Energy Sector Management Assistance Program

Energy Efficient Cities Initiative

GOOD PRACTICES IN CITY ENERGY EFFICIENCY

Los Angeles, USA- Light Emitting Diode (LED) Street Lighting Retrofit

Project title	Light Emitting Diode (LED) Street Lighting Retrofit
Sector	Public Lighting
Type of project	Street lighting retrofit
City and country	Los Angeles, California, USA
City population	3.8 million (2010)
Total budget	US$56.9 million
Annual energy reduction	Year 1-5 estimates: 68,640 MWh (40%) Year 1-2 reported: 21,241 MWh in retrofitted fixtures (59%)
Project status	Active (Started in 2009)

Project Summary:

The City of Los Angeles (LA) Light Emitting Diode (LED) street lighting project is the largest LED street lighting retrofit ever undertaken globally—a collaboration between the LA Bureau of Street Lighting, the LA Mayor's Office, the LA Department of Water & Power, and the Clinton Climate Initiative (CCI) Cities Program. Over a period of five years (2009-2014), the project will replace 140,000 of the city's more than 209,000 street lights with LED technology which is expected to enhance the quality of municipal street lighting, reduce light pollution, improve street safety, and save energy and money. The US$56.9 million investment required will provide an estimated US$10 million in annual energy and maintenance cost savings (68.6 GWh/year) while avoiding at least 40,500 tons of CO_2e emissions each year.

The project was initiated only after comprehensive planning and evaluation yielded positive results and feedback from stakeholders, a constructive model for other cities to follow. The technology and financial evaluation of the project was conducted with the help of CCI and other external entities. The Bureau financed the project with a seven-year, US$40 million dollar loan from the city, along with a US$3.6 million contribution from the Bureau's Street Lighting Maintenance Assessment Fund (SLMAF) and a rebate from the LA Department of Water & Power-totaling US$13.2 million. The loan amount will be repaid to the city from energy and maintenance cost savings. Other benefits include the elimination of hazardous mercury from street lighting fixtures, job creation, improved illumination and visual quality of street lighting, enhanced safety on the roads, and reduced local and global air pollution. The positive feedback this project has received from local communities, politicians, law enforcement officials and others strengthens the case for the use of LEDs in municipal lighting projects.

1. Introduction

Los Angeles is the most populous city in California and the second most populous in the United States, after New York City. LA has a total population of 3.8 million (2010) that is geographically spread over a land area of 469 square miles (1,214 square km). It is part of the combined metropolitan area of Los Angeles-Long Beach-Santa Ana, which has a total population of 12.7 million people (2007). LA's economy is driven by international trade, entertainment, aerospace, technology, petroleum, fashion, apparel, and tourism, making it the largest manufacturing center in the western U.S. Other significant industries include media production, finance, telecommunications, law, healthcare, and transportation. The Los Angeles-Long Beach-Santa Ana metropolitan statistical area has a per capita income of US$52,174 and a total gross domestic product (GDP) of US$735.7 billion—making it the third largest economic center in the world, after the Greater Tokyo Area and the New York-Newark-Bridgeport combined statistical area.

In May of 2007, Mayor Villaraigosa unveiled GREEN LA–An Action Plan[1], which committed the city to lead the nation in fighting climate change. The GREEN LA Plan included the most ambitious goal of any large U.S. city, and set LA on a course to reduce its' greenhouse gas (GHG) emissions 35 percent below 1990 levels by 2030, going beyond the targets of the Kyoto Protocol. The cornerstone of GREEN LA is maximizing energy efficiency (EE) potential and increasing the city's use of renewable energy to 35 percent by 2020.

One of the areas with vast potential for EE is LA's public lighting system. LA owns the second largest municipal street lighting system in the U.S., with more than 209,000 street lights that span over 7,000 miles of streets. The system is operated and maintained by the Bureau of Street Lighting, which was established in 1925 and currently employs over 250 people. LA's streetlights feature more than 400 distinct fixture styles and each year these lights consume approximately 197,000 MWh of electricity. The Bureau pays a variable rate per fixture to the municipal utility company, LA Department of Water and Power (LADWP), which calculates rates based on the real kWh usage of the fixture as determined through field tests. Prior to 2009, the Bureau's annual electricity bill totaled approximately US$15 million—nearly 29 percent of its US$52 million operating budget. The Bureau itself renders maintenance services to the system, and its funding is provided primarily by the Street Lighting Maintenance Assessment Fund (SLMAF) through a yearly assessment paid by city residents. The SLMAF generates US$42 million per year for the Bureau operations. In 1996, the passage of Proposition 218[2] froze SLMAF revenues, and with rising energy, labor and material costs, resulted in projected deficits for the Bureau. The Bureau thus worked with the City Administrative Officer (CAO) and other departments to address these projected deficits, while continuing to provide and maintain proper service to its customers, through operating costs reductions. The LED street lighting retrofit project played a pivotal role in the City's planning efforts in this regard, while concurrently supporting the goals under GREEN LA.

2. Project Description and Design

In 2008, LA began evaluating new technologies as retrofit options for its municipal lighting system. The Bureau of Street Lighting initially considered both light emitting diode (LED)[3] and induction technologies[4] for its street lighting retrofit program. The Bureau established a

[1] More information is available at: http://www.ladwp.com/ladwp/cms/ladwp010314.pdf

[2] Proposition 218 was a constitutional initiative, approved by California voters in November 1996, and applied to each of California's nearly 7,000 municipal and other local/regional bodies. It changed local government finance, resulting in significant revenue losses. http://www.lao.ca.gov/1996/120196_prop_218/understanding_prop218_1296.html

[3] A LED is a semiconductor light source that generates light at a precise wavelength when a current is applied; multiple LEDs are networked together in a single fixture in combination to generate the appropriate light output for each particular application. Many of today's LED fixtures boast lifetimes of 50,000 hours, or almost 11.5 years when operated 12 hours per night, and unlike all other street lighting technologies, LED fixtures contain no mercury.

[4] An induction light is an electrode-less light source in which gas contained within a glass tube is excited by electromagnetic induction. Because of the absence of an electrode, a principal failure point for a gas discharge light source, these white-light sources can theoretically last up to 100,000 hours before replacement is necessary. High-

New Technology Group to test and evaluate available cutting-edge technologies in the market and recommend suitable options. The technology choice was driven by multiple factors that weighed heavily in favor of LEDs: (a) longer life span[5]; (b) more durable and damage-resistant technology; (c) significant reduction in the Bureau's maintenance costs; and (d) superior optical control[6]. The rapidly declining cost of LED technology since 2008—and the anticipated continuing decline in cost over the next five years—made LED fixtures more appealing than the alternative induction fixtures. The Bureau also concluded that LED technology represented a paradigm shift in lighting that reflected its ambitions as a global leader on climate change.

In order to complete the proposal of the retrofit program, the Bureau had to overcome several logistical challenges. For example, the Bureau had to quantify the potential cost and savings for such a retrofit program, assess alternative financing mechanisms with a specific focus on energy and maintenance, coordinate with other city agencies (e.g., LADWP, Mayor's Office), and plan the rollout of a remote monitoring system to measure and verify fixture energy consumption and performance.

The Bureau requested assistance from the Clinton Climate Initiative's to help analyze the retrofit project. Beginning in March of 2008, CCI assisted the Bureau in the development of the street lighting retrofit project in two areas: (i) developing a detailed economic cost-benefit analysis, examining both LED and induction technologies; and (ii) exploring the financing options. They concluded that the rapidly declining cost of LED technology and the anticipated continuing decline in cost over the next five years made the LED fixtures more appealing from a cost perspective than the induction fixtures. Additionally, the projected energy and maintenance savings associated with the LED retrofit was very attractive to the Bureau which was considering ways to finance the project internally.

The final proposal outlined by the Bureau for mayoral approval was a US$57 million capital project lasting from 2009 to 2014, to be executed in five discrete year-long phases:

- Phase 1 (July 2009): Retrofit of 20,000 fixtures were planned for Year 1, and
- Phases 2-5 (July 2010-2014): 30,000 fixtures each year in Years 2-5.

In October 2008, Mayor Villaraigosa approved the five-year, 140,000 fixture retrofit project, allowing the Bureau to commence its formal rollout.

The program focused on retrofitting high pressure sodium vapor (HPSV) cobra-head street light fixtures that are located on residential streets and offer poor optical efficiency (approximately 65 percent) relative to the high optical efficiency (over 80 percent) of many LED fixtures. The focus on cobra-head fixtures reflected the readiness of LED technology for cobra-head applications and the fact that LED fixtures for decorative post-top fixtures are less ready for implementation at scale (Figure 1). While the project focuses on HPSV cobra-head fixtures, metal halide, mercury vapor and incandescent cobra-head fixtures will also be replaced in later phases. The new LED fixtures would be installed with remote monitoring units (RMUs), which would automatically monitor energy usage and report streetlight failures directly to the Bureau for immediate repair.

pressure sodium, mercury vapor, metal halide, and fluorescent technologies are all examples of gas-discharge light sources.

[5] The LED fixtures replaced typical streetlight lamps that last only 4-6 years with lamps lasting 10-12 years.

[6] LEDs provided directional light, that, when properly oriented in a fixture created precise and uniform patterns of light.

Figure 1: Street Lighting Fixture Types in Los Angeles

Photos 1 & 2 are Cobra-head fixtures; photos 3 & 4 are decorative fixtures that are less suitable for LED retrofits.
Source: City of Los Angeles, Bureau of Street Lighting.

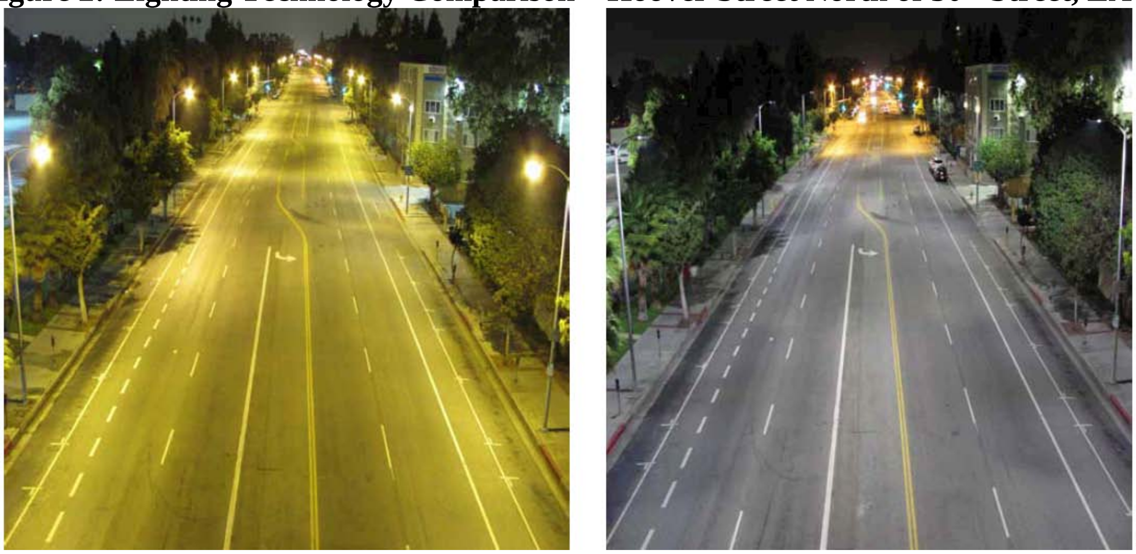
In November 2008, the city appraised prospective LED streetlight fixture manufacturers over a three-month product evaluation period. Manufacturers were invited to send four fixtures for testing to the Bureau at no (or at a significantly reduced) cost. These fixtures were tested on residential streets across LA. The Bureau measured light levels for evaluating fixture performance and sent surveys to area residents to solicit feedback on the new LED fixtures (Figure 2). Based on test results, the Bureau selected manufacturers for its year one installation of over 20,000 fixtures. The LED equipment manufacturers and vendors for Year 2-5 were to be selected at a later stage, keeping in mind the rapidly changing market scenario for the LED technology. This approach provided the city with flexibility in product selection—a critical attribute given the rapid evolution of LED fixture technologies and costs that were expected to occur during the five-year implementation period. Every six months, the Bureau reevaluates the LED fixture market, drafts specifications based on best available technology, and purchases equipment, which keeps them on the leading edge of fixture innovation. To date, the Bureau has conducted five phases of testing and evaluation of LED products.[7]

Due to the large scale of the project, and the large number of fixtures that were being submitted to the City for evaluation, the Bureau established minimum technical performance criteria for the procurement of LED lighting equipment. Manufacturers who wanted to participate in the program had to meet performance criteria for their product development. Among other benchmarks, the fixtures were required to save 30-40 percent in energy consumption, meet the Illuminating Engineering Society of North America (IESNA) standards for local/residential streets illumination levels, be glare-free, provide a warranty of no less than 50,000 hours, be controlled with a photoelectric control, and provide dimming

[7] More information on the testing and evaluation of LEDs can be found on the Bureau's website at: www.ci.la.ca.us/bsl/

features using a remote monitoring device. Similar performance criteria were established for the RMUs, which were required to be able to turn the fixtures on and off remotely, report on energy usage, use an automated global positioning system (GPS) reporting system, allow for dimming of an LED fixture, and report data in XML[8] format for the city to download on a daily basis.[9]

Figure 2: Lighting Technology Comparison—Hoover Street North of 30th Street, LA



Left photo shows a lit road before the project using HPSV; right photo shows the same road using LEDs.
Source: City of Los Angeles, Bureau of Street Lighting.

CCI also solicited proposals on behalf of the city from a number of financial institutions that were attracted by the measurable cost savings, the long equipment life, and the awareness that this could be the first of many future opportunities. The proposals received outlined a range of ideas, from basic tax-exempt leasing to non-recourse debt/equity structures focused solely on energy and maintenance savings. However, as the Bureau moved further along in the financing process, validating its business plan and demonstrating the potential upside of the investment, LADWP and the city recognized the value of getting more directly involved in project funding to ensure rapid execution. As a result, even though external funding sources remained available, it was decided that the Bureau would fund the project internally, with loan assistance from the city, and a repayment structure based on energy savings and utility rebates. The Bureau carried out all planning and installation work for the project.

3. Cost, Financing, Benefits, and Results

LA's LED street lighting retrofit project required a total investment of US$56.9 million that included material costs for LED fixtures and RMUs (US$48.56 million), labor ($US7.63 million) and miscellaneous equipment (US$0.71 million) required to complete the installation of the LED lights. The material costs are based on an initial cost of US$450 per LED fixture compared to US$150 for current street lighting fixtures. It is anticipated that this cost will decrease throughout the five-year program. The labor costs includes the cost of

[8] XML stands for Extensible Markup Language. Like HTML, it is designed to transport and store data. XML is designed to be self-descriptive and the goals of XML emphasize simplicity, generality, and usability over the Internet.

[9] More detail on the minimum performance requirements for the LEDs and the remote monitoring units are available on the Bureau's website at: http://www.ci.la.ca.us/bsl/.

additional personnel needed by the Bureau to complete the retrofit project and other overhead costs and precautionary funding to cover various factors that could contribute to delays in construction projects, such as hiring delays, overtime accounts, and vacancies etc. The equipment costs for this project include leasing vehicles needed to complete the retrofit, information technology (IT) needs and other miscellaneous equipment needs during the 5-year implementation phase of the project (Table 1).

Table 1: LA LED Street Lighting Retrofit Project Costs

Line Item	Description	Cost ($'000)	Subtotal ($ million)
Material	LED Fixtures + RMU	48,557	48.56
Labor	Personnel	7,410	
	Labor contingency	225	7.63
Equipment	Vehicle leasing	630	
	Furniture/IT needs	81	0.71
Total			56.90

Notes: For material costs, the Bureau estimated material costs of US$8.7 million, US$12.7 million, US$10.4 million, US$8.4 million, and US$8.3 million for Years 1-5, respectively. Labor costs were projected to be US$1 million, US$1.5 million, US$1.6 million, US$1.6 million, and US$1.7 million for Years 1-5, respectively, plus US$225,000 contingency for overtime, etc. Equipment included leasing of six aerial lift trucks for about US$120,000 per year, plus US$81,380 for miscellaneous furniture and IT needs.
Source: CCI Economic Analysis for the Bureau of Street Lighting Los Angeles

Financing. The project is funded through a loan, an energy rebate, and the SLMAF budget. SLMAF contributed US$3.6 million; a seven-year, US$40 million loan was secured from city and utility funds, and LADWP contributed a rebate of US$0.24/kWh reduced (about US$13.2 million). The loan debt service payments are paid through savings from current energy and maintenance costs with no adverse impact to the Bureau's general fund.

Cost Effectiveness. The project generates energy and maintenance cost savings that will create a cash flow to repay the loan and provide budgetary savings in later years. According to CCI's economic analysis, the project is expected to yield US$8.1 million per year in energy and maintenance savings, providing a payback period of seven years and an internal rate of return (IRR) of 10 percent. The total financial return for the project, after factoring in the energy rebates is even more attractive, with total savings of US$10 million per year, reducing the payback period to only 5.7 years and improving the IRR to 23 percent. The total energy savings projected are estimated to be 68,640 MWh/year (40% reduction), with corresponding CO_2e emission reductions of 40,500 tons for the City.

Other Benefits. In addition to the project being able to pay for itself with actual cost savings, there were a number of other benefits. The most important was the precarious budget situation facing the Bureau before the project was conceived. Had the project not been undertaken, the Bureau would have faced fiscal deficits and would have required a general subsidy, been forced to limit services, or necessitated a citywide ballot measure to adjust citizen service fees paid to the SLMAF. Additional benefits included: (i) longer LED lifespans which reduce fleet maintenance and fuel usage for replacements; (ii) reduced mercury and other chemical components that require hazardous disposal procedures; (iii) improved illumination levels and lighting quality; (iv) reductions in light pollution and sky glow (unnecessary illumination of night sky by artificial lighting); (v) creation of employment—the Bureau has hired 11 new staff and LED manufacturers report some 300 private sector jobs; and (vi) achievement of the City's GHG emission reduction targets under GREEN LA. Further, the retrofitted fixtures have been well received in the community.

Project Status. As of September 2011, the project was running ahead of schedule and the Bureau had already installed 52,059 LED streetlights on residential streets. The installation of the LED street lighting fixtures has also been faster than expected (50,000 fixtures were planned for this period), partly due to the fact that the installation crews were able to improve the installation process as they gained experience with the LED fixtures and became more familiar with the technology. Results from this initial phase also show higher energy and maintenance cost savings than had been expected—21,800 MWh/year (59 percent) and annual energy cost savings of US$1.9 million for the first two years of the project. These improvements are largely the result of continued improvements in LED fixture efficacy over the period of project implementation. These additional energy savings, combined with the continued decline in the price of LED fixtures in the U.S. market and the ability of the City to auction removed street lighting units (as opposed to simply recycling them), will serve to help reduce the actual payback period for the project.

4. Project Innovation

LA's LED street lighting retrofit project is the largest scale LED outdoor lighting project ever implemented, with 140,000 fixtures replaced in five years. This has allowed the technology to be demonstrated at scale, while the volume of fixtures allowed for some price reductions. As a result, the project has been able to achieve a rate of return of about 10 percent (from energy and maintenance savings only) and 23 percent (with utility rebates). With such a large demonstration project, commercial deployment of LEDs for street lighting applications could have been delayed.

The city also made use of utility rebate programs to help defray some of their initial investment costs, while avoiding substantial investments in new supply capacity. The LADWP offered its commercial customers a number of rebate programs that defray the costs of implementing energy and water efficiency upgrades. These programs helped to subsidize a wide range of technologies that included lighting, office equipment, HVAC, high performance windows, plumbing equipment, retro-commissioning, and solar and refrigeration technologies. The cost for retrofitting its street lamps and fixtures with advanced energy efficient LED technologies made the Bureau eligible to receive a rebate provided by LADWP under its commercial lighting program. It is estimated that the rebate (US$0.24 per kWh reduced) contributed approximately US$13.2 million towards the project, greatly improving the return to the city.

5. Lessons Learned

LA's approach to this project shows the importance of upfront planning, assessments of technological alternatives, coordination among various agencies, and leading by example. The city performed its due diligence during the planning phase of this project by soliciting the right technical expertise for evaluation of potential lighting technologies in terms of lumen output, lighting quality, efficiency, life and cost. It also considered LED appropriateness given the types and ranges of streetlight fixtures in LA. The city also pilot-tested the LEDs to assess actual performance in the target areas, solicited feedback from the affected communities, developed minimum performance standards and other technical specifications for procurement for the first batch under Year 1 of the project, and agreed on standard operating and maintenance protocols to ensure a successful outcome.

Various financing schemes and budgetary realities were considered in order to make the project financially feasible. Accessing the utility incentive programs for emerging technologies with maximum efficiency gains thus proved critical in making the project viable and shows how such programs can influence technology choice and project-level energy savings.

This project also demonstrates how municipalities can use their unique positions to initiate change in favor of advanced energy and environmental technologies. LA not only used its jurisdiction, scale and capacity to show the viability of LEDs to its community and the private sector; it used the success from this project to make policy changes in favor of this energy-efficient and environmentally-friendly technology. Additionally, by establishing minimum performance criteria for LED equipment, the city indirectly exerted its buying capacity to nudge the lighting industry towards providing the market with advanced LEDs products.

The project serves as an inspiration for other cities that have the political and community support for energy and environmental friendly investments and projects but lack the capital or the budgets for implementation. By taking on the challenge of a large-scale, capital-intensive LED street lighting retrofit project at a time when it faced with revenue cuts, LA was able to prove that willingness to take risk, backed up by careful technical and financial planning and successful implementation can help overcome daunting challenges in the fiscal and energy conservation areas for municipalities. This project also revealed that when the operational savings accumulate as quickly as they did in LA, EE financing can become less of an impediment than an opportunity—one that municipalities should maximize in every way possible.

6. Financial Sustainability, Transferability, and Scalability

In recent years, LEDs have begun to penetrate the street and area lighting market. There are, however, serious barriers in the full scale market deployment of this advanced lighting technology. The technology remains very capital intensive, has a fragmented market, and people lack knowledge about LED benefits. There is also a good amount of uncertainty associated with the viability of this technology for large scale applications. LA's project has begun to address some of these difficult barriers.

The successful implementation of this project has resulted in a policy shift in the Bureau through which the use of LEDs (in some cases induction lighting) for new projects in LA has become standard practice. On December 15th, 2010, the Bureau issued a notice to all designers and contractors working on new construction and retrofit projects in the city that the use of traditional street lighting technologies such as High Intensity Discharge (HID) and High Pressure Sodium (HPS) were no longer acceptable. The Bureau directed all teams that if the construction of street lighting had not been approved and initiated at that point, then all plans would need to be redesigned to use LED lighting fixtures unless otherwise approved by the Bureau's Director.

The successful implementation and financial performance of LA's project points to the significant potential for scalability and transferability to other cities around the world. Street lighting costs can represent one of the largest components of a city government's utility bill, often accounting for 10 to 38 percent[10] of the total bill. For this reason, replacement of traditional streetlight fixtures such as incandescent, HPS, metal halide etc. with LED technology represents a viable solution for reduction of both energy and operational and maintenance costs. This project can be used as a template for innovative, cost-effective street lighting with improved reliability, reduced light pollution, and energy savings.

CCI is currently building upon its efforts in LA and working with other cities on large-scale street lighting retrofit projects. CCI's Outdoor Lighting Program expects to encourage many other cities to initiate similar programs. LA's project is featured as a best practice by the Innovation Exchange of New York City's online resource bank of international best practices—another avenue by which LA's experiences will be shared. The large-scale implementation of this project encourages other cities in the United States and across the world to scale up their LED demonstration applications for outdoor street lighting. Examples include Ann Arbor, Michigan, U.S. (1,000 LED fixtures installed in 2007), Anchorage, Alaska, U.S. (4,000 fixtures installed in 2008; plans to install 16,000 total), and Ontario, Canada (47 fixtures installed in 2007) among others. Furthermore, this potential is only expected to increase in the future as LED technology improves and costs decrease over time.

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ANNEX: CITY AND PROJECT PROFILE

CITY PROFILE

1. **Name of the City**	**Los Angeles, California (U.S.)**
2. **Area**	**469 square miles (1,214 square km)**
3. **Population**	**City- 3.8 million (2010); County - 9.8 million (2010); Metro area – 12.9 million (2009)**
4. **Population Growth Rate**	**0.4% (2010-2011)**
5. **GDP of the City**	**US$551 billion for the Metro area (2009)**
6. **GDP Growth Rate**	**-3.0 % for the Metro area (2008-2009)**
7. **GDP per Capita**	**US$42,784 (2009)**

PROJECT PROFILE

1. **Project Title**	**Light Emitting Diode (LED) Street Lighting Retrofit**
2. **Sector**	**Public Lighting**
3. **Project Type**	**Street lighting retrofit**
4. **Total Project Capital Cost**	**US$57 million**
5. **Energy or energy cost savings**	**US$10 million/year (68,640 MWh/year or 40%)**
6. **Internal Rate of Return**	**23%**
7. **Project Start Date**	**July 2009**
8. **Project End Date**	**June 2014**
9. **% of Project Completed**	**45%**

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