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Street Lights Meet Internet of Things
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Introduction

The Internet of Things (IoT) is pervasive and revolutionizing how we live, travel and work. In kitchen appliances, IoT is improving food freshness and easing meal preparation. IoT is used in sensors and cameras in Advanced Driver Assistance Systems (ADAS) helping motorists to avoid crashes or running off the road. IoT is at the retail checkout stand and in machines that talk to other machines (M2M) on assembly lines. It is worn on our bodies providing us with vital health information like heart rate, distance walked and calories burned.

The power of IoT is also seen in government, in building automation and services like public safety, water supply and traffic signal timing. However, there is one government asset that holds tremendous potential for delivering a broad spectrum of IoT services more effectively and efficiently, and is completely underutilized; it is the **street light**. This municipal asset is extremely well positioned, evenly spaced and fed with continuous electrical power to accommodate IoT applications. Street lights exist on almost every street and intersection, illuminating sidewalks, traffic lanes, parking spaces and crosswalks. As governments convert to Light-Emitting-Diode (LED) street lights, the light source becomes even more valuable as it serves as a semi-conductor instead of a filament. This technology opens tremendous opportunities to add a wide range of IoT sensors and detectors wirelessly connected to each other and other networks that can be monitored and controlled remotely.

This paper will address the following:

- why street lights hold so much potential for local governments to vastly improve delivery of services and quality of life
- what is preventing government policy-makers and managers from investing in LED lighting improvements and IoT applications
- why investor owned utilities (IOUs) should embrace networked lighting and IoT, and how to assist governments to install smart lighting systems

Why street lights hold so much potential for local governments

There are approximately 58 million street and highway lights in the U.S. Adding IoT to them in strategic locations can add significant value beyond just increased energy savings; it can reduce time, human resources and equipment in the delivery of a wide range of services such as public safety, climate protection and traffic management. The University of California, Davis serves as good example. The California Lighting and Technology Center (CLTC) collaborated with the university police to convert from high pressure sodium (HPS) outdoor campus lighting to a networked LED system with occupancy sensors. The end result is a safer campus with higher quality light, an 89% reduction in energy use and a savings of about $125,000 per year in electricity and maintenance costs that can go to other needs.

However, it is not so easy for government agencies to convert from existing light sources to LED technology. IOUs, who control the rate structure for most of the street lights in the nation, have been slow, and in some cases very resistant to change billing schedules to allow LED use, or to authorize additional electric loads needed for IoT sensors and devices (often referred to by the utility as ***parasitic*** or ***non-conforming loads***). The dilemma is:

How then can governments achieve IoT on street light systems if utilities continue to restrict <u>when</u> and <u>how</u> the electrical power can be used?

Most IOUs are slow to convert their company-owned lights to LED

Street lights in cities and counties are either owned by the customer (local government) or the company (utility). There are many different models in place which determines which agency performs maintenance and repairs. Generally though, local governments pay for power only on the lights they own, and they pay for both power and maintenance for the lights and poles they lease from the utility. Being that sodium-based lights burn more power and have shorter life expectancies than LED lights, it is not surprising that local governments are converting to higher quality and less costly lighting solutions on customer-owned lights than IOUs are on company-owned lights.

In California, State Assembly Member Roger Hernandez (48th District near Los Angeles) introduced Assembly Bill 719[9] requiring electrical corporations (IOUs) to replace low-efficiency light bulbs with high-efficiency light bulbs on street light poles that the corporations own. His analysis showed that at the time he introduced the bill, of the 653,209 streetlights that Southern California Edison owned and operated on behalf of cities and towns, only 16 lights had been replaced with energy efficient lights. This almost non-existent conversion rate was similar with the State's two other IOUs (SDG&E and PG&E). Hernandez was quoted saying:

"Our streetlights are neglected public facilities that are operating on outdated energy technology with cities footing the higher energy costs associated with this old technology. Corporate utilities that stand by without making energy efficiency retrofits, profit from the status quo when more energy is consumed by their customers, at the expense of the tax payers and the environment".[10]

AB-719 was signed into law by Governor Brown on October 07, 2013 and the effect is already noticeable. On August 14, 2014 the California Public Utilities Commission (CPUC) approved PG&Es 2014-16 rate case request calling for the expenditure of over $18M to convert all of PG&E's company-owned HPS lights to LED. PG&E's funding request did **not** add in costs for smart, controlled LED lighting which could further improve energy savings for its customers, be less impacting on the environment and reduce maintenance expenditures through wireless monitoring. The hope is that as more IOUs across North America convert their company-owned lights to LED, they will incorporate controls and IoT as part of their corporate mission.

What is preventing government policy-makers from investing in LED lighting improvements?

What do cities want to do with their street lights?

Cities want the ability to decide to leave a street light on, dim it, turn it off, be notified of a malfunction or possibly attach other sensors and devices to it. Traffic managers, particularly those working in congested metro-regions, would like the freedom to utilize street light circuits to install a camera on a

light pole to observe traffic flows and then perform signal timing adjustments. Police departments want to place high resolution cameras to help solve a child abduction case. Local business associations would like to string holiday lights or dynamic advertising signs. Parking lot operators would like to display space availability to approaching motorists. These are just a few civic services that could occur on a streetlight pole (or within the streetlight head), but they cannot become a reality unless IOU policy-makers change the way their corporations bill for streetlight electricity. Below are examples of language that is typical in streetlight billing schedules that restricts local governments from deploying modern, integrated IoT solutions:

- San Diego Gas & Electric—LS-2, Section 12. Lamp Loads: "All fixtures that include the **capability of adjustable lamp wattage** will be billed at the **maximum wattage** setting to calculate the lamp load."[2]

- Pacific Gas & Electric—LS-2, Service Installation, f. Non-Conforming Load: **"**Any load, other than the lighting loads listed in the rate table, is a **non-conforming load**."[3]

- Kansas City Power & Light—Schedule ML "Lamps **shall** be controlled with a photo-electric cell or other positive controlled device which **restricts service to non-daylight hours**.[4]

It is hard for government policy-makers and managers to consolidate services and be innovative when they must work around regulations like those above. In all fairness to the IOUs, the language has been on the books for decades, and it was written to limit the times and the use of electrical power to strictly nighttime lighting. But just as the cellular phone has revolutionized our daily lives—first as a mobile phone, then an office assistant, now a camera and tomorrow our wallet—streetlights are now in the cross hairs of LED, software, hardware, controls and communications companies for revolutionary change. This intersection of street lights and IoT, and the necessity to streamline and modernize public services will be the key drivers for badly needed change in utility street light schedules and billing structures. The end result of these changes should be:

"utilities will be fairly compensated for the electricity they sell and governments will not be restricted to <u>how</u> or <u>when</u> they use the electrical service as long as it is within the total allowable electrical load on the circuit".[5]

Some cities are proactively working with their utilities to test IoT on customer-owned lights

In San Diego, California the City has converted about 3,000 of its decorative Gaslamp Business District lights to networked LED lights. Surveys taken by the City of merchants and pedestrians using the streets at night has been overwhelmingly positive. The City wants to remain at the forefront of California public agencies which have decided to install energy efficient and controllable lighting systems. San Diego is now in the process of seeking approval from its IOU, San Diego Gas & Electric (SDG&E) to install and test 300 cobra-head style LED lights with wireless controls. SDG&E presented an Advice Letter 2665-E on behalf of San Diego to the CPUC on November 10, 2014.[11] At the time of this writing, the City and SDG&E are currently in the process of determining the final provisions and performance requirements for the test.

In Mississauga, Ontario, Canada, Enersource Hydro (municipal utility) and the City of Mississauga are working jointly to convert 49,000 streetlights from HPS to networked, smart LED lights communicating to the City and Utility through a mesh-network wireless system and series of gateways. The City is ultimately responsible for the operation and maintenance of the light systems. Policy development and

administration are undertaken by City staff, and design, operation and maintenance is contracted to Enersource Hydro. The conversion is over 90% complete and both the City and Enersource speak highly of its success in reducing electricity and maintenance costs and improved quality of light.[12]

Florida Power & Light (FPL) and Silver Spring Networks wireless metering company jointly announced in February of 2015 that FPL will install Silver Spring Networks' smart wireless meters on 500,000 existing streetlights in 35 counties across Florida, in what is believed to be the largest conversion of existing lights to networked lights in the United States.[13]

San Jose, California is recognized as a national leader in the testing and adoption of smart, networked lighting. The City Council Policy on Lighting 4-2, first adopted in 2008[14] calls for all new lighting to be smart, networked solid-state lighting. By the end of 2015, the City will have converted about 20,000 of its 62,000 lights to networked, LED lighting taking advantage of a loan from Opterra Energy Systems that will be paid back through a bundled energy savings program of LED lights, automated buildings and installation of solar panels at City facilities. The City and PG&E have been officially testing networked lighting systems since 2008, and in 2011 PG&E submitted an Advice Letter[15] to the CPUC and won its approval for a pilot to allow the City to pay for only the power consumed through the use of smart energy metering chips in the streetlight heads. On February 06, 2015, San Jose City Council unanimously approved the installation of 50 *SmartPoles* by Philips Lighting containing wireless small-cell cellular equipment within the pole.[16] The new LED street lights and cellular equipment in the *SmartPoles* will utilize wireless metering to improve cell phone reception and enable the City to demonstrate other IoT applications, such as traffic and weather sensors or networked electric vehicle chargers.

Why Investor Owned Utilities should embrace networked lighting and IoT

Renewable energy and LEDs are disruptive to IOUs

Investor Owned Utilities have seen dramatic drops in power consumption by local governments over the last decade, whether in buildings, parking lots or at traffic signals. Every time another solar panel appears on the roof of a building or over a parking lot, the result is an incremental ongoing loss of revenue to an IOU. Prior to LEDs, traffic signals utilized incandescent light bulbs in signal heads rated as high as 150 watts. In 2006, it was reported in San Jose, California that after conversion to LED signal indications, annual energy consumption dropped from about 15.1 million kWh to just over 1.3 million kWh, a decrease of over 90% and annual energy bill savings of nearly $1.7 million.[6]

IOUs are "for profit" corporations. Thus the response when energy consumption goes down or the user-base shrinks is to take actions to discourage further losses of energy consumption (*revenue*) from its remaining customer base, improve its internal efficiencies to save money and raise electrical rates as needed to meet the mission and objectives of the corporation and its investors.

IoT, fuel cells, LEDs, lithium battery storage systems, renewable energy systems, and other technological advancements will continue to disrupt traditional thinking and outdated physical and business models in IOUs. Competitors, such as Community Choice Aggregations[7] (CCA) will continue to take customers away from the IOUs by offering cleaner, locally produced electricity.

The IOUs should learn from history by what happened to the railroad industry in the early 1900s. The need for more mobility and freight transportation was in high demand! Yet, the railroad companies let others fill the need (cars, trucks, airplanes, even the telephone). They let others take customers away from them because they considered themselves to be in the ***railroad*** business rather than in the

transportation business. Theodore Levitt, describes why the railroad companies or other seasoned growth industries stop growing or go into decline in his acclaimed work Marketing Myopia[8] in the 1960 Harvard Business Review:

"Every major industry was once a growth industry. But some that are now riding a wave of growth enthusiasm are very much in the shadow of decline. Others which are thought of as seasoned growth industries have stopped growing. In every case the reason growth is threatened, slowed, or stopped is not because the market is saturated. It is because there has been a failure of management."

Applying this to the IOU situation, local governments will not stop seeking to continuously modernize, improve and lower the cost of their services. They understand they must do so to respond to key drivers like public safety, an aging population, migration of people to urban centers, poor air quality, extreme weather events and rapid expansion of wireless computing devices, just to name a few. IoT providers will not stop offering local governments cost effective, integrated and interoperable technology solutions. Utilities can, and must help governments achieve success with IoT. IOUs can do this by being less product- and rule-oriented, and more results- and customer-oriented. Below is one example:

Pedestrian safety in school zones as an example

Traffic managers are routinely asked by school officials and parents to make it safer for kids to walk to school. The safety need is greatest during school hours; coincidentally, this is also the time when the electricity is **not** being used by a streetlight. Because of the restrictions currently in place on how street light circuits can be used by utility customers, local governments teamed with sign manufactures to find an alternative solution to address child safety during school hours. They worked together to install LED speed-feedback signs on existing light poles and power them with solar panels and batteries since the electricity servicing a streetlight could not be used. They got innovative! They **avoided** the utility company all together by using solar panels and batteries to power the device.

While this type of solution costs a city more to purchase than a grid-powered sign, a school safety solution that would have taken months to go through the utility approval and permitting processes, now takes a matter of days to install and activate by avoiding the IOU. This scenario of removing the IOU from the equation is common and without change, utility companies will continue to lose customers and the opportunity to sell readily available electricity on existing streetlight circuits.

The photo taken in San Jose, California by the author illustrates the case (note the wooden utility pole located within feet of the solar-powered traffic safety device). Hundreds of thousands of these speed feedback signs are now in place across North America and few use grid power for the reasons described. Like the railroads, if IOUs thought of themselves as being in the ***power selling*** business, rather than in the ***streetlight*** business, this might not have been the case.

IOUs hold the keys to IoT applications in municipal street light systems

IOUs are deploying smart, wireless utility meters throughout North America. Brian Rich, VP of Information Technology at PG&E states:

"PG&Es SmartMeter Program is enabling us to create a comprehensive and open smart grid ecosystem with full integrated and interoperable intelligent devices. Whether through smart meters or in-home networking applications, our goal is to leverage smart grid technologies to serve our customers better with enhanced choice and control."[17]

IOUs are working to save costs and reduce their carbon-footprint through the use of smart meters. They should support the use of smart meter technology in street light heads similar to the same technology used in electric, gas and water meters throughout their territories. They are allowing private customers to track near real-time energy use over the internet, and make decisions on how much energy they choose to use and when to use it. The same monitoring and controls, and freedom to decide should be afforded to their public customers.

For decades, IOUs have relied on ambient light-based photo-cells to activate lights and estimate the number of hours that municipal street light systems would be operational. Photo-cells have done a fairly good job of turning lights on and off, but one would be hard-pressed to say they are within 1% or even 10% of accurately measuring how much electricity is consumed by street lights. For reasons such as dust, dirt, fog, smog, tree limbs, birds, etc., photo-cells are subject to wide operational variations and failures. In some cases it has been reported that photo-cell malfunctions account for nearly 20% of maintenance calls to street lights. The time to change from this outdated technology to advanced lighting control systems is now.

Summary

California Assembly Member Hernandez said it well: "Generally it is the entity paying the energy bill that has a motivation to reduce energy consumption. Utilities lack an incentive, particularly for IOUs, to pursue street light efficiency improvements".[10]

Government agencies, utility companies and technology companies need to collaborate to create a win-win-win situation to support advanced lighting controls and IoT on customer-owned and utility-owned street light systems:

- Government leaders should adopt policies and code changes that call for advanced street lighting systems that support agency goals through integration of other devices and networks. They should involve agency heads such as the Police Chief, IT Director, Traffic Engineer, Sustainability Officer and Parking Manager to determine desired IoT applications on secure, future-proof networked lighting systems prior to procurement.
- Utilities, particularly IOUs need to collaborate with local governments and technology companies to develop **NEW** hybrid street lighting and IoT schedules and rate structures. They should actively seek regulatory approvals that allow smart wireless energy meters in street lights and other devices on poles and authorizes government agencies to physically or wirelessly connect a range of devices on street light circuits and be billed for time-of-use energy consumption.
- Technology and communications companies need to partner with LED and lighting manufacturers, government agencies and utilities to develop an open, secure, scalable and standard lighting platform that enables enterprise-wide IoT solutions and leverages the streetlight to sense traffic, occupancy, environmental conditions and safety, that addresses government agencies' most challenging problems.

By working together, we all benefit when: **Street Lights Meet Internet of Things**.

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