**6. Outdoor Lighting Controls and Adaptive Lighting Strategies**

The resources listed below discuss the use of lighting controls to reduce light levels (and energy use) during times of the night that are less active. Different types of technologies and systems are described. All links below are up-to-date as of January 2020.

California Energy Commission (CEC). (2015). Achieving Energy-Efficient Lighting in California. Appendix A: Adaptive Outdoor Lighting. Retrieved from <http://www.energy.ca.gov/2015publications/CEC-500-2015-085/CEC-500-2015-085-AP.pdf> This appendix shows ways that outdoor lighting controls can be used to reduce energy use.

California Energy Commission (CEC). (2017). Nonresidential Outdoor Lighting Controls – Final Report. Retrieved from <https://efiling.energy.ca.gov/> This report presents recommendations to support updates of California’s Building Energy Efficiency Standards (Title 24, Part 6) to include new requirements or to upgrade existing requirements. This report recommended that California require lighting power reductions of at least 75 percent when there is no activity detected for at least 15 minutes during after-hours periods.

California Lighting Technology Center (CLTC). (2014). Western Exterior Occupancy Survey for Exterior Adaptive Lighting Applications (Phase 2). Retrieved from <http://www.etcc-ca.com/sites/default/files/reports/westernexterioroccupancysurveyphase2_finalreport_20140806.pdf> Three west coast utilities (PG&E, Southern California Edison, and Bonneville Power Administration) collaborated to monitor energy-savings potential at eight outdoor lighting sites.

California Lighting Technology Center (CLTC). (2018, ongoing). Integrated Outdoor Lighting Solutions. Retrieved from <https://cltc.ucdavis.edu/publication/integrated-outdoor-lighting-solutions> CLTC created a testbed to evaluate performance and interoperability of smart lighting components from multiple manufacturers. Results expected to be posted in the future. Using Leotek luminaires, digital drivers, and Silver Spring’s Streetlight.Vision (SLV) Central Management System (CMS).

California Lighting Technology Center (CLTC). (Ongoing) Advanced Outdoor Lighting Control Systems. Retrieved from <https://cltc.ucdavis.edu/san-diego-gas-and-electric-streetlighting-project> In San Diego and Chula Vista, CA, additional savings from the use of dimming and scheduling are expected once those features are implemented.

California Public Utilities Commission (CPUC). (Ongoing). Database for Energy Efficient Resources (DEER). Retrieved from <https://www.cpuc.ca.gov/General.aspx?id=6755> DEER 2020 spreadsheet lists monthly “Coincident Demand Factor” comparing with and without motion sensors in parking lots and garages. These resources are available free-of-charge, but require a login and password that are also freely available. Follow instructions for DEER and PEAR.

DesignLights Consortium (DLC). (Ongoing). Qualified Product List. <https://www.designlights.org/> DLC establishes criteria for the Qualified Product List (QPL). North American electrical utilities offering lighting rebates typically require that commercial lighting and controls products meet QPL criteria. Lighting products meeting technical criteria are listed in the QPL searchable database. Using additional filters “System Scope: Exterior” and “Advanced Capabilities: Energy monitoring,” results in a list of parking area lighting systems with advanced lighting controls.

DiLouie, C. (2013). Exterior Lighting Control Strategies. Lighting Controls Association. Retrieved from <http://lightingcontrolsassociation.org/exterior-lighting-control-strategies/> Lighting control strategies are discussed for varying outdoor lighting applications and code compliance. The use of occupancy sensors and time clock control is described as being an essential element of energy-efficient and effective outdoor lighting and these technologies are described in some depth.

DiLouie, C. (2014). Outdoor Lighting Controls: The State of the Art. Lighting Controls Association. Retrieved from <http://lightingcontrolsassociation.org/outdoor-lighting-controls-the-state-of-the-art/> Over time outdoor lighting controls have become more sophisticated and technologically complex in response to new building energy efficiency codes as well as the controllability of new LED technology. This article explains some of the available outdoor lighting control technologies and outlines some of the potential benefits associated with integrating these options into new installations.

Lighting Controls Association (LCA). (Ongoing). Retrieved at <http://lightingcontrolsassociation.org/> LCA is part of the National Electrical Manufacturers Association (NEMA), dedicated to educating the professional building design, construction, and management communities about lighting control technology, application, and benefits. This website lists the latest lighting control products, training, research results, and industry standards.

Lighting Research Center and Taitem Engineering. (2017). Optimizing Solid State Lighting and Controls in New Low-Rise Affordable Housing. Retrieved from <https://www.nyserda.ny.gov/> This report shows the results from demonstrations at three low-rise residential sites in New York State. Demonstrations included sensor-controlled, bi-level wall pack and parking lot area lighting, in terms of energy efficiency and occupant satisfaction.

Lighting Research Center, Demonstration and Evaluation of Lighting Technologies and Applications (DELTA). (2019). Field Test DELTA Snapshots: Sensor-Controlled Bi-Level Lighting for Parking Lots. Retrieved from <https://www.lrc.rpi.edu/programs/DELTA/pdf/DELTA2019.pdf> This shows the results of a demonstration of sensor-controlled parking lot lighting in Seattle, WA. The researchers investigated impact of delay times, grouping, and dimming settings on energy savings and occupant acceptance.

National Lighting Product Information Program. (2010). Dynamic Outdoor Lighting. Retrieved from <https://www.lrc.rpi.edu/programs/nlpip/lightingAnswers/dynamicOutdoor/abstract.asp> This publication addresses strategies for implementing “dynamic” outdoor lighting installations, typical 2010 technologies, energy, environmental, and cost benefits, and potential liabilities and barriers. The applications discussed in this report include parking lots, parking garages, outdoor walkways, and streets, which are the most common places where dynamic outdoor lighting might be found.

Navigant Research. (2018). Smart Streetlighting. Retrievable from <https://www.navigantresearch.com/reports/navigant-research-leaderboard-smart-street-lighting> Navigant Research is a market research firm with expertise in energy. In 2018, Navigant analyzed control systems from 14 vendors of “smart” street lighting. Criteria included: vision; go-to-market strategy; partners; product strategy; geographic reach; market presence; sales, marketing, and distribution; product features and portfolio; product integration; and staying power. This report is available for purchase from Navigant’s website.

Northwest Energy Efficiency Alliance (NEEA). (2011). Technology and Market Assessment of Networked Outdoor Lighting Controls. Retrieved from <https://cltc.ucdavis.edu/sites/default/files/files/publication/2011_NEEA_Network_Outdoor_Controls_Report.pdf> Energy Solutions submitted report to NEEA analyzing several control systems for roadway and parking lot applications. Since publication, at least one system (Lumewave/Echelon) has been discontinued.

Rea, M. S., and Bullough, J. D. (2011). Intelligent Control of Roadway Lighting to Optimize Safety Benefits. In 14th International IEEE Conference on Intelligent Transportation Systems (ITSC). Retrieved from <https://ieeexplore.ieee.org/document/6082966> This shows two studies from the Lighting Research Center regarding roadway lighting. One estimated nighttime crash reduction associated with roadway intersection lighting systems, and the other characterized the visual performance benefits of these same lighting systems. These were used to produce a transfer function that enables roadway engineers to establish cost-effective control strategies for roadway lighting.

Shahzad et al. (2016.) “Energy-Efficient Intelligent Street Lighting System Using Traffic-Adaptive Control” IEEE Sensors Journal 16(13):1, July. Retrieved from <https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=7457604> The authors propose traffic-flow-based smart (LED) street lighting for energy optimization. The proposed system was implemented and tested in a real environment at Hanyang University in South Korea.

U.S. Department of Energy, Better Buildings Alliance. (2013). Exterior Lighting Control Guidance. <https://betterbuildingssolutioncenter.energy.gov/sites/default/files/attachments/exterior-lighting-control-guidance.pdf> This group created an exterior lighting control guide in 2013; at that time LED technology was just becoming a viable option in outdoor lighting.

U.S. Department of Energy, Gateway Program. (2009). Application Assessment of Bi-Level LED Parking Lot Lighting: Raley’s Grocery in West Sacramento, CA. Retrieved from <https://www1.eere.energy.gov/buildings/publications/pdfs/ssl/gateway_raleys.pdf> This publication shows sensor-controlled parking lot lighting, with aggregated energy savings results.

U.S. Department of Energy, Gateway Program. (2010). Demonstration Assessment of Light-Emitting Diode (LED) Parking Lot Lighting, Phase I: TJ Maxx in Manchester, NH. Retrieved from <https://www1.eere.energy.gov/buildings/publications/pdfs/ssl/gateway_tjmaxx.pdf> This publication shows sensor-controlled parking lot lighting, with aggregated energy savings results.

U.S. Department of Energy, Gateway Program. (2012). Use of Sensors in LED Parking Lot and Garage Applications: Early Experiences at Four Sites. Retrieved from <https://www1.eere.energy.gov/buildings/publications/pdfs/ssl/2012_gateway_sensors.pdf> Sites in Beaverton, OR and Rockville, MD are not covered other Gateway publications. Other publications, listed herein, focus on TJ Maxx store and Raley’s grocery store.

U.S. Department of Energy, Gateway Program. (2013). Demonstration Assessment of LED Parking Structure Lighting. Retrieved from <https://www1.eere.energy.gov/buildings/publications/pdfs/ssl/2013_gateway_dept-labor.pdf> Sensor-controlled lighting in parking structure, at Department of Labor in Washington, DC.

U.S. Department of Energy, Gateway Program. (2015). Exterior Lighting at Princeton University. Retrieved from <https://www.energy.gov/sites/prod/files/2015/10/f27/gateway_princeton-exterior_brief.pdf> Demonstration of sensor-controlled lighting in a pedestrian path, parking lots, and west parking garage in Princeton, NJ.

U.S. Department of Energy, Municipal Solid-State Street Lighting Consortium. (2014). Retrieved from <https://www.energy.gov/eere/ssl/model-specification-networked-outdoor-lighting-control-systems> Model specification for networked lighting control systems. This website states that MSSLC is no longer active, but existing technical resources continue to play a valuable role in guiding streetlight conversion projects.

U.S. Department of Energy. (Ongoing). Next Generation Lighting Systems (NGLS) Outdoor Evaluations. Retrieved from <https://www.energy.gov/eere/ssl/ngls-outdoor-evaluations> NGLS Testing at Virginia Tech Corporate Research Center began in summer 2019. Methodology was posted, and results are expected in coming years. Methodology criteria include minimum functionality checklist, presence detection performance criteria, control node performance criteria, and lighting performance criteria.

University of Illinois at Urbana-Champaign Facilities and Services (2014). Adaptive Bi-Level Lighting. Retrieved from <https://www.fs.illinois.edu/docs/default-source/News-Docs/adaptive-bi-level-lighting.pdf> This one-page project summary gives an overview of a project to install bi-level lighting at a parking lot.