REALTERM ENERGY

Control More Than Your Light Levels: How Lighting Controls Provide Utilities with a Great Opportunity to Lower Maintenance and Operating Costs While Increasing Service Levels

WHITE PAPER

This White Paper provides a summary of the numerous benefits of adaptive controls, an overview of current industry norms and some advice on how to overcome the obstacles common to this type of technology, such as networking complexity and lack of standardization.

ADAPTIVE CONTROLS WHITE PAPER

Utilities, whether co-operative, municipally owned or investor-owned, are facing many simultaneous challenges to their existing business model. Energy retailers, digital startups, renewable energy generators, net metering schemes, prosumers, active regulators and engaged shareholders are all demanding changes to the status quo. Having to respond to flatter growth profiles, more distributed energy resources (DERs), smart grids, digitization, decarbonization, grid resilience, new regulatory mandates, taxation changes, aging assets, a more demanding customer base, plus the need to tackle succession planning and other human resource issues is proving incredibly demanding. Often struggling just to tread water, many utilities are tackling the problematic elements of their distribution and transmission infrastructure, but are not taking the time to properly assess and prioritize alternatives or potential cost-saving measures. However, the economic, social and political changes are all occurring at the same time as numerous technological developments that offer many new ways for utilities to offer services. RealTerm Energy is very bullish on the utility sector, as we believe open-minded utilities are well positioned to evolve from primarily one-way deliverers of power to two-way, networked generators, distributors and managers of electricity and electrical services. We have also witnessed how utilities benefit from taking a strategic overview of existing practices and how installing adaptive controls on streetlight networks pays off in many ways over the medium and long terms.

Adaptive lighting controls can provide real value in terms of reductions in energy consumption and greenhouse gas (GHG) emissions, remote monitoring with real-time data collection, improved asset management and improved public safety. This White Paper will itemize these numerous benefits, overview current industry norms and provide some advice on how to overcome the challenges to obstacles common to this type of somewhat new technology.

Street and parking lights are typically powered at a constant level throughout the night. Over time, light levels decrease due to dirt accumulation, luminaire age and failures. The result is inferior lighting using more power. Lighting controls get to the heart of this energy waste by enabling owners to adjust to appropriate conditions (including ambient light and road conditions), set schedules and monitor their system in real time.

BENEFITS OF AN LED UPGRADE

Outdoor area lighting is a major contributor to energy use and offers both utilities and municipalities a major opportunity to reduce their energy consumption and operating costs in a very publicly visible manner. While some owners have installed adaptive controls on High-Pressure Sodium (HPS) streetlights, the majority have taken the opportunity to simultaneously upgrade to LED lighting. LEDs are especially well suited to controls because they are dimmable, rapidly turn on to full illumination and do not decrease in service life from frequent ON and OFF operations.

LED streetlights offer greater energy efficiency to luminaires using HPS lamps, a wide range of possible CCTs, better luminous intensity distributions, more effective light distribution (less annoying uplight and backlight) and color rendering that improves public safety and security. Existing LED streetlight installations have demonstrated the following quantifiable benefits: 40%–70% decrease in energy consumption, high CRI (70-80s), 40%–70% reduction in maintenance requirements and additional energy savings of upwards of 20% with adaptive controls (DOE, *A Look at Area Lighting* and LSNetwork, *Building Intelligent Communities).*

For some specific real-world examples, see the DOE's Gateway Outdoor Projects page https://energy.gov/eere/ssl/gateway-outdoor-projects and RealTerm Energy's case studies http://www.realtermenergy.com/en/led-lighting-solutions/case-studies.aspx.

COMMON SETUP AND FEATURES

Before getting into the functionality of a typical system, it's helpful to first define what is meant by the term "adaptive controls." The DOE refers to an adaptive lighting system as one that "automatically adjusts the light output based on sensor input from the space they serve to optimize performance" (*Adaptive Street Lighting Controls* webinar, 2013). A typical system is composed of the following four distinct elements:

- **Central management system (CMS):** the computer core platform that provides all shared system services to include consolidation and storage of all system data. The CMS includes the user interface that allows you to view data, set schedules, run reports, etc.

- **Field devices:** the networked components (hardware and embedded software) installed in the field that function together to adaptively control and remotely monitor luminaires. Controllers execute lighting changes at the luminaire while gateways connect two communication networks that use different protocols, translating from a wireless field device protocol to a standardized wide area network (WAN) protocol, which is typically either Wi-Fi, Ethernet or cellular.

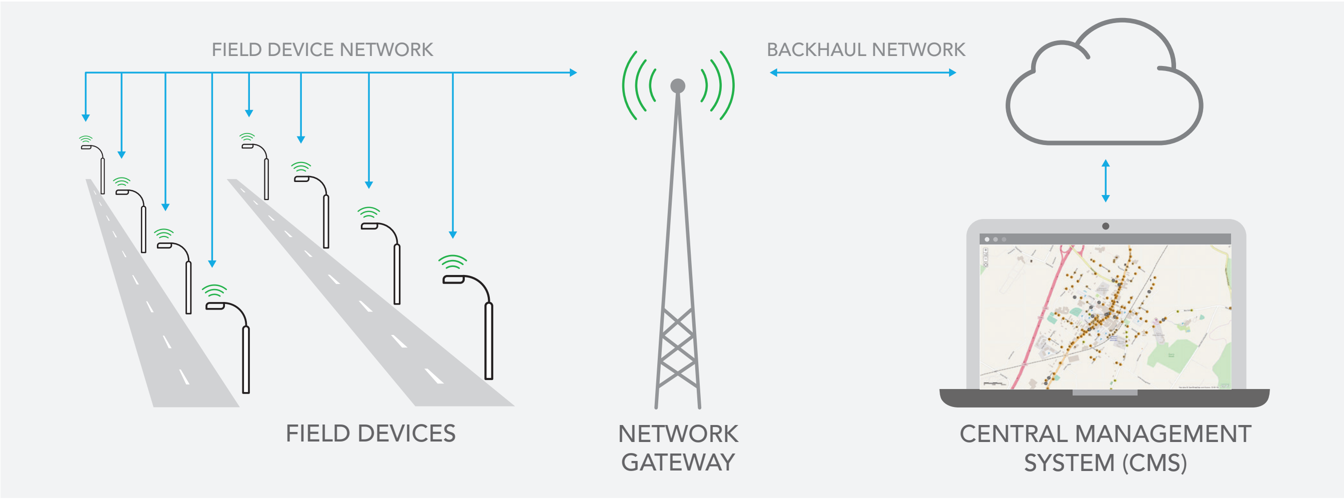
- **Field device network:** normally a local network that connects and allows communication between field devices. There are a wide range of communication options with many different protocol options.

- **Backhaul network:** in most cases, a wired or wireless wide area network (WAN) that connects and enables communication between one or more field device networks to the CMS, typically through a gateway that acts as the aggregation point for numerous field devices.

Ideally, these components are all interchangeable, interoperable and scalable to ensure maximum functionality and fewer problems (more on this below). This combination of components allows users to manage, monitor and measure their lighting system.

Adaptive controls allow for dimming over the full range supported by the driver. Scheduling can be time-based (dimming during low traffic hours) or event-based, depending on whether users would like a set schedule or more responsive management, which can take into account varying ambient light levels, weather patterns, traffic patterns or other quantifiable measures. Some users also apply a long-term management strategy whereby adaptive controls reduce the power supplied at the beginning of the luminaire life and increase it over time to counteract lumen and/or dirt depreciation. On the other end of the spectrum, some systems provide integrated sensors that respond to usage variation through active monitoring or scheduled usage patterns based on predictive algorithms. Adaptive controls can also monitor a variety of power and luminaire parameters, including current, voltage, power factor, lamp burn hours, network communication failures, as well as other potential failure events. Alarms can be sent to the appropriate user(s) once a measure reaches the target level and are generally recorded and stored at the central server for later use, such as issuing a work order. Additional common measurements include scheduling records, such as the start/stop time and dimming level (%), and most CMSs provide user-friendly data visualization with accurate maps and charts.

STREET LIGHTING MANAGEMENT SOLUTION ARCHITECTURE



PROPER DESIGN REQUIRED

Standard lighting technologies are usually designed with reference to standardized design practices whereas adaptive controls move the user beyond business as usual. A higher level of care but also preparation is required, since "adaptive lighting is about managing a lighting level as an asset rather than just managing luminaires and poles" (Gibbons and Bhagavathula). Robust photometric design is recommended for lighting systems that include adaptive controls because designers will need to incorporate a range of illumination required over time that may or may not include varying ambient light at different times of day and numerous traffic patterns (pedestrian, cyclist and vehicle). The IES recognizes this challenge and states that while designers can adjust dimming for changing pedestrian levels and roadway classifications, "the installation shall continue to meet the required uniformity ratio and veiling luminance ratio given in this recommended practice" (RP-8-14, p. 18).

VALUE PROPOSITION

Adaptive controls provide value for systems owners via reductions in energy consumption and greenhouse gas (GHG) emissions, reduced maintenance costs, improved asset management, improved public safety, plus numerous emerging opportunities.

REDUCED ENERGY CONSUMPTION

Whether a long-term or more adaptive dimming approach is utilized, adaptive controls enable users to match light levels to desired usage, resulting in savings of 20%–40%. The reduction in energy usage may or may not result in a corresponding reduction in energy costs for municipalities, depending upon the billing system and/or tariff deployed by the utility in question. For utilities, dimming is eligible for conservation and demand response programs in certain jurisdictions, since the case can be made for GHG avoidance.

REDUCED MAINTENANCE COSTS

Operating streetlight luminaires in a less intensive manner will increase the asset's lifespan, resulting in lower maintenance costs and an overall longer timeline for which to finance the project. There are additional maintenance savings for whomever maintains the network as well, since the control system's asset management capability saves crews time and money by empowering them to rapidly locate the asset and ensure they have the right equipment on the truck for the first visit. This will eliminate the practices of night patrols and/or having to maintain an outage hotline. Utilities may also be interested in converting alarm data into digital work orders, eliminating slow and expensive manual processes, and enabling direct communication with workers already in the field and uploads of job status updates. Quicker repairs and efficiently scheduled maintenance win big with management and citizens alike.

IMPROVED ASSET MANAGEMENT

In addition to prolonged service life and improved customer satisfaction, adaptive control systems usually enable owners to create a rich asset database that integrates with GIS mapping software. Adaptive controls can also help with inventory management by reducing the number of different fixtures required, since wattage can be dialed up or down as required. Integrated GPS receivers in the field devices allow for better tracking of field assets.

IMPROVED PUBLIC SAFETY

While the research in this area is still developing, early reports indicate that drivers and pedestrians like the improved visibility of the accompanied LED upgrade and have not really noticed the effects of dimming. Some owners have also enhanced the perception of public safety by ramping up light levels in areas of time-limited increased pedestrian activity (e.g., when bars close, events finish in stadiums) or enabling motion sensors to respond automatically (e.g., along pathways, campuses, parking lots).

EMERGING OPPORTUNITIES

The plethora of IOT and smart city devices now available and in development are rapidly transforming a streetlight pole from a nuisance piece of infrastructure to very valuable, electrified vertical real estate. The data and related services made available by these digital sensors can often partly or fully offset the incremental cost of the adaptive control network. Related smart city services can include, but are certainly not limited to, the following: citizen engagement, environmental (particulate matter, UVA/UVB, pollen, oxygen and carbon dioxide), weather (ambient and ground temperature, wind, humidity, precipitation), seismic activity, audio and video monitoring, parking availability, interactive billboards, traffic management, road maintenance (snow removal and salt optimization), mini-cell and Wi-Fi. While the range and complexity of potential services are too numerous to go into detail here, it is strongly recommended that those considering adaptive controls leverage the installation process to also include relevant smart city services.

CHALLENGES

Like any evolving technology that serves to connect and operate other existing technologies, adaptive controls are not without their challenges. The primary challenges can be grouped categorically as compatibility (interoperability and interchangeability), security and regulatory issues.

COMPATIBILITY

Control devices need a common communication protocol and not one that is locked up in a proprietary data model. Interoperability "unlocks the data in a system by allowing it to be communicated to and used by other systems, analyzed by other applications and managed or archived in other ways, thereby enabling true ownership," (Gaidon, p. iii). Vendors often downplay the complexities involved in making the different components and software systems talk to one another, and effort and integration work are required to ensure API architectures and information models communicate readily. The goal is for all hardware and software to be interoperable to ensure different devices, applications, networks and systems work together. This protects systems owners from manufacturer obsolescence and being a victim to a monopoly while permitting greater data exchange and promoting service-based architecture. Similarly, devices and networks should also be interchangeable with each other and provide a defined level of identical operation without additional configuration to prevent the same problems from occurring. The DOE and the National Transportation Communications for ITS Protocol (NTCIP) are both working on supports and design standards for interoperability and interchangeability.

SECURITY

Security should be a serious consideration for the deployment of any adaptive control system and should be evaluated at every level of the system to include local network, backhaul communication and CMS data storage. Device level network should encrypt data packets using AES-128 encryptions at a minimum. Backhaul communications typically use standard IP security and encryption standards that are common in the networking world. Data storage for the CMS should also utilize both physical and cloud security measures. Many control companies host their CMS on AWS or Azure servers, enabling them to provide Level 1 security measures. Please note that many AMI companies have compatible lighting controllers that can be integrated into an existing or future AMI network. This serves to leverage the same security measures used by the AMI system and provides the added benefits of densifying the mesh network and reducing the number of different networks that need to be maintained.

REGULATORY

The crux of the issue is that a control device is not recognized as a metering device. Existing metering standards are not applicable and most existing utility infrastructure does not support data provided by control devices. There is currently a gap, although it is rapidly narrowing, between the level of accuracy required by a metering device and that provided by most controls. However, several utilities are currently working on this issue, the technology continues to evolve and NEMA is working on a revenue grade energy measurement device standard that will bring clarity to the matter. A related but more straightforward issue for municipal systems owners is that controls will also require new utility tariff(s) to ensure the benefits of dimming are recognized on the bill.

MAKING THE BUSINESS CASE

Like any other tangible physical asset, owners should examine the lifecycle costs (LCC) or the total cost of ownership (TCO) for each control option explored, which means creating a detailed cash flow analysis with net present value (NPV). NPV indicates the total net benefit of each option over time in today's monetary terms and should include a discount rate for inflation and an annual increase in energy and maintenance costs. Factors to be included are the installation cost, projected reduction in energy costs, expected decrease in maintenance costs, anticipated life of the equipment, software or connectivity costs and any available incentives. California's Speed Program, LSNetwork and the DOE's Municipal Solid-State Street Lighting Consortium (MSSLC) all have very helpful guidance on how to plan for and procure adaptive controls. See RealTerm Energy's White Paper *Death by a Thousand Specs* on how to use lifecycle costing, value-based scoring and more consultative processes in streetlight procurement: http://www.realtermenergy.com/media/website_document.file/WhitePaper-RTE-Value-Based-RFPs.pdf.

The MSSLC's *Model Specification for Networked Outdoor Lighting Control Systems* is a living document that includes tips for drafting requests for qualifications (RFQs), requests for information (RFIs) and requests for proposals (RFPs) for lighting control systems. Similarly, the Illuminating Engineering Society of North America (IESNA)'s *Design Guide for the Selection, Installation, Operations and Maintenance of Roadway Lighting Control Systems* (DG-28-15) and the DesignLights Consortium (DLC)'s *Networked Lighting Controls Specification* should be consulted for the latest technology developments and standards.

REFERENCES

California's State Partnership for Energy Efficient Demonstrations (SPEED) Program. ***Adaptive LED street & area lighting: Selecting, financing and implementing best-practice solutions***, www.partnershipdemonstrations.org.

Department of Energy (DOE) SSL Program. ***Adaptive Street Lighting Controls***, webinar presentation, June 11, 2013, https://energy.gov/eere/ssl/adaptive-street-lighting-controls.

Department of Energy (DOE) SSL Program. ***Connected Lighting Systems Meetings Report***, October 12, 2016, https://energy.gov/sites/prod/files/2016/10/f33/cls-report_oct2016.pdf.

Department of Energy (DOE) Municipal Solid-State Street Lighting Consortium. ***Model Specification for Networked Outdoor Lighting Control Systems***, https://energy.gov/eere/ssl/model-specification-networked-outdoor-lighting-control-systems.

Department of Energy (DOE) SSL Postings. ***Get the Facts: LED Street Lighting***, June 21, 2016, https://energy.gov/eere/ssl/articles/get-facts-led-street-lighting.

Department of Energy (DOE) SSL Postings. ***LED Outdoor Area Lighting***, October 18, 2016, https://energy.gov/sites/prod/files/2016/10/f33/postings_10-18-16.pdf.

Department of Energy (DOE) SSL Postings. ***A Look at Outdoor Lighting***, October 11, 2017, https://energy.gov/sites/prod/files/2017/10/f37/postings_10-11-17.pdf.

DesignLights Consortium (DLC). ***Networked Lighting Controls Specification***, https://www.designlights.org/workplan/networked-lighting-controls-specification/.

Marinoa, Francesco, Leccesea, Fabio and Pizzutib, Stefano. ***Adaptive street lighting predictive control***, *Energy Procedia* 111(2017), 790–799. 8th International Conference on Sustainability in Energy and Buildings, SEB-16, September 11–13, 2016, Turin, Italy.

Gaidon, Clement and Poplawski, Michael. ***Connected Lighting System Interoperability Study, Part 1: Application Programming for Solid-State Lighting Program***, prepared by the Pacific Northwest National Laboratory for the Building Technologies Office, Energy Efficiency and Renewable Energy, U.S. Department of Energy, October 2017.

Gibbons, Ronald and Bhagavathula, Rajaram. ***Looking for 'Just Right' in Roadway Lighting***, https://www.ies.org/lda/looking-for-just-right-in-roadway-lighting/.

Illuminating Engineering Society (IES). ***Roadway Lighting Recommended Practice***, (RP-8-14), 2014.

Illuminating Engineering Society (IES). ***Design Guide for the Selection, Installation, Operations and Maintenance of Roadway Lighting Control Systems*** (DG-28-15) 2015, https://www.ies.org/store/design-guides/selection-installation-operations-and-maintenance-of-roadway-lighting-control-systems/.

LSNetwork. ***Building Intelligent Communities with Advanced Streetlighting***, February 2017.

LSNetwork Canada. ***Adaptive Controls for Roadway and Parking Lighting***, July 2015.

Lonmark International. ***Open Streetlight Control System for Smarter Cities: Market, Challenges, Solutions and Next Steps***. August 2014, www.lonmark.org.

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