# Smart city initiatives: Street lights

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## Abstract
In the near future, smart city technologies could play a fundamental role in urban sustainable development; economically, socially, and environmentally. Smart cities bring new ways to generate important revenue for cities, wealth for citizens, information for society, and efficiency for businesses and government. As energy prices and concern over climate change have increased, cities have been proactive in exploring 'smart' ways to reduce energy (heat and electricity) consumption, public and private alike. Street lighting, which is supported through the local budget, is one of the main expenses related to public electricity consumption. A relatively new method that has been implemented to reduce electricity expenditures has been to replace conventional street lights with LED based street lights in order to save energy. These new type of street lights are also low-maintenance, making for a more environmentally and economically friendly configuration. They can be programmed to be dimmed to a lower level if there is no vehicle or pedestrian traffic and have the power increased as traffic is sensed. This paper explores only the benefits of switching from incandescent street lights to LED based street lamps. Specifically, it shows the cost savings and greenhouse gas savings from switching from the incandescent lights to the LED lamps.

**Keywords:** smart street lights, LED lights, digital age

## 1. Introduction
There are multiple definitions of a Smart City. However, according to Giffinger, et al. (2007) a smart city has six characteristics: a smart economy, smart mobility, a smart environment, smart people, smart living, and a smart government. This paper uses this definition when referring to a Smart City. Smart City technologies are expected to be important for sustainable economic development of cities. Smart City technology promises to provide answers to urban challenges such as transportation, public safety, the environment, and energy. In particular, cities will face four major challenges over the next fifty years: urban population growth, population aging, environmental changes, and governance (Cohen, et al., 2008). The technology, using a combination of sensors, data, and analytics, will help increase information flows, reduce costs, and improve efficiency for local governments. Furthermore, Smart Cities are vital for generating revenue, knowledge, and diversity in cities (Castro, Jara, and Skarmeta, 2013). As a result, billions of dollars are being invested by cities and governments around the world.

The first sustainability goal for cities to achieve is arguably a reduction in energy consumption and greenhouse gas (GHG) emissions (Castro, Jara, and Skarmeta, 2013). To achieve this goal, a foundation for communications must be developed. As such, machine to machine communications are required and can be created by cities through Smart Lighting.

General Electric (GE) was founded by Thomas Edison in 1892 by Edison Electric Light Company and Thomson-Houston Electric Company with headquarters in Schenectady, New York State. More than 50 years ago, the LED (light-emitting diode) technology was invented by Dr. Nick Holonyak, Jr., a researcher at GE. Today, LED bulbs represent a possible solution for street lighting improvement. Smart LED lights can be mounted with smart objects that can transmit data that can be used for analysis to manage street maintenance, water and gas leak detection, crime prevention, traffic management, and environmental conditions. Since energy consumption for cities is very large and expensive, estimates put public lighting at a minimum of 10% of the total electrical energy consumer categories (Andrei, et al., 2009). As a result, there is considerable attention put towards reducing the energy consumption of street lighting.

The rest of the paper presents as an example, for historical reasons, the case of Schenectady. The potential economic benefits of switching from street lights to street LED lamps are examined; specifically, the costs savings recorded by switching from incandescent lamps to LED lamps.

**2. Switching to smart lighting in Schenectady, New York State**

The City of Schenectady in Upstate New York in the United States has a population of approximately 65,000 people. Currently, Schenectady has more than 4,600 traditional high-intensity discharge lamps, throughout the city. Schenectady is planning on replacing all the high-intensity discharge lamps with new, more efficient, Smart LED lighting technology. These new lights are expected to save over $370,000 per year in pure energy costs and an energy savings of over 2 million kilowatt-hours of electricity per year. Based upon these estimates, the reduction in GHG emissions is estimated to be 1,546 tons of carbon dioxide; equivalent to over 3.3 million miles of passenger car travel every year. Additionally, a reduction in industrial waste will also be experienced. Traditional high-intensity discharge lamps need to be replaced approximately every two to three years. Smart LED lighting, on the other hand, has a life-span of ten years or more. These Smart LED lights also send a signal when the light is no longer functional. This combination of longer life-span and information reduces maintenance costs to the city.

The new Smart LED lights have time-optical-control which are used to control the street lamp. Multiple sensors on the light are able to control the illumination of the LED light. The sensors can control the amount of illumination based upon the time, and can be turned on or off depending upon pedestrian and vehicle traffic. When vehicles or pedestrians pass by the LED lights will illuminate to some percentage of total illumination based upon settings determined by city officials. Furthermore, the illumination of the LED lights can also be set based upon the degree of sunlight. If the sunlight gets low early in the afternoon, the lights will turn on early but if the day has a lot of sunlight late into the afternoon and evening then the lights will remain either off or stay at a low level of illumination. This Smart LED lighting system reduces a large amount of meaninglessly wasted energy consumption and increases perceived pedestrian and driver safety. As a result, the quality-of-life of citizens is improved while reducing the economic burden of street lighting.

While these benefits are projected, they are based upon small pilot projects currently in operation in the City of Schenectady. One project has six Smart LED lights, complete with wireless internet. The second pilot project is larger, with 38 Smart LED lights and wireless internet. This paper will present the results of the second pilot project.

For the National Grid Maintained, the cost is based on Outdoor Lighting Service Rate Tariff PSC #214. In 2015, the City of Schenectady spent over $1,090,836 on energy costs (Table 1). Energy supply costs accounted for 21% of the total with more than $224,000. Delivery costs were 25% of the total energy costs, at over $271,000. The final 55% was spent on facility charges, with a cost of over $595,000.

Table 1. City of Schenectady Street lighting energy costs

| | Cost ($) | Percentage (%) |
|---|---|---|
| Energy Supply Costs | $224,165.23 | 21% |
| Delivery Costs | $271,659.36 | 25% |
| Facility Charges | $595,012.35 | 55% |
| **Total** | $1,090,836.94 | 100% |

*Source: The city of Schenectady*

Under these usage conditions in 2015, Smart LED lighting is simulated to reduce energy supply and delivery charges 70% to 75%.

In comparison to current costs, energy supply costs are expected to be slightly more than $56,000 (Table 2) and delivery costs are simulated to be reduced to nearly $68,000. The total estimated annual savings are expected to be nearly $372,000.

Table 2. City of Schenectady simulated LED street ligh csts

| | Cost ($) |
|---|---|
| Energy Supply Costs | $56,041.31 |
| Delivery Costs | $67,914.84 |
| Facility Charges | $595,012.35 |
| **Total** | $718,968.50 |

*Source: The city of Schenectady*

As one can surmise from the energy cost savings, energy usage will decrease substantially.

During a one-month period during summer months, June 22 to July 22, 2016, the City of Schenectady experienced nearly a 900 kWh decrease in usage in the second, larger pilot project. If the traditional high-intensity discharge lamps along a stretch of the same road were continued to be used, energy consumption would have been 1,610 kWh. By comparison the Smart LED lights used just 764 kWh over the same period and conditions for a substantial energy savings. This energy savings are illustrated in Fig. 1.

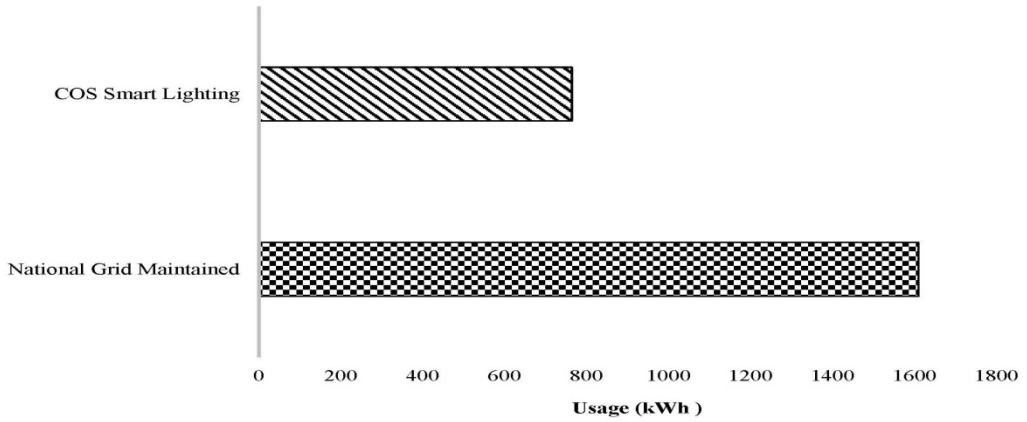


Fig. 1. Energy savings from smart LED lighting (kWh)
*Source: The city of Schenectady*

The supply charges for the June 22, 2016 to July 22, 2016 time period was $70 with the new Smart LED lights. In comparison, if the traditional high-intensity discharge lamps remained in usage, over the same time-period the supply charges would have been $133. Fig. 2 shows the supply charge savings comparisons from traditional high-intensity discharge lamps to Smart LED lights.

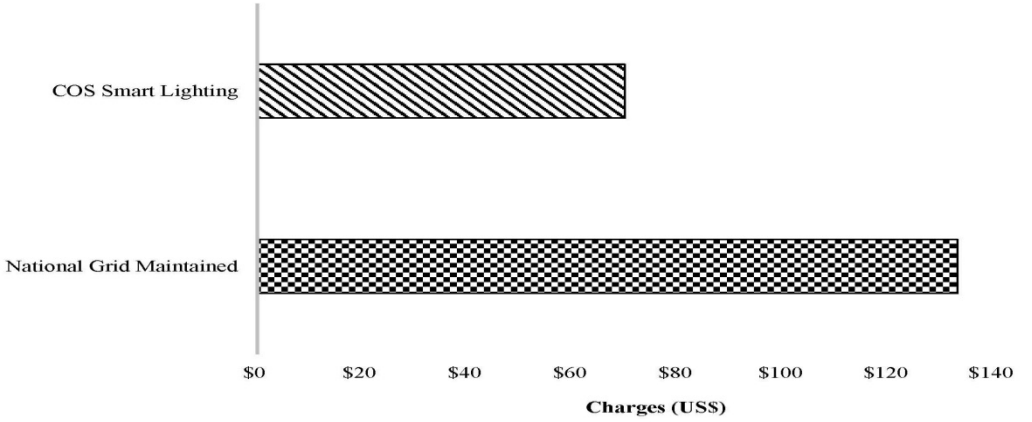


Fig. 2. Supply charge savings from smart LED lighting
*Source: The city of Schenectady*

Delivery charges also decreased substantially by switching street lights from the traditional high-intensity discharge lamps to Smart LED lighting. Were the traditional high-intensity discharge lamps continued to be used, delivery charges would have been $168. By comparison, the delivery charges for the new Smart LED lights were $70. This contrast is shown graphically in Fig. 3.

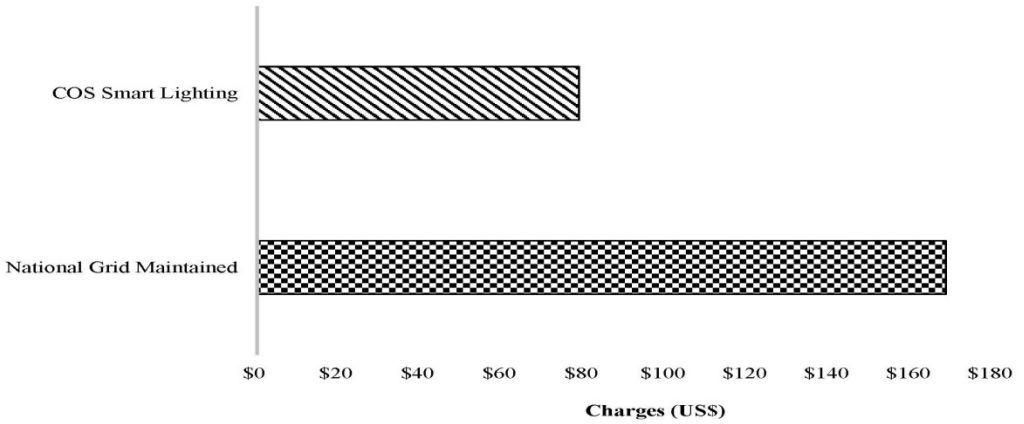


Fig. 3. Delivery charge savings from smart LED lights
*Source: The city of Schenectady*

A summary of the changes in the costs from switching from traditional high-intensity discharge lamps to Smart LED lighting is shown in Table 3.

Table 3. City of Schenectady changes in energy. Use and charges with LED street lighs

| | **Before** | **After** | **Change** |
|---|---|---|---|
| Energy Usage (kWh) | 1610 | 764 | -53% |
| Delivery Charges (US$) | 168.42 | 78.74 | -53% |
| Supply Charges (US$) | 133.07 | 69.87 | -47% |
| Facility Charges (US$) | 198.99 | 278.67 | 40% |
| **Total Charges (US$)** | 500.48 | 427.28 | -15% |

*Source: The city of Schenectady*

As the table illustrates, energy consumption decreased by 53%. Similarly, delivery charges also decreased by the same percentage and supply charges decreased by 47%. The only charges to increase were facility charges which rose 40%. However, the total decrease in charges was 15% for a savings of nearly $75 for one month for a small stretch of road.

## 3. Conclusion

This paper presents the results of a pilot project in Schenectady, New York of switching from high-intensity discharge lamps to Smart LED lighting. As the results have shown, for a one-month period there was a significant decrease in energy consumption from the street lights, and, as a result, a decrease in the associated charges. With a full-city deployment of Smart LED lighting, the expected cost savings are expected to be well over $200,000. This decrease in cost is significant while also providing wireless internet capability throughout the city and providing extra benefits, such as decreases in crime. This paper is important because it shows that Smart LED lighting does provide the expected benefits of improved environmental sustainability and improved efficiency, leading to cost savings.

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