sensors shall be as follows *[select one]*:
41. Tier 1 – Adjustment for “sensitivity” may be preset at the sensor before installation, or field-adjusted at the sensor after installation. “Time delay” may be set at the sensor as well as in the system software.
42. Tier 2 – Adjustments for “sensitivity” as well as “time delay” shall be made in the system software. Time delays can be different for different control “profiles” or during different “schedules” (see below).
43. Fade upon sensing occupancy or vacancy – fade time to raise/dim luminaires up or down, between 0-59 seconds or up to 60 minutes, may be programmed in the control system software. Different fade times may be used for occupancy versus vacancy.
44. “Daylight hold off” – if sufficient daylight is present in the space, allow the lighting control system to “hold off” luminaires in certain zones (keeping those luminaires off or at a minimum light level preset in the system software, based on the prevailing control profile).
45. Programming of system behavior based on occupancy and vacancy sensing *[select one]*:
46. Tier 1:
	1. Upon sensing occupancy, turn luminaires on to a predetermined level set in the lighting control system software. Allow for a “transition” time (to fade luminaires up) from 0-59 seconds or up to 60 minutes.
	2. Upon sensing vacancy, and after a specified “time delay”, turn luminaires off or dim to a predetermined level set in the lighting control system software. Allow for a “transition” time (to fade luminaires down) from 0-59 seconds or up to 60 minutes. Time delays and fade rates can be different for occupancy sensing versus vacancy sensing.
47. Tier 2 – In addition to the behavior as described in Tier 1, after sensing vacancy, allow for an “intermediate step” where luminaires dim to a different predetermined level after a specified “time delay”. Alternately, allow lights to “blink” off then on as a visual indication to occupants that the occupancy sensors have already timed out – before reducing light levels based on settings for the “vacant” state. Fade rates for this intermediate step may be different than for the base behavior as described in Tier 1.
48. Tier 3 – Allow for two “intermediate steps” as described above in Tier 2.
49. Tier 4 – Allow for an unlimited number of “intermediate steps” as described above in Tier 2.
50. Scheduling – control system shall allow the creation of a schedule that will determine which “control profiles” are in effect at what times, including:
51. Normal schedule – allows creation of “typical” schedules.
52. Temporary schedule – allows creation of atypical or one-time events that would override the normal schedule.
53. Format:
54. The lighting control system shall utilize a Microsoft Outlook-style calendar for the creation of “normal” as well as “temporary” (or “exception”) schedules. Any “temporary” schedule shall override the “normal” schedule in effect at that time.
55. “Default” behavior – default behavior may be created without selecting specific blocks of time to determine when the default behavior is in effect.
56. Individual events for either “normal” or “temporary” schedules may be any duration of time based on increments of 1 minute, and as short as 2 minutes in duration.
57. The control system shall be capable of creating “overnight” events (spanning midnight).
58. Events may be created that repeat indefinitely (with no end date).
59. Provide automatic system time adjustments for Daylight Savings Time as well as for leap years. This may be achieved internally, or it may be done by reference to an external NTP (Network Time Protocol) server. *[If an NTP server is available and can be linked to the lighting control system, keep that language and delete reference to this being done “internally”.]*
60. Tuning – the control system shall allow for presetting a reduction in light levels throughout a specific zone(s). This variable will be set in each control profile and will be active when a given profile is active based on the schedule.
61. Demand response/demand reduction (DR):
62. Methods of activation: *[select one]*
63. Tier 1 – The lighting control system shall allow programming of manual or scheduled reduction of light levels based on preprogrammed values.
64. Tier 2 – Provide all of the options for preprogramming a reduction of light levels as mentioned for Tier 1. In addition, provide an interface to an Automated Demand Response (ADR) server to automatically activate demand response/demand reduction functions in the lighting control system as described above.
65. Severity of events – regardless of whether demand response events are activated manually or by a signal from an ADR server, allow for preprogramming demand response/demand reduction events with at least three degrees of severity.
66. “Opting out” – the lighting control system must allow any zone to “opt out” of a manual or automated demand response event.
67. Manual overrides – the following devices or methods may be used to manually control any zone or combination of zones *[include those that are required on a project and delete the others]*:
68. Types/methods of manual override:
69. Wallbox switches/dimmers.
70. Preset scene selector panels (for example, used in a conference room to dim all zones to predetermined levels by pushing a single button for each scene).
71. Touch screens.
72. Smartphone apps.
73. Software-based control.
74. Input from a BMS (for example to turn all luminaires to full on in an emergency situation other than during loss of normal power).
75. “Logic” for override behavior – variables can be set in the system software to control the behavior of manual override devices or methods. *[Based on descriptions below, if specific behaviors are required in your project, make sure to describe them here.]*
76. Control profiles:
77. Control system software shall allow for creation of “profiles” that contain variables for controlling the behavior of luminaires. Control profiles may be activated automatically by creating blocks of time in the schedule during which a specific profile is in effect. The software shall also allow for creation of a “default” – when a specific control profile is active unless a separate scheduled event is created that overrides the default control profile. These variables include (but are not limited to):
78. Occupancy sensor input – whether or not occupancy/vacancy sensors are used, time delays upon sensing occupancy or vacancy before lights turn on or off (or dim), sensitivity, transition times between states, etc.
79. Daylight harvesting – high and low setpoints to create a deadband for dimming or switching fixtures in response to available daylight, time delay before change of electric lighting is allowed, fade rate(s) for dimming lights up or down, etc.
80. Daylight “hold off” – keeps lights off if there is enough available daylight even if there is occupancy in the space, and allows setting the threshold for the “hold off” function.
81. Manual override – allows for occupant override of the preprogrammed control profile, and for setting the maximum override time period before luminaires revert to preprogrammed operation.
82. Writing control profiles: control profiles (also called control narratives or sequences of operation) must be written that contain values for all of the variables provided by the system. Unless there is already a company-wide standard for typical lighting control profiles, the designer shall create control profiles prior to commissioning and submit to the owner for review and approval.
83. Power metering – the lighting control vendor shall provide a means to measure instantaneous power use on a per-luminaire or per-zone basis. *[Verify the availability of power metering functions with the manufacturer, and if so, how they operate in the proposed system. If this function is desired, indicate the granularity required for the measured power use data.]*
84. Node licenses or additional recurring costs. *[Verify with the manufacturer whether licenses or other charges are assessed based on the quantity of system components or for any other reason at all]*.
85. BACnet integration:
86. Some lighting control systems have provisions to allow for integration with other building management systems using BACnet (or other) protocol. If this function is desired, verify the availability of a BACnet (or other) interface with the vendor during design and specification.
87. Integration with other systems using BACnet (or other) protocol may require the purchase of additional licenses for the BACnet portion of the lighting control system. Verify with the vendor during design and installation.
88. Integration with other systems using BACnet (or other) protocol may bypass the programming that controls behavior of luminaires in the lighting control system. In that case they would “pass through” commands and usage data. Verify with the vendor during design and installation.
89. Graphic user interface (GUI): *[select one]*
90. Tier 1 – Display “near real time” status of zones (for example – on, off, dimmed level) overlaid onto a floor plan of the space. “Near real time” is defined as the status of zones being updated at intervals of no greater than 1 minute.
91. Tier 2 – In addition to the display of “near real time” status of the zones as described in Tier 1, allow for manual override of a zone(s) directly from the graphic user interface.
92. Tier 3 – In addition to the functionality as described in Tier 2, allow for access to reporting of historical zone information directly from the graphic user interface. Such information shall include (but not be limited to):
93. Peak demand (kW) in any 15-minute period.
94. Energy use for every 15-minute period (measured in kWh).
95. Occupancy for every 1-hour period (in both minutes of occupancy and percentage).
96. Demand response/demand reduction condition (if any, including level of severity).
97. Alarms, alerts or error messages for any equipment not performing as required, including control system communication errors.
98. Emergency (EM) lighting – for overhead luminaires:
99. A licensed electrical engineer shall determine which new or retrofitted luminaires (or which fixture segments in continuous rows) require EM power feed or integral batteries for emergency lighting, in accordance with applicable code requirements.
100. EM luminaires designated by the electrical engineer shall provide emergency lighting functions upon loss of normal power.
101. When normal power is available, all EM luminaires shall operate according to the control profiles as set in the system for normal operation in their respective zones.
102. If required by code, bypass control system wiring (power and/or control wiring) to maintain code-compliant emergency egress lighting functions.
103. A licensed electrical engineer shall determine if a change to the normal or emergency operation of EM luminaires will require submission of documents to an “authority having jurisdiction” (AHJ), to verify that they will still provide emergency lighting according to applicable codes.
104. A licensed electrical engineer shall determine if new or retrofitted luminaires will change the light levels or power draw on emergency power sources in an emergency lighting situation, and if any such changes prevent the lighting system and luminaires from operating according to code requirements or within the capacity of the EM power source.
105. System failures – verify with the manufacturer what will happen when each component fails, considering (by not limited by) the following questions *[list specific requirements based on the questions below]*:
106. Server – for example, if a centrally located server fails or loses power, will other system components continue to operate normally? Will there be a loss of usage data during the time that the server was down?
107. Gateways – for example, if wired or wireless gateways fail or lose power, will luminaires still operate normally? Will usage data be lost during that time?
108. On-board controllers – for example, if controllers fail or lose a signal from the control system, will they still operate normally, or shut off, or turn on to full output?
109. Sensors and switches – for example, if sensors or switches fail, will luminaires still operate based on default behavior as determined by the server/software?
110. Software – for example, similarly to any complex computerized system, software for lighting control systems may be regularly updated by the manufacturer. What happens if the software is updated and causes the system to operate abnormally? Is there a way to force the software to revert back to a previous version that is known to make the system work as specified? What is the procedure used by the manufacturer to correct bugs in the software or firmware in devices (and how regularly is that done)? How will bug fixes affect the operation of the system in the space?
111. Normal vs. abnormal operation – if there are critical tasks being performed in a space, it’s essential to know how the system will operate under “normal” as well as “abnormal” conditions. Any manufacturer with a proven track record of having deployed their system for at least three years should have a clear understanding of what happens based on various configurations and topologies and under different conditions.
112. “Failsafe” operation – if the system starts to behave erratically for any reason at all, is there a method available to entirely bypass the system and operate luminaires manually? Will local switches (or any other components or methods) still operate luminaires even if the rest of the system is disabled? How about occupancy sensors or photosensors?
113. Standby power – if “standby power” in luminaires is necessary to maintain continuity in on-board control circuitry, that power usage shall be limited to a maximum of 1 Watt per luminaire.
114. Fade rate – the lighting control system shall be capable of allowing the light level to fade (raise/dim up or down) between 0-59 seconds, or up to 60 minutes *[if longer fade rates are required, change these values as necessary]*. Fade rates may be different for different control profiles and/or during different schedules.
115. Reporting:
116. Information to be reported/saved/stored by the control system:
117. Peak demand (kW) in any 15-minute period.
118. Energy use for every 15-minute period (measured in kWh).
119. Occupancy for every 1-hour period (in both minutes of occupancy and percentage).
120. Demand response/demand reduction condition (if any, including level of severity).
121. Alarms, alerts or error messages for any equipment not performing as required (including control system communication errors).
122. Event logs – record logs of all events in the system (schedule changes, occupancy or vacancy, dimming lights in response to photosensor input, manual overrides, alarms, errors, etc.).
123. Storage – store all historical data indefinitely in server, including energy usage and event logs.
124. Data format – CSV (comma separated values) or Microsoft Excel. Data files may be exported from the system on an as-needed basis.
125. Access to historical data. *[If data cannot be accessed through the graphic user interface, allow data to be accessed through standard menu options in the control system software – verify with the manufacturer.]*
126. Reports and graphs. *[Verify with the manufacturer what types of reports and graphs the system can create during design and specification.]*
127. Notifications:
128. The lighting control system shall have some method of sending notifications about errors, alarms, alerts, warnings, etc.
129. E-mail or text notifications – the lighting control system’s notification function shall send e-mails and/or texts *[specify which are desired]* to designated staff. *[Determine if the lighting control system can be programmed to send notifications to only one or more than one person, and if each recipient can receive different forms of alerts, warnings, error messages, etc.]*
130. Daily reports – send daily reports of equipment requiring servicing or replacement. *[Verify with potential vendors if such a function is available, and if so, how it operates.]*
131. Backup – provide a means to automatically backup programming (schedules, control profiles, etc.), usage data files and event logs on a regularly scheduled basis.
132. Backup files on the system’s server.
133. Provide some method to backup files to a USB drive and/or remote storage device, or to e-mail backup files. In the event of loss of program or usage data on the server, backup files may be uploaded to the server to restore normal operation (for control profiles and schedules, in addition to usage and event logs). *[Verify with potential vendors if such a function is available and, if so, how it operates.]*
134. Energizing system before commissioning – provide a means to energize all luminaires at full output prior to commissioning the lighting control system.
135. Connecting control system components and connecting to the system: *[Review all of these considerations in this section with the owner at the outset of the project; include language describing the desired (or allowable) methods of connection and delete the others.]*
136. Connections between system components:
137. Most (but not all) lighting control systems have a centrally located server. This will usually be installed in an IT server room or electrical closet. Typically, some of the components are connected to the server – such as gateways to luminaires, controllers, sensors, switches, touch panels, DALI ballasts or drivers, etc.
138. Most systems allow for connection between some or all of these components and the server via the owner’s existing communications network (intranet) – if the owner allows that. For example, gateways connected to luminaires are often provided with IP addresses and can therefore be connected to an existing communication network (intranet). If the server is also connected to the network, then it can communicate with the gateways without the need for additional wiring.
139. If the owner will not allow for using any of their internal communications networks (intranets) to connect system components, then they will need to be connected with additional dedicated wiring, unless the system is designed to allow some or all of these connections to be made wirelessly.
140. Connecting to the system (remote access):
141. Most lighting control systems are designed to allow remote access to the operating software as previously described, usually residing on a centrally-located server. A common method is to access a webpage or program on the server from a remote location.
142. If the owner allows the server (and/or other system components) to reside on an internal communications network (intranet), then it may be possible to access the system’s software from any computer on the owner’s network. It may also be possible to access the software from any remote location. In some cases, this may require a VPN (virtual private network) to access the server from outside the owner’s internal network. It is essential to make this determination during the design and specification of the lighting control system.
143. If the owner will not allow for using their internal communications network to access the software residing on the server (or other system components), then it may be necessary to install a dedicated wireless access point (for example, using a 3G modem, aircard, etc.) – or some other method of communicating with the system without accessing the existing building network – in order to gain remote access.
144. Access to the system’s software will be needed by some or all of the following:
145. System operator/administrator – this is usually someone on the building operation/engineering staff.
146. Lighting control system manufacturer – this may be required for troubleshooting, software updates, commissioning, recommissioning, rezoning, etc.
147. Lighting designer/electrical engineer/others – specifiers may want access to verify that the system has been installed and is operating as designed, or to retrieve usage data for analysis.
148. Users – many systems have methods to allow individual occupants to control luminaires and/or other devices connected to the system. For example, an occupant in a private office may be given access to or have control over the luminaires only in his or her room, but is not able to control luminaires in other private or open office areas.
149. “Dashboards” – many systems have methods to allow for displaying system usage (e.g., kWh/hour, kW <load> in percent or amount, usage compared to baseline <actual kW/max kW>, demand response event status, if any, etc.). A common method is for a remotely located monitor to connect to the server’s software by accessing its URL for the dashboard display.
150. User access levels – allow different users to access different functions in the system. *[Verify whether the system allows for different access levels during design and specification and, if so, how.]* Examples of different levels of access and functionality might include: *[Include those required by the owner and delete the others.]*
151. System administrator – has access to all functions and control over all luminaires (and/or other devices) on the system.
152. Tenants – if a system is used to control luminaires in a multi-tenant space, tenants may be given access only to luminaires in their space.
153. Individual users – occupants may be given control over the luminaires in their own private office, or luminaires that are located over their workstation in an open office area.
154. Guests – other people may be given access to monitor the system, without being able to make any changes.
155. Commissioning – a commissioning agent for the lighting control system shall be selected by the owner and design team. The commissioning process shall include the following steps:
156. Verification of correctly installed wiring and components.
157. Creating zones in the lighting control system software (including graphic overlays for the graphic user interface).
158. Discovery of lighting control system components including gateways, controllers, sensors, switches, wall panels, etc. (This can only be accomplished once the system is installed and up and running.)
159. Creating profiles and schedules for typical operation, as well as atypical events like testing after initial start-up, daylight calibration, demand response events, 100-hour fluorescent lamp burn-in, etc.
160. Assignment of luminaires/groups of luminaires to appropriate zones as created above. (This can only be accomplished once the system is installed and up and running.)
161. Calibration of photosensors.
162. Correction of any faults, warnings, alerts, alarms, etc.
163. Verification that all aspects of the control system software are operating properly and that the system is recording data as described above.
164. Setting appropriate values to establish baselines. These typically include any or all of the following:
165. Hours of operation.
166. Fixture types and wattages. Note that it may be desirable to have a “pre-install” baseline as well as a “post-install” baseline if the luminaires are replaced or retrofitted.
167. Electricity cost (per kWh, which may vary based on time of day).
168. Percentage of occupancy (this can be established beforehand by using loggers and analyzing the data).
169. Cost of CO2 (carbon dioxide emissions rate, based on electricity or gas cost – in some cases, CO2 emission reductions are taken into account when considering financial incentives, payback, etc.).
170. Resetting all usage and event data recorded since initial system installation to zero, if desired.
171. Clearing all active alarms, warnings, alerts, etc. (after insuring that the system is functioning normally).
172. User training:
173. Lighting control system vendor shall provide *[specify amount]* hours of on-site training for designated representatives of owner and design team to learn how to operate the system.
174. Lighting control system vendor shall provide reference manuals in print and/or PDF form *[specify which]*, as well as context-sensitive help screens in the control system software itself.
175. Technical support:
176. Allow remote access to the lighting control system server (with appropriate safeguards including firewalls, passwords, etc.). At a minimum, the lighting control system vendor shall be granted remote access in order to troubleshoot the system in the event of a malfunction of any of the hardware or software as described in this document.
177. Within *[specify period of time, e.g., one month, one year, etc.]* from initial system power-up, the lighting control system vendor will make site visits at their own expense in order to correct any problems within the lighting control system.
178. Vendor experience – any prospective lighting control system vendor must have at least three years of experience in supplying and successfully implementing advanced lighting control systems with similar features and operation as described above.
179. Procurement process issues for luminaires:
180. Submittals – luminaire vendors shall submit the follow for approval before fabrication and shipping equipment to the job site. *[Verify how long the manufacturer will need to produce these drawings and whether they will require any materials from the owner or specifier (such as CAD background drawings, control schedules, etc.). Determine who will review and approve these materials prior to releasing a purchase order.]* The submittals must include (but are not limited to) the following:
181. Luminaire detail drawings – showing all views necessary to fully describe the luminaire. This may include plan views, section drawings, run configurations, mounting details and/or any other drawings necessary to show every aspect of the luminaires to be installed.
182. Integral controls components – besides the LED driver(s), which may or may not be part of the lighting control system itself, any additional on-board or remote-mounted components must be shown on the drawings, as well as all associated wiring (cord sets, individual conductors, etc.). These may include fixture controllers, on-board sensors, UL924 relays and/or other components required by the lighting control system.
183. Quantities – the luminaire vendor shall indicate quantities required for each fixture type (based on different fixture types, different mounting conditions, different length units, different on-board control equipment, normal vs. EM, etc.).
184. Samples – luminaire vendors shall provide a working sample of each fixture type for review and approval by the owner and design team. Each sample shall be a complete, functional unit ready to be energized, including any on-board lighting control equipment required.
185. Procurement process issues for lighting control systems:
186. Submittals – lighting control system vendors shall submit the following for approval before fabrication and shipping equipment to the job site. *[Verify how long the manufacturer will need to produce these drawings and whether they will require any materials from the owner or specifier (such as CAD background drawings, control schedules, etc.). Determine who will review and approve these materials prior to releasing a purchase order.]* The submittals shall include (but are not limited to) the following:
187. Plans – showing location of all lighting control system components and how they are connected.
188. One-line diagrams – showing all lighting control system components and how they are connected (but not showing exact locations on a plan of the space).
189. Wiring diagrams – the lighting control system vendor shall provide drawings showing **every wiring connection for all system components**.
190. Control schedules – these are typically spreadsheets that indicate what resides in each control zone, such as:
191. Luminaires, including quantity of each fixture type in that zone, wattage for each fixture type, type of load (incandescent, fluorescent, LED, low-voltage magnetic, etc.).
192. Total wattage for the entire zone.
193. It is also desirable to indicate if any of the luminaires in a particular zone provide emergency lighting.
194. Occupancy sensors associated with that zone.
195. Photosensors associated with that zone.
196. Dimmer switches or touch screens associated with that zone.
197. Manufacturer’s catalog sheets of all equipment.
198. Samples – the lighting control system vendor shall provide the following sample equipment: *[The topology and wiring methods for many new lighting control systems are different than the existing topology and wiring in most buildings. It is advantageous for the installing contractor to acquire samples of certain equipment in advance of the installation. These may be provided as free samples by the manufacturer prior to received a purchase order, or subsequent to receiving a purchase order, or the manufacturer may want to provide these samples only as part of an actual order. Verify with the lighting control vendor.]*
199. LED drivers – these may be 0-10V, DALI and/or other types. (Not all electrical contractors have experience installing ballasts that contain more than just a hot wire, neutral wire, and a ground.)
200. Fluorescent ballasts (assuming that any fluorescent luminaires are still used in the space) – these may be 0-10V, DALI and/or other types.
201. On-board controllers (such as wired or wireless controllers that switch power to as well as dim the driver or ballast).
202. Centrally located load controllers.
203. Sensors – wired or wireless occupancy sensors or photosensors.
204. Wall-mounted dimmer switches or touch panels.
205. Emergency transfer devices (such as UL924 compliant components).
206. Takeoffs/Bill of Materials – the lighting control system vendor shall provide a Bill of Materials for review by the project team based on takeoffs prepared by the electrical contractor. Takeoffs (counting number of luminaires and other components such as sensors, switches, etc.) shall be created by the electrical contractor based on drawings and a walk-through of the existing space and submitted to the luminaire and lighting control system vendors to aid them in preparing Bills of Materials for the project.
207. Spares – the lighting control system vendor shall provide limited quantities of spare components for certain items. *[Specify which (e.g., LED drivers, on-board controllers, sensors, switches, etc.) and quantities or percentages of additional spares required.]*
208. Service plans – the lighting control system vendor shall provide a plan to cover on-going service of the lighting control system. *[Verify the availability and details of such plans with the manufacturer prior to placing a purchase order.]* These service plans might cover any or all of the following (or more): *[Keep items desired in a service plan and delete the others.]*
209. Troubleshooting – either during or after the warranty period ends. (See u. Technical Support for a more detailed discussion about troubleshooting considerations.)
210. Training – beyond what is provided immediately upon completion of system commissioning.
211. Software and firmware upgrades:
212. Manufacturer shall provide upgrades for system software and component firmware for a period of *[specify time period]* from the date of completion of the on-site commissioning process. It may be desirable to negotiate a longer period for receiving software and firmware upgrades as part of the initial system cost.
213. Lighting control system software is typically upgraded by the manufacturer by remotely accessing the server. Component firmware may be upgraded by remotely accessing the component, or directly via a USB drive and/or other external method. *[Verify the methods of upgrade with the manufacturer.]*
214. Recommissioning – changing or adding control zones, recalibrating sensors, adding any additional equipment or components, etc.
215. Warranties – vendors shall provide the following warranty periods from date of final acceptance:
	* 1. Luminaires – Ten (10) years.
		2. LED drivers – Five (5) years.
		3. Lighting control system – Five (5) years.