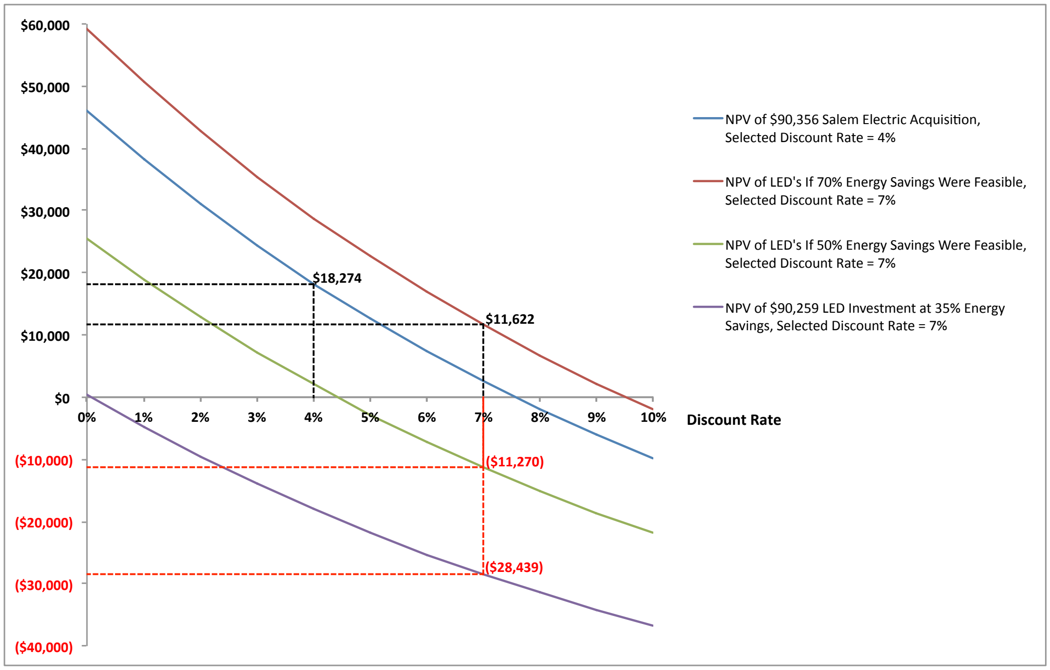

Salem Streetlights: Solutions for a Sustainable System

Spring 2011 • Planning, Public Policy and Management

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SCI
Sustainable Cities Initiative

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About SCI

The Sustainable Cities Initiative (SCI) is a cross-disciplinary organization at the University of Oregon that seeks to promote education, service, public outreach, and research on the design and development of sustainable cities. We are redefining higher education for the public good and catalyzing community change toward sustainability. Our work addresses sustainability at multiple scales and emerges from the conviction that creating the sustainable city cannot happen within any single discipline. SCI is grounded in cross-disciplinary engagement as the key strategy for solving community sustainability issues. We serve as a catalyst for expanded research and teaching, and market this expertise to scholars, policymakers, community leaders, and project partners. Our work connects student energy, faculty experience, and community needs to produce innovative, tangible solutions for the creation of a sustainable society.

About SCY

The Sustainable City Year (SCY) program is a year-long partnership between SCI and one city in Oregon, in which students and faculty in courses from across the university collaborate with the partner city on sustainability and livability projects. SCY faculty and students work in collaboration with staff from the partner city through a variety of studio projects and service-learning courses to provide students with real-world projects to investigate. Students bring energy, enthusiasm, and innovative approaches to difficult, persistent problems. SCY's primary value derives from collaborations resulting in on-the-ground impact and forward movement for a community ready to transition to a more sustainable and livable future. SCY 2010-11 includes courses in Architecture; Arts and Administration; Business Management; Interior Architecture; Journalism; Landscape Architecture; Law; Planning, Public Policy, and Management; Product Design; and Civil Engineering (at Portland State University).

About Salem, Oregon

Salem, the capital city of Oregon and its third largest city (population 157,000, with 383,000 residents in the metropolitan area), lies in the center of the lush Willamette River valley, 47 miles from Portland. Salem is located an hour from the Cascade mountains to the east and ocean beaches to the west. Thriving businesses abound in Salem and benefit from economic diversity. The downtown has been recognized as one of the region's most vital retail centers for a community of its size. Salem has retained its vital core and continues to be supported by strong and vibrant historic neighborhoods, the campus-like Capitol Mall, Salem Regional Hospital, and Willamette University. Salem offers a wide array of restaurants, hotels, and tourist attractions, ranging from historic sites and museums to events that appeal to a wide variety of interests. 1,869 acres of park land invite residents and visitors alike to enjoy the outdoors.

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Executive Summary

The City of Salem operates and maintains a complex and costly network of over 10,500 streetlights. This report examines several challenges within Salem's current streetlighting system and provides recommendations to enable the city to achieve a more sustainable operations structure.

Three primary attributes affect the operational sustainability of streetlights in Salem: funding sources, ownership arrangements, and energy efficiency. Funding is relevant because Salem, ideally, would use funds from the state gasoline tax exclusively to finance required street maintenance, and would draw revenue for streetlights from a difference source. At present, Salem allocates approximately 20 percent of gas tax funds to pay for streetlights. Simultaneously, Salem allocates roughly one million dollars annually from the city's General Fund to meet its needs for street maintenance. Secondly, ownership arrangements are relevant because Salem has a unique streetlight ownership and maintenance structure that involves three separate entities. Shared ownership constitutes a complicated system consisting of over 100 combinations of lights and ballasts. Without streamlined ownership, the city is unable to modify maintenance costs or introduce technology to ensure least-cost streetlight operations. Implementing energy efficient technology is a key opportunity for the city to reduce cost of streetlighting. As part of the University of Oregon's Sustainable City Year program, the Salem Public Works Department commissioned students in a Master of Public Administration Capstone course to investigate both fundraising and cost saving opportunities within this system.

The research team performed three analyses to identify the best means of reducing the burden of streetlight operations and ownership. The principal analysis evaluated the city's many options for raising streetlight revenue based on equity and cost. Two additional analyses determined the financial implications of (1) the acquisition of streetlights owned by Salem Electric and Portland General Electric and (2) investment in energy-saving technological upgrades.

Through the first analysis, the research team determined that Salem will likely experience immediate stabilization of funding and increased funding by implementing a direct user fee. A fee of this type presents the most favorable form of tax collection for an entity of Salem's size, taking into consideration cost of collection and residents' ability to pay. Results of our secondary financial modeling indicate that investment in LED upgrades and streetlight acquisition may produce positive returns for the city, although Salem would not realize these benefits for many years.

Based on the results of the analyses described above, the research team offers a three-tiered policy recommendation to the city. First, we recommend that the city adopt a direct streetlighting fee, levied as an electric utility pass-through.

A fee of $1.50 per month per street address will fully fund Salem's streetlight operations. In addition, this funding mechanism allows the city to include an additional $0.25 fee per month for the creation of a streetlight improvement fund.

After the implementation of a direct streetlight fee, the research team recommends that the city use revenue generated by the suggested capital improvement fee to purchase the Salem Option A segment of streetlights. In addition, the team recommends that Salem table the option to upgrade PGE Option C lights to LED technology.

Introduction

Currently, the City of Salem provides approximately 10,500 streetlights for the safety and well-being of its residents. These streetlights cost the city roughly 1.5 million dollars per year in combined electricity and maintenance costs, representing 20 percent of Public Works Department expenditures. The city uses a combination of ownership and rental options in partnership with two electric utilities, Portland General Electric (PGE) and Salem Electric (SE). The shared ownership model has contributed to a system with over 100 combinations of lights and ballasts. The city has identified this streetlight system as an important opportunity to increase the efficiency of government operations and the long-term stability of financial resources.

In conjunction with the University of Oregon's Sustainable City Year program, the City of Salem commissioned a team of students in a Masters of Public Administration Capstone course at the University of Oregon to recommend a more sustainable model for their streetlight operations. The city seeks a streetlighting system that is financially and politically sustainable in an era of public/private partnerships, regulatory change, rising energy costs, and unstable government revenue. At the same time, Salem is considering the environmental cost and benefits of their municipal infrastructure.

Voters in Salem have historically wavered in their support of streetlight-related infrastructure taxes. In 2003, voters overwhelmingly repealed the Streetscape Utility Fee, but in 2008, they solidly supported the Streets and Bridges Bond Measure. In addition to the wishes of residents, the city must consider the financial needs of the all city departments in any discussion of redistribution of city funds.

Increasing funding for one purpose limits the amount of available funds for future projects. In the article "The Marginal Cost of Public Funds," Edgar Browning (1976) explains this phenomenon as the opportunity cost of taxing. There is not an infinite funding supply for any government to draw from, and therefore any tax has the cost of not only the program that it is funding, but also the cost of not providing another program. With the understanding that funds are limited, and a particular expenditure comes at the expense of another, our analysis and recommendations will not address these ideas; the City of Salem has performed an internal analysis and determined that streetlights were their priority.

The following report examines available mechanisms to improve the sustainability of Salem's streetlight operations. The first section defines Salem's streetlight operations problems and provides a survey of possible solutions. The remaining portions of the report provide in-depth analysis of the most suitable alternatives and recommended actions for the city to achieve more sustainable streetlight operations.

Problem Statement

Salem's streetlights are currently funded exclusively with State Highway Fund (gas tax) revenue. The State Highway Fund is the primary funding source for the Department of Public Works' street-related expenses, including traffic signal operations, street trees and landscaping, street maintenance, transportation planning, and traffic engineering and signs. Streetlight operations cost the city roughly 1.5 million dollars per year, utilizing 20 percent of Salem's State Highway Fund resources. These costs represent the city's greatest single expenditure of gas tax funds, diverting resources from other necessary street maintenance needs. In 2007, for example, street maintenance received less than one percent of gas tax resources while streetlight operations received 19 percent. This led the city to reallocate 40 percent of water/sewer franchise fee revenues to pavement maintenance (City of Salem Public Works, 2008).

The Department of Public Works is facing strained resources and, consequently, receives approximately one million dollars in an annual subsidy from the General Fund to maintain public infrastructure. In an effort to eliminate the need for this subsidy and increase the resources available for street maintenance and improvement, the city would like to reduce or eliminate their streetlight operations expenses.

Salem's complex streetlight ownership structure presents an additional challenge for the Department of Public Works. Portland General Electric, Salem Electric, and the city each own various components of Salem's streetlight system (see Figure 1). So-called Option A systems are owned and maintained by the utilities. Option B systems are owned by the city and maintained by the utilities. The PGE Option C system is owned and maintained by the city, with electricity furnished by PGE. A small number of lights are rented from Salem Electric. The viability of acquiring the utility-owned portions of Salem streetlights is mixed. PGE owns and maintains the PGE Option A portion of Salem's streetlight system. According to PGE Lighting Systems, "at this time PGE [is] not

Segment	# of Lights	% of Total System	% Utility Owned % City Owned
PGE Option A	2,769	26.23%	31.38%
Salem Electric Option A	538	5.10%	
Salem Electric Rentals	6	0.05%	
PGE Option B	4,935	46.75%	68.62%
Salem Electric Option B	1,624	15.38%	
PGE Option C	685	6.49%	
Totals	10,557	100%	100%

Figure 1: Salem Streetlight Ownership Structure. Source: Adapted from R.W. Beck Report, 2000

selling any of our assets” (Tracy Aguilar, personal communication, February 17, 2011).

Without streamlined ownership, the city is unable to modify maintenance costs or introduce technology to ensure least-cost streetlight operations. Salem’s ownership structure is a potential cost burden but provides an opportunity for the city to increase the efficiency of streetlight operations through reduced maintenance costs and energy efficiency.

The City of Salem Department of Public Works has commissioned this capstone group to identify mechanisms through which the city can reduce the cost of streetlight operations. In an effort to provide a comprehensive series of policy recommendations, we have identified three potential ways to reduce these costs and streamline the finance structure:

- Implement an alternative funding mechanism.
- Change the streetlight ownership structure.
- Increase the energy efficiency of streetlights with technology.

The remainder of this report will identify specific solutions to Salem’s streetlighting problem, evaluate these potential solutions, and provide policy recommendations.

Research Questions

The research team developed the following research questions to guide our analysis toward solutions to Salem's streetlight problem. The primary question (Question 1) encompasses our goals most broadly. The subsequent questions provide secondary levels of analytical depth to steer our research toward the three previously identified solution categories: alternative funding, ownership structure, and energy efficiency.

Question 1: What steps would be required to achieve a "sustainable" streetlight funding and operations system, and what long- and short-term costs are associated with implementing each?

a. What defines a sustainable system?

Question 2: What alternative resources are available to fund streetlighting?

Question 3: What energy and cost efficiency mechanisms exist?

Question 4: What are the advantages and disadvantages of changing the ownership and maintenance structure?

a. Is buyback from each utility feasible?

b. What cost reductions can be achieved through buyback?

These questions provide the foundation upon which we identified and analyzed the options available to Salem to reduce the cost of their streetlight operations.

Research Design

To address the research questions, the team identified available alternative funding, ownership, and efficiency mechanisms and performed three discrete analyses on these options. First, the team evaluated the expected costs associated with implementing each alternative funding option. For each funding mechanism, we quantified the following costs: equity, cost of implementation, cost of operation, and ease of implementation.

Second, the research group analyzed the acquisition of Salem Electric's Option A streetlight system to assess the merits of the prospective investment (simple payback period, discounted payback period, net present value, and internal rate of return). This analysis updates the acquisition cost (investment) from Salem Electric's prior proposal from late 2009 (see Appendix A). The net annualized savings for this option remains unchanged. A template displaying the financial metrics is included in Appendix B to illustrate this methodology.

Finally, this report presents an analysis of the investment in LED upgrades, specifically within the PGE Option C segment of Salem's streetlight system. The city currently owns and operates this segment and pays PGE for electricity costs. In addition to calculating the upgrade cost (investment) and associated cash flows for this option, the research team calculated simple payback period, discounted payback period, net present value, and internal rate of return. The supporting data, calculations, and underlying assumptions used to derive the investment amount and net annualized savings are presented in Appendices C1 and C2. The metrics for the financial analyses are presented in Appendices D, E, and F. This analysis facilitates a comparison with the proposed Salem Electric Option A acquisition, and is intended to support an informed investment decision by the city.

These three analyses are then synthesized to generate policy recommendations. The net present value of each proposed capital project is compared to determine the superior investment option(s). The net benefits of alternative revenue streams were compared as well, which resulted in our recommendations for action by the City of Salem. In turn, we expect these actions, which are described in the recommendations section, to increase the efficiency and reduce the cost of Salem's streetlight operations.

Existing and Available Systems

Streetlight provision is integral to municipal public safety and transportation infrastructure. For the City of Salem, however, streetlights present a significant burden on scarce city resources, specifically gasoline tax revenues. Many opportunities exist to reduce the cost of streetlight operations (electricity and maintenance), including changing the funding source, decreasing the electricity required, and changing the ownership structure. The following catalog of existing systems provides a survey of conventional streetlight finance systems, efficiency measures, and ownership arrangements used in Oregon and across the nation. This survey is intended to place Salem's current operations system in a larger context and identify alternative opportunities to reduce the cost of streetlight operations.

Funding Mechanisms

Municipalities employ a wide range of funding streams for local streetlight operations. In 2010, the League of Oregon Cities (LOC) conducted a "Street and Traffic Light Survey" which, among other questions, asked cities "How are your streetlighting operating costs funded?" Of Oregon's 242 cities, 37 percent completed the survey. These responding cities represent 78 percent of Oregon's city residents and 55 percent of Oregon's overall population. While no particular mechanism appears to dominate streetlight finance, the LOC 2010 draft survey results report that funding typically originates from two primary categories: city funds and locally assessed user fees (see Figure 1). This section describes these categories and the conventional streetlight finance mechanisms used throughout Oregon and the United States.

City Funds

Many municipalities rely, at least in part, on a range of general and shared city funds to finance their general operations. According to the LOC "Street and Traffic Light Survey" 2010 draft results, Oregon municipalities employing city funds generally do so through revenue, State Highway Fund transfers, or a combination of these resources (LOC, 2011).

State Highway Fund Sources

State Highway Fund revenue is generated by the Oregon Department of Transportation through driver's license fees, vehicle registration and title fees, fuel taxes (gas tax), and weight-mile taxes levied on trucks and other heavy vehicles (ODOT 2010). Fuel tax revenue comprises the majority of revenue generated. Roughly 16% of the fund's net revenue is allocated to cities, based on their population, and must be used for roads, bridges or rest areas (ODOT 2010).

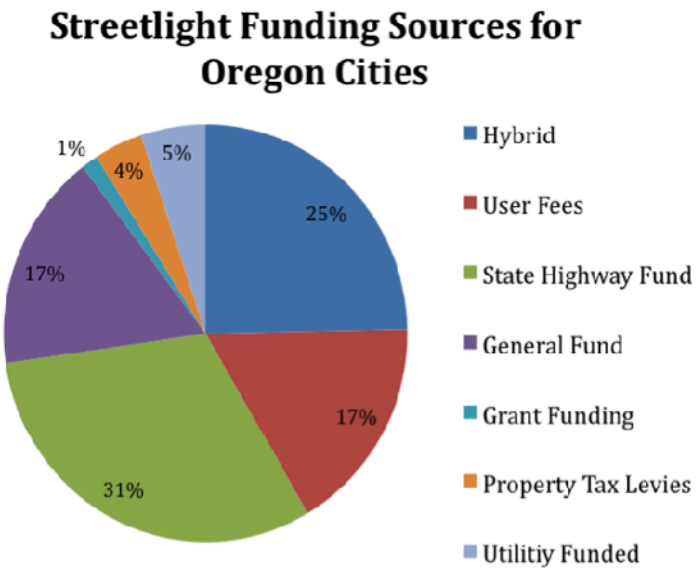

Figure 2: Percent of responding Oregon cities utilizing existing funding. Source: League of Oregon Cities, 2011.

Like Salem, several Oregon cities place the entire burden of streetlight funding upon their State Highway Fund transfers (see Figure 2). According to the 2011 LOC draft survey results, nearly one-third of respondents report funding their streetlights entirely through State Highway Fund transfers.

Many additional localities rely primarily, but not exclusively, on State Highway Fund revenue. The City of Lebanon, for example, funds streetlight operations through a City "Street Fund" that receives 90% of its resources from the State Highway Fund and 10% from transfers including landfill permits and miscellaneous revenue (City of Lebanon 2010). Recent financial constraints further reduced Lebanon's 2010-2011 transfers for street light operations expenses by $93,000. The city mitigated this loss by transferring the street fund's $65,000 street sweeping expense to their storm water fund. This was possible through the implementation of a storm drain utility fee and storm drain maintenance program.

The City of Joseph, similarly, finances the operation of their 135 streetlights through a combined revenue stream of State Highway Fund Revenue and City Transient Lodging Tax.

General Fund Sources

Many other municipalities finance streetlight operations entirely with General Funds resources. General Funds serve as operating funds for local governments, accounting for all fiscal resources aside from those required by specific funds. The majority of local governments in Oregon utilize a General Fund, and some small localities rely exclusively on it for budgeting (Oregon Department of Revenue 2009). General Funds resources in Oregon vary in origin between municipalities but are, for the most part, generated through property tax assessment, incoming federal and state transfers, and fees, including franchise and license fees (Oregon Department of Revenue 2009).

In Oregon, approximately 17% of cities participating in the LOC Streetlight Survey rely exclusively on this streetlight funding mechanism. Cities that fund streetlight operations entirely with General Fund resources include Grants Pass, Newport, North Bend, Oregon City, and Roseburg (LOC, 2011). Other cities rely primarily on their General Fund, supplemented by other sources. Winston, for example, finances the operation of their 327 streetlights with a combination of General Funds and franchise fees levied on utility companies.

Streetlight Fees

While many cities pay for their streetlights with general city funds, other municipalities employ various fee structures to fund streetlight operations. These can vary greatly from local lighting districts and bond issues, to "out-of-the-box" systems such as "adopt a light" and streetlight advertising. In Oregon, the most common forms of user fees are property tax levies and special lighting districts.

Lighting Districts

Increasingly, cities throughout the country have stopped providing funding for streetlights and are relying on citizen-created lighting districts to pay for the provision of streetlights. Lighting districts are similar to other service districts that exist (e.g. water, sewer, and sanitary) and allow residents to approve and operate local services at their desired level (Special Districts, 1957). In his book on special districts in America, Bollens (1957) cites the need for special districts to mitigate instability of traditional local governmental units. They enable provision of essential services regardless of city/county boundaries. This option allows citizens to set appropriate funding and operation levels through a tax or fee structure; property taxes are typically used.

Direct User Fees

The final common funding method identified is a direct user fee. These fees, referred to in this report as "streetlight fees" are levied per household as a user charge for streetlight consumption. These fees are developed on the assumption that all residents and businesses derive equal benefit from the streetlights, charging every household and business equally. Roughly 17% of respondents to the LOC Streetlight Survey charge residents a direct, monthly fee to finance streetlight operations. These fees vary based on the individual needs of municipalities; however, they generally range between two and five dollars per month in Oregon (LOC, 2011). In 2007, Florence implemented a $2 per month fee for all of its customers; this is very similar to how Cornelius funds streetlights. Other cities (e.g. Medford, Wilsonville, and Portland) have created a tiered fee system that is contingent on the number and type of streetlights in proximity to the property (LOC, 2011).

Out-of-the-box Funding Mechanisms

Beyond the conventional funding schemes described above, creative municipalities around the world have adopted "out of the box" mechanisms to generate streetlight operations revenue.

Streetlight Adoption

One unconventional funding option, successfully implemented in Colorado Springs, is a streetlight adoption system, by which residents individually finance the operation costs of streetlights for an annually or monthly assessed fee. In Colorado Springs this fee ranged from $75 - $180 per light per year (Chacon, 2010). With this system, cities chose a minimum level of lighting that they were willing (or obligated) to provide, leaving additional lighting levels up to residents' preferences. In Colorado Springs many street light "adopters" choose to illuminate groups of lights as opposed to just a single light.

Mileage Traveled Tax

One funding option, proposed in response to the increasing number of alternative fuel vehicles and decreasing gas tax revenues in Oregon, is the mileage tax. A 2005 Department of Transportation report to the legislature proposed that all new alternative fuel vehicles in Oregon be required to pay a tax on all miles driven. This proposed tax was to improve tax equity among drivers, as the current shift in gasoline consumption is placing an unfair burden on drivers of traditional fuel vehicles. The plan also allows for a local option that will allow cities to add an additional amount of tax to provide for local initiatives (Whitty and Imholt 45).

Private Streetlight Funding

Portland, Oregon has a stipulation in its streetlight code that requires homeowners' associations (HOAs) to provide private streetlight funding. This is not a unique policy and is similar to the streetlight district idea, but is implemented on a smaller scale. The City of Houston, Texas has a similar policy requiring residents in subdivided areas to pay for streetlights through local HOAs. This policy helps to mitigate the growing cost of streetlighting and allows for a stable, long-term funding source for streetlights in new residential neighborhoods.

Streetlight Advertising

One particularly entrepreneurial "out of the box" funding mechanism currently used by the City of Johannesburg, South Africa, allows companies to purchase advertising space on streetlights. This method of streetlight finance creates a market for streetlighting, but may pose some unique legal challenges for a city. Johannesburg has been able to turn streetlighting into a profit maker instead of a cost center.

Ownership of Streetlight Systems

Municipalities in Oregon utilize a wide range of ownership arrangements for their streetlights. According to the LOC Streetlight Survey, 70 percent of responding Oregon cities own streetlights in their municipality, and 68 percent have streetlights owned by utilities. An additional 12 percent of municipalities report that private entities own streetlights in their city (LOC, 2011).

Several municipalities throughout the U.S. have changed the ownership structure of their streetlighting systems with the goal of reducing operating costs. Through acquisition, cities purchase streetlights owned by utilities, to avoid utility maintenance fees, streamline operations, and install energy efficient technologies. Further, if the offsetting maintenance costs incurred directly by cities are lower than the rates formerly charged by the utilities, this will result in net savings. The Oregon Public Utility Commission reviews and approves rates submitted by various utilities. Maintenance rates are often greater than a utility's actual cost, which allows utilities to profit. If and when a municipality can obtain utility-owned lighting, it is possible for the municipality to save on maintenance costs if its own costs to maintain the system are lower than what the utility formerly charged.

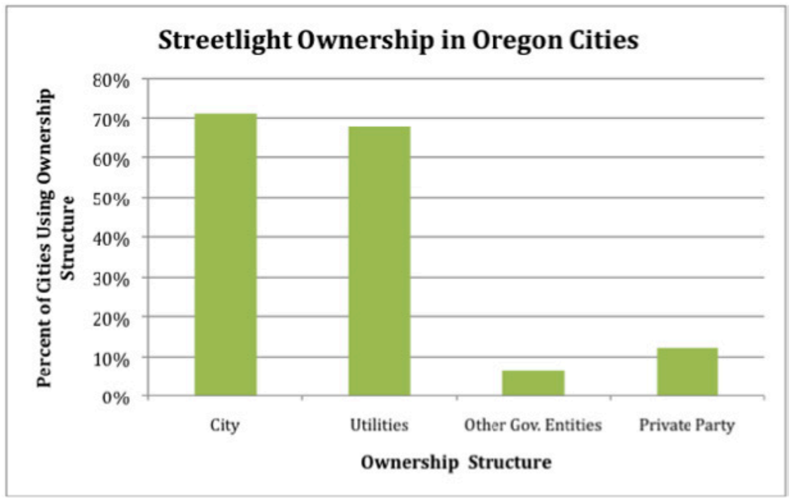

Figure 3: Ownership structures for Oregon streetlights. Source: League of Oregon Cities Streetlight Survey, 2011.

The Massachusetts Municipal Association reported that "Worcester [Massachusetts] expects to save more than $1.6 million a year by purchasing more than 13,000 streetlights from National Grid, a move made possible by a sharp decline over the years in the utility's selling price." According to National Grid, 14 other municipalities also purchased streetlights from them (Evich, 2011).

Another significant benefit of city ownership of streetlight systems lies with the inherent ability to assert a higher degree of control than a utility typically allows (LOC, 2011). Recently, Myrtle Creek, Oregon provided an example of the importance of control by choosing "to turn out eighty-nine lights in order to save money on electricity cost" (LOC, 2011).

Late in 2009, Salem Electric reaffirmed its willingness to sell its Option A lighting system for $80,440 (R. Kuhlman, personal communication, November 5, 2009). Salem Electric's system had also been offered for $31,161 in 2000 (R.W. Beck, 2000, p. ES-2). In a report prepared for Salem's Mayor and City Council, it was estimated that purchasing the Salem Electric Option A system would result in a net annual savings of $12,400 (P. Fernandez, personal communication, December 14, 2009). At that time, a change in ownership from Salem Option A (utility owned) to Option B (city owned) would have saved $26,200 in maintenance, with offsetting annual replacement costs to the city of $13,800; resulting in the net annual savings of $12,400 (P. Fernandez, personal communication, December 14, 2009). The undiscounted payback period of such an investment would have been 6.5 years ($80,440/ $12,400 = 6.48) had the city accepted Salem Electric's offer (P. Fernandez, personal communication, December 14, 2009).

On March 7, 2011, Salem Electric extended a new offer for the purchase of the Option A portion of their system at an updated price of $90,355.62. The maintenance fee savings associated with this acquisition is estimated to be $26,200 per year while new replacement costs to the city are estimated to be $13,800 annually. This would result in a net annualized savings of $12,400 (K. Hottmann, personal communication, March 14, 2011). Salem has not made an acquisition decision at this time, since other viable alternative investments warrant further consideration. Since resources for capital projects are limited, an investment in Salem Electric Option A system acquisition would be in competition with other proposed capital projects (investments). The net present value of each proposed capital project can be compared to determine the superior investment option(s).

Efficiency Mechanisms

Another investment opportunity involves upgrading a given portion of city owned streetlights from high intensity discharge (HID) to solid-state lighting, such as light-emitting diodes (LEDs) or magnetic induction lights (LOC, 2011). According to the LOC Streetlight Survey, 13 percent of responding cities currently use LED technology for streetlighting. In addition, 10 percent use some magnetic induction technology and 14 percent use some other efficiency technology (LOC, 2011). Increasing the energy efficiency of Salem's streetlights presents an additional means by which the city can reduce the cost burden of streetlight operations. Several technologies are available to the city in many stages of technological feasibility. These efficiency mechanisms range from LED lighting that is currently used in

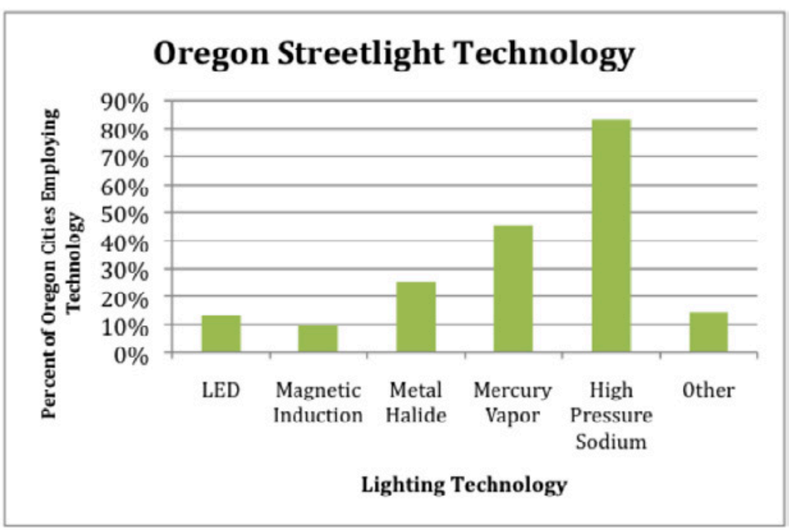

Figure 4: Lighting technology in Oregon streetlights. Source: League of Oregon Cities Streetlight Survey, 2011.

cities throughout the nation to solar lighting systems still in the early stages of adoption.

LED Lighting

Several cities throughout the state of Oregon have completed partial upgrades and/or research studies of LED streetlights in hopes of assessing their efficiency and fiscal impact. LEDs consist of clusters of small, high-intensity bulbs and are extolled for their power efficiency and clear luminosity.

The United States Department of Energy (DOE), in collaboration with Pacific Gas and Electric, studied the feasibility of LEDs as replacements for existing street light fixtures in San Francisco. The study provides a suitable comparison to Salem, since both cities have similar street light fixtures. The DOE study recommends that other cities investigate LED technology as well, evaluating their efficiency based on performance, energy and power usage, and general fiscal considerations such as payback period and net present value (New Streetlights, 2011).

LED streetlights are becoming a popular choice in localities because of their potential to cut electricity use by nearly 50 percent (New Streetlights, 2011). In Oregon, Klamath Falls began a pilot program in December 2009 to convert to LED streetlights. The program replaced 20 traditional streetlights with 20 LED bulbs. The existing fixture consumed an average of 138 watts per luminaire over the monitored period. As a result, the estimated annual power consumption for the luminaire, assuming 4100 hours of operation annually, is 567 kWh. The energy consumption for the LED luminaires, in contrast, ranged from a low of roughly 41 watts to a high of roughly 69 watts per luminaire (TRN-4.01, 2011).

For cities seeking to invest, the high initial cost of LED street lights proves to be a barrier, especially in terms of total city-wide retrofit. To counteract the initial capital investment, energy savings also help to buy down the incremental cost of LEDs relative to other options. The DOE study shows expected maintenance cost savings and lower electricity costs due to wattage of the bulbs. Additionally, the DOE study highlights the utility of product warranties for LED technology, which range from 2 to 7 years (TRN-4.01, 2011). During this period of time, the consumer can typically receive a full refund for any product that is faulty or does not perform up to expectations.

City managers and public officials alike should compare the discounted payback of LED investments with traditional streetlights' capital and operations costs when planning retrofits or new street light projects. This assessment should include estimated energy and maintenance savings in addition to environmental and city-wide sustainability.

LED systems generate heat that can decrease luminaire lifespan if not managed properly. While thermal management technology is incorporated in new systems, retrofitting existing HID lights requires examining means of mitigating the thermal demands of LEDs.

There is currently a lack of comprehensive standards for the use of LEDs in streetlighting. The DOE has begun the process of developing these standards, though it will likely be a matter of years before solid-state lighting requirements reach a level of maturity similar to HID lighting standards.

Magnetic Induction Lighting

While LED installations have become the prevailing form of solid-state lighting and efficiency efforts, there are additional bulb options and lighting technology systems that provide potential energy savings. Although LEDs have garnered the majority of press and installation of solid-state lighting (SSL), a different form of SSL is available: magnetic induction (MI) lighting. When compared to LEDs, MI lighting has equal or greater energy savings, reduced use of mercury, and a major increase of bulb lifespan of up to 100,000 hours versus 50-60,000 hours for comparable LEDs (How Magnetic, 2010). Additionally, MI bulbs do not have the long-term output dimming associated with LEDs.

The core technology of MI bulbs, while older than LEDs, is less developed. Since LED manufacturers have devoted large amounts of funding and marketing to LEDs, it is unlikely that MI bulbs will be able to compete effectively beyond small, niche markets. In addition, MI lamps require Federal Communications Commission certification to avoid causing interference with other electronic devices (US Lighting, 2005). Also informal opinion gathering by the City of Portland (Evaluating Street Lights, 2010) and the City of Palo Alto (Demonstration Assessment, 2010) has shown that stakeholders range from ambivalence to active dislike of MI lighting. Finally, the light output tends to be less uniform than other forms of bulbs.

Variable Illumination and Behavior Response

In addition to installing more efficient bulbs, a potential area for savings is reducing the total amount of energy used by five distinct but complementary strategies: dim existing lights, reduce hours of illumination, use sensor technology to turn on lights only when needed, take lights out of service, and delay or eliminate the replacement of dead bulbs.

Dimming existing lights allows the city to maintain existing areas of coverage while reducing electricity consumption. However, the ability to dim bulbs is not built in to all fixtures, thus limiting the breadth of possible implementation. Currently, the market for dimming components is not fully developed, making this an option that likely will be viable at some point in the future.

By modifying the time of day at which lights come on and turn off, the city could potentially recognize system-wide savings. As with the dimming option above, this approach is dependent on having the necessary technical infrastructure.

Using the same principle as motion-activated home lighting, sensor-triggered lighting would allow the city to provide illumination only when and where it is needed. For example, lights in business districts or industrial parks could be configured to illuminate only during periods of active use.

The City of Salem may be able to identify existing lighting that could be removed from service with minimal impact on livability. As with the options above, removing lights from service provides an opportunity to reduce system costs. A related idea is to make a per-light decision on replacing dead bulbs; instead of automatically replacing any dead bulb, the city could choose to replace only bulbs in lights that meet designated criteria. Portland is currently implementing this strategy (LOC, 2011)

Longer-Term Areas for Savings

As new lights are added to the system, Salem has the opportunity to require certain characteristics consistent with its goals of efficiency and sustainability. Specifically, the city could require new lights be solid-state (LED or MI), be dimmable, and have flexible scheduling and triggering. By implementing these criteria, the city ensures a technologically flexible and environmentally-friendly system moving forward.

Alternative Systems

As alternative and renewable energy sources have increased in prevalence, there have been efforts to apply these tools to streetlighting. These have included LEDs powered by solar energy or by wind. Aside from the reduction in energy costs, these systems provide the ability to establish streetlighting in areas that are “off the grid,” such as developing countries or in the case of power disruption caused by natural disasters. Unfortunately, off-grid systems also require a means of storing and managing energy for use when solar or wind energy is not available, which adds to the cost of the system. A pilot program will begin in New Jersey to examine the feasibility of including this type of hybrid system in an economic development district. It is anticipated that this project will provide practical “real world” assessments of the advantages and drawbacks of incorporating these systems into existing infrastructure. The DOE often has pilot program funding available through its Gateway program that the city might consider as a means to test the feasibility and economics of emerging technologies (Department of Energy, 2010).

The previous sections define the barriers Salem faces to sustainable streetlight operations and the many options available to overcome these barriers. Given the extent of funding, ownership, and energy efficiency mechanisms discussed, the research group narrowed our analysis to the six most suitable alternatives for the city: streetlight fee, property tax levy, streetlight adoption, lighting districts, acquisition of Salem Electric Option A, and LED upgrades for PGE Option C lights.

We selected these options based on preferences expressed by Salem’s Department of Public Works, frequency of use among similar municipalities, and feasibility with respect to existing infrastructure and technology. The remainder of this report will evaluate these six alternatives and provide recommendations for action based on this analysis.

Evaluation of Funding, Acquisition, and Energy Efficiency Mechanisms

The central objective of this analysis is to identify the most sustainable streetlight operations system for the City of Salem. Satisfying this goal requires a clear definition of sustainability, specific to streetlighting systems. In addition to environmental elements, such as energy efficiency and light pollution, a sustainable streetlighting solution must address the system's financial stability and endurance.

William Thompson, Public Works director at the City of Palo Alto, defines a truly sustainable streetlight system by the following guidelines:

- Simplify and streamline lighting management
- Improve controllability of the system
- Advance energy efficiency
- Improve visibility
- Create neighborhood identity and evoke civic pride
- Reduce light pollution
- Reduce waste of spent lamps

Thompson explains further that by using advanced energy efficient technology, the other guidelines can be easily met and maintained by any small to medium size city or district similar to Salem. Investing in a long-term solution with stable resources to maintain a city's investment should be a manageable goal for the City of Salem in creating a sustainable streetlight system.

The following sections provide cost and investment analyses of steps for achieving sustainability within the framework established above. Discrete analysis of funding and efficiency options yielded the following results. This analysis focuses on the first three elements – simplify and streamline lighting management, improve controllability of the system, advance energy efficiency – when evaluating alternatives.

Funding Mechanisms

After surveying available funding mechanisms, we selected four options for detailed analysis and comparison. We identified these funding options (streetlight fee, property tax levy, streetlight adoption, and lighting districts) based on the Department of Public Works' staff preferences and the level of success these systems have achieved in other municipalities. Analysis of these options was performed using the following criteria: cost of implementation, ease of implementation, cost of operation, and equity.

The cost of implementation measures the amount of resources required to employ each funding mechanism. This concept includes the costs of program and policy development and delivery. Our discussion of program implementation costs includes labor costs, such as hiring new administrative staff, and operational expenses, such as office supplies or the use of streetlight maintenance equipment.

To evaluate the difficulty of implementing funding mechanisms, we identified the degree to which significant barriers to designing or administering programs and policies exist.

The cost of operation evaluates the resources required to monitor, control, and evaluate programs and policies. Similar to cost of implementation, this concept involves measuring labor and operational resources.

Equity, as used in this analysis, refers to the distribution of the financial burden that different revenue-raising mechanisms place on Salem residents and business owners. We used this criterion to determine the fairness of the various streetlight-funding options available to the city. Salem's streetlights represent a pure public good, from which all residents and businesses derive indistinguishable utility. Under this assumption, equity measures the degree to which a funding mechanism places the same costs on all residents and businesses and provides everyone with the same quantity of illumination. When making recommendations, we favor systems with a higher degree of equity.

Figure 5 (below) summarizes the results of our analysis of the four funding mechanisms. Ordinal values were assigned to these results to allow comparison of qualitative information in a single matrix. This very general analysis highlights the low costs and high equity associated with a streetlight fees as compared to the other options. The subsequent discussion sections provide more detailed evaluations of options.

Streetlight Fee

Implementation and Operation

Creating a direct fee for the provision of streetlighting is a low-cost option for the city to implement. The collection of a small monthly "streetlight fee" would be very expensive if the city decided to create a separate bill for the collection of the fee, but adding the charge to existing billing infrastructure would produce

Funding Mechanism	Cost of Implementation	Difficulty of Implementation	Cost of Operation	Equity
Streetlight Fee	Lowest	Low	Lowest	Highest
Property Tax Levy	Low	Lowest	Highest	High
Streetlight Adoption	High	Highest	High	Lowest
Lighting Districts	Highest	High	Low	Low

Figure 5: Funding Mechanism Evaluation (Ranked by Category)

very little additional costs to the city. Difficulty of implementation is relatively low with a flat-rate user fee. A simple calculation to determine the fee rate can be done by dividing the number of Salem households and businesses by the cost of streetlighting. These numbers are already known to the city, and therefore would allow for the city to easily establish a monthly streetlight fee that is directly related to the cost of provision. This method is also extremely low cost for future operation. By adding the fee to another utility billing, or implementing a "pass-through," the city is able to pass the cost of collection to another entity.

Equity

Charging a flat user fee is the most equitable form of tax collection on an entity-to-entity basis, charging all residents and businesses the same fee for the same service. This method ensures equity between residents and businesses as well. All entities pay the same fee for the same use of the public good (lighting) that streetlights provide.

Property Tax Levy

Implementation and Operation

As a streetlight funding mechanism, property tax levies are generally associated with the lowest difficulty of implementation. In Salem's current financial climate, including a streetlight charge in local property taxes may be much more difficult. The Oregon Constitution places a limit on households' property tax burden. If a household's property taxes exceed this limit, Salem must "compress" the amount owed. When in compression, localities must reduce local option taxes, such as a streetlight fee, first (Oregon Department of Revenue, 2011). Many households in Salem currently face compression. Under these circumstances, implementing a streetlight fee via property tax levy may be more difficult and will likely fail to generate the revenue needed to finance Salem's streetlights.

One particular advantage of the property tax levy is that households and businesses are responsible for only one payment per year and county offices are responsible for the collection of the tax. This creates minimal implementation and operational costs for Salem. Other considerations for implementing and operating a property tax levy are similar to the monthly fee previously discussed.

Equity

Adding a streetlight charge to property taxes is associated with moderate equity by placing the entire tax burden on landowners. This method requires landowners to directly pay the streetlighting fee, which may or may not be passed on to renters. In this situation, the city would create an extra burden on property taxpayers as well as short-term inequality where rental rates are currently under contract.

Streetlight Adoption

Implementation and Operation

While the implementation of a streetlight adoption program does not require the development of elaborate tax administration systems, there are moderate administrative costs associated with this mechanism. To establish an adoption program, the city must develop criteria and identify which streetlights are "unnecessary;" such lights would be available for adoption. With more than 10,000 lights currently in operation, this process will likely require considerable time and, most likely, new staff to develop and manage the program. The city's lack of ownership of all streetlights may make the process of evaluation easier (fewer lights to examine); however, this will reduce the cost savings.

Another important cost to consider is the fee to retire and re-illuminate streetlights. Under a streetlight adoption program, the city must incur costs to turn off streetlights identified as unnecessary, in addition to the fee to re-illuminate adopted lights. According to the Department of Public Works, streetlights cost the city $75 to turn off and another $75 to switch back on.

The cost to operate this system relies on the amount of participation from residents and businesses. Because the financial burden will fall on only some people, there will most likely be lower long-term compliance and administrative costs. This method's primary advantage is the flexibility it provides the city to determine the exact level of savings they will achieve. Each light has a specific power consumption rate. Examining the desired rate savings in conjunction with the desired cost saving will allow the city to provide the level of lighting they prefer. The method allows residents, businesses, and the city flexibility because any streetlight can be re-illuminated with sponsorship. This means that if a person felt that their street needed to be fully lit, they could pay for the city to use the lights.

Equity

Streetlight adoption fails to satisfy the equity criteria. With this program, a segment of the population will bear higher financial responsibility for the streetlight operations. In addition, low-income residents may be unable to pay to sponsor the lights that they value, creating inequity in provision.

Lighting District

Implementation and Operation

This method of streetlight finance is associated with low operations costs, but moderate implementation costs and low ease of implementation. The primary barrier to implementing a lighting district policy involves the formation of districts. There are two ways for Salem to form lighting districts. First, the city may require new development areas to provide their own streetlights and continue to finance existing lights. This policy is expected to incur relatively low implementation and operations costs, but fails to significantly reduce the burden of streetlight operations. Alternatively, the city may relinquish control of all lights and allow residents and businesses to form districts. This system removes the financial burden of streetlighting from the city and requires low operational costs. In terms of implementation, this method will likely incur high costs to facilitate lighting district formation and contracts with utilities. In addition, this method will likely generate labor and resource costs to retire and re-illuminate streetlights.

Equity
The lighting district model creates significant inequity among residents. Special service districts develop to independently provide a good or service that their municipality is not providing. Historically, these districts are not used to provide public goods. If the city implemented lighting districts for the entire city, individual areas would take on different portions of streetlight operations cost but experience equal public good benefits. This creates problems of free riders and inconsistent distribution of illumination throughout the city.

Acquisition of Salem Option A

In order to evaluate Salem's option to purchase streetlights owned by the utilities, we calculated the net annualized cost savings associated with the investment. This analysis determined the simple payback period, discounted payback period, net present value, and internal rate of return on a prospective $90,356 investment in acquiring the Salem Option A streetlight segment. An acquisition of the PGE owned lights (PGE Option A segment) was not evaluated because PGE is not willing or able to sell the lights that are currently under contract with Salem.

As seen in Figure 6 (below), acquisition at the current purchase price of $90,355.62 produces a net present value (NPV) of $18,274 assuming an 11-year life and 4% discount rate. This acquisition would have a discounted payback period of 8.79 years and save the city $12,400 per year. These annual savings include the projected gain from lower maintenance costs that Salem would realize if this additional 5% of streetlights were under the city's control. This does not include any efficiency improvements that Salem would be able to implement by upgrading these lights at a future point, which would be possible when these lights are owned by the city.

Discount Rate Selection

The objective of NPV analysis is to determine the net present value of the discounted cash flows of an investment. Selecting an appropriate discount rate requires consideration of what can be earned on alternate investments of comparable risk and return. Knowing the difference between the discounted payback period and the simple payback period can make a critical difference in selecting an investment with a positive, rather than a negative, NPV. The objective of the investor is to only undertake investments with a positive NPV where the internal rate of return exceeds the discount rate (Brealey and Myers, 2003).

Several models exist for selecting the appropriate discount rate when analyzing a public investment. In light of the low risk associated with the Salem Option A acquisition, an argument for the application of a 1% discount rate could be made. The federal Office of Management and Budget (OMB) suggests the use of a 7% discount rate for public projects (OMB Circular A94, 1992). David F. Burgess and Richard O. Zerbe (2011) suggest that "the social opportunity cost of capital (SOC) is superior to other suggested approaches in its generality and its ease of use," and recommend the use of a "range of real rates that vary between 6% and 8%."

For the analysis of the prospective Salem Electric acquisition, the research team utilized a 4% discount rate, as it represents a midpoint between a 1% discount rate reached through the Brealey and Myers theory, and the 7% rate suggested by Circular A94 and supported by Burgess and Zerbe. The selection of 4% as the applicable discount rate is predicated on the interest rate obtainable on comparable investments of similar risk and return levels. Since the acquisition would essentially consist of a title transfer, the associated risks are relatively low. The reliability of the Salem Option A lighting segment is also well known, and the assumption of maintenance related risks are no greater than those currently borne by Salem Public Works.

	Discount Rate			
	1%	4%	7%	10%
Net Present Value	$38,203	$18,274	$2,628	($9,817)
Discounted Payback Period	7.60 years	8.79 years	10.55 years	13.69 years

Figure 6: Sensitivity Analysis for the Acquisition of Salem Electric Option A Lights

The influence of discount rates over payback periods can be discerned in Appendices B, D, E, and F. Figure 6 illustrates the impact of various discount rates on a prospective investment of $90,356 and associated annual savings of $12,400 over an 11-year project life with an associated simple payback period of 7.29 years.

Efficiency Mechanisms

The research team conducted a second NPV analysis of the potential $90,259 investment in 131 LED upgrades within the PGE Option C segment of Salem's streetlight system. This presents an alternative to the prospective $90,356 investment in acquiring the Salem Electric Option A lighting segment. Unproven service lives of LEDs in the field are accompanied by greater risk and uncertainty, which led the research team to select a 7% discount rate. This rate is in alignment with OMB Circular A94 and supported by Burgess and Zerbe.

The city can feasibly obtain an energy savings rate of 35% by investing in a 120W LED Array fixture by Holophane (K. Fough, personal communication, May 5, 2011). These LEDs would replace 131 of the 250W HPS luminaires currently owned and maintained by the city. While the energy savings of the LEDs is indisputable, the LED fixture cost is high, at $600 each. Holophane LEDs have a 5 year warranty, but this does not include the cost of labor for their replacement (K. Fough, personal communication, May 5, 2011). The research team estimates that roughly 20% of the 131 fixture pilot program LEDs (26) would require replacement during the warranty period (see schedule in Appendix C2). We expect the number of remaining LED fixtures requiring replacement beyond the warranty period to increase annually as they approach their estimated maximum service life of 11.41 years. While LED prices will likely decline over time, replacement after the warranty period would be entirely at the city's expense. See Appendices C1 and C2 for further computational assumptions building to the expected net annualized savings of $8,244.09.

	SE Option A Acquisition (Prospective)	LED Upgrades @35% Energy Savings: (Prospective)	LED Upgrades @50% Energy Savings: (Theoretical)	LED Upgrades @70% Energy Savings: (Theoretical)
Investment	$90,356	$90,259	$90,259	$90,259
Net Annualized Savings	$12,400	$8,244	$10,534	$13,587
Project Life (years)	11	11	11	11
Discount Rate	4%	7%	7%	7%
Simple Payback Period	7.29 yrs	10.95 yrs	8.57 yrs	6.64 yrs
Discounted Payback Period	8.79 yrs	21.50 yrs	13.54 yrs	9.25 yrs
Net Present Value	$18,274	($28,439)	($11,270)	$11,622
Internal Rate of Return	7.58%	0.08%	4.41%	9.51%

Figure 7: Salem Electric Option A Acquisition vs. PGE Option C LED Upgrades

The NPV analysis of a prospective investment in 131 LEDs at a 35% energy savings rate is presented in Appendix D. At the city's request, two additional LED investment scenarios were also created, at increased annual energy saving rates of 50% and 70%, with all other variables held constant. NPV analyses for these two theoretical investments are presented in Appendices E and F. Figure 7 presents the financial performance metrics for each prospective and theoretical investment alternative. In addition, Figure 8 graphically presents the ranges of NPV of these investments at different discount rates.

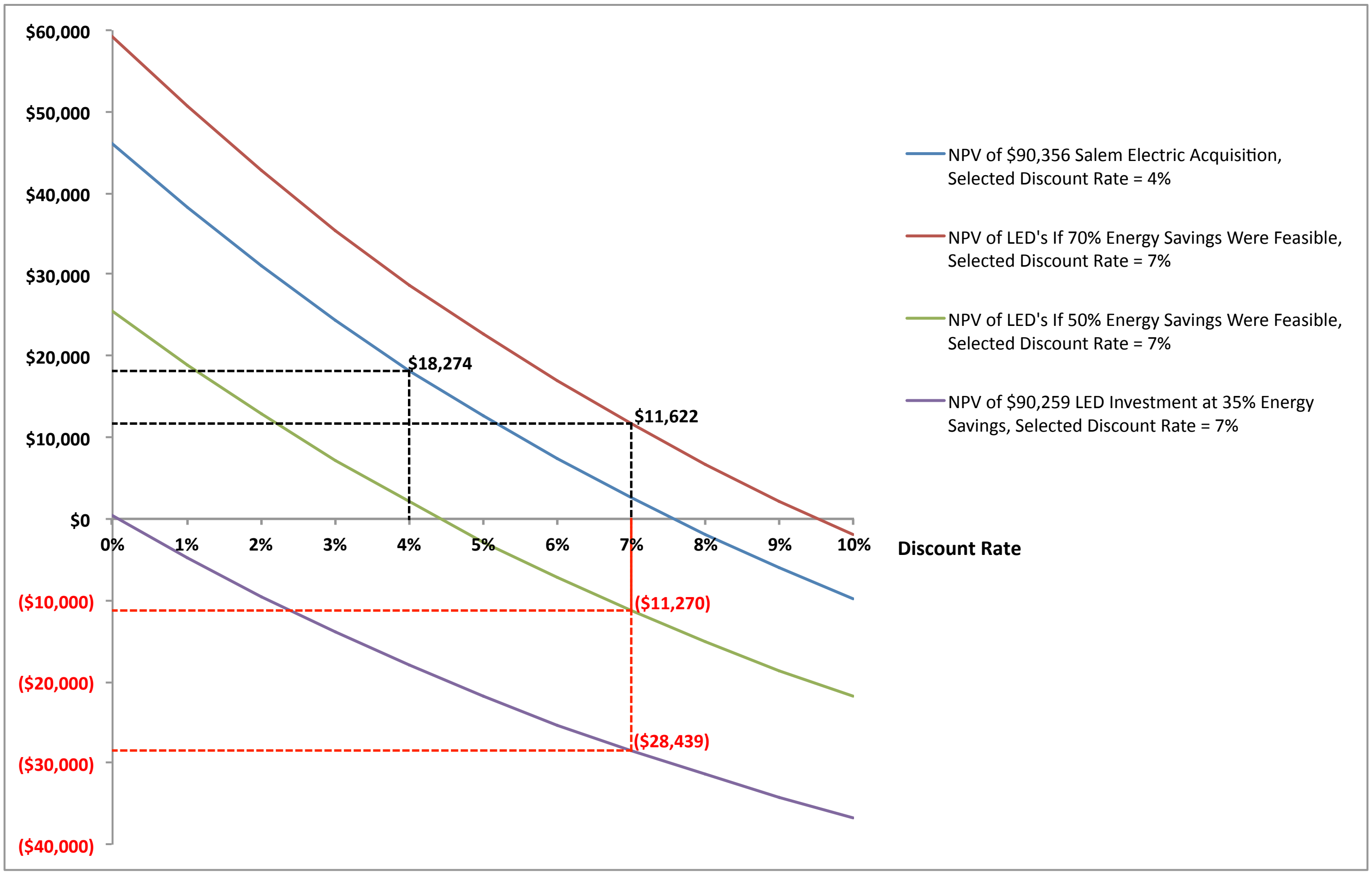

Figure 8: Net Present Values of Four Investment Scenarios at Various Discount Rates

Recommendations

These findings have led us to the following policy recommendations, which we feel have the greatest potential to benefit the Public Works Department and the city at large. Adoption of these recommendations is expected to have positive impacts on Salem, such as improved road conditions, increased cost-efficiency of streetlight operations, and decreased energy consumption. The first recommendation, implementation of a streetlighting fee, is the primary city action that the research team proposes. The subsequent recommendations are secondary steps.

Implementation of a Streetlighting Fee

The most cost-effective streetlight funding option available to Salem is the establishment of a $1.50 per month streetlight fee. The research team recommends this option based on its low administrative costs, ease of implementation, and ability to raise sufficient revenue.

A primary benefit of this funding mechanism is the capacity to easily generate the revenue needed to fully finance the city's streetlight operation costs. A fee of $1.50 per month would generate more than sufficient revenue to fund streetlights at current levels. This burden would not exceed $18 per year per address and is not expected to have a substantial impact on any individual or group of people. $18 represents approximately 0.04 percent of Salem's median annual household income (US Census Bureau, 2009).

With the direct user fee, there is technically no cap on the amount of revenue that can be collected. This enables the creation of a financially sustainable fund that will pay for the streetlights at any level the city desires. This fund will be discussed in greater detail in the Capital Charges section. Other advantages that this fee structure provides are the possibility for upgrades to infrastructure and the ability to adjust the fee annually.

Based on our evaluation of existing systems and the preferences of the City of Salem Department of Public Works, the most effective streetlight fee format will uniformly charge city residents and businesses, regardless of their perceived level of benefit from streetlights.

Municipalities across Oregon and the nation have successfully implemented direct streetlight fees. Tualatin, for example, collects a "Road Utility Fee" from all city residents and businesses through their the monthly water and sewer bill and distributes bills to those within city limits who do not have a water/sewer bill. This fee covers the cost of streetlight operations and other street maintenance needs. Tualatin's system allows for changes to be made rapidly; in 2005, the fee was increased by $0.50 monthly for sidewalk repair and tree replacement (City of Tualatin Website, 2011). The City of Conneaut, Ohio implemented a similar system but generated controversy by only charging a fee to addresses within 500 feet of a streetlight. This implementation decision created resentment from residents based not only on inequity in levying the fee, but on lost revenue from households outside of the 500-foot fee zone. We recommend that the City of Salem consider the implications of the distribution of user fees when evaluating revenue options.

Delivery Mechanism

Because it is inefficient to bill such a small charge separately, we recommend that Salem include their streetlight fee with existing utility fees. Bundling is a common and successful delivery method for cities that employ a monthly streetlight fee. This delivery mechanism allows municipalities to use existing billing systems, providing ease of implementation and generating maximum revenue per dollar collected. Some cities include their streetlight fee with municipal water/sewer bills, while others contract local power utilities to collect the fee through their monthly billing.

The research team recommends that Salem consider contracting the local electric utilities to administer the streetlight fee. While water/sewer billing infrastructure exists, the system would not allow the city to bill every household separately with as much ease. Some multifamily units are billed collectively, reducing the ease with which the streetlight fee can be more equitably administered.

Capital Charges

A final implementation strategy recommended for Salem is the inclusion of a capital improvement charge with the monthly streetlight fee. By charging an additional fee of $0.25 - $0.50 per address per month, the city can generate a streetlight capital fund. A charge of $0.25 per month could generate over $250,000 annually. This revenue can provide Salem with resources necessary to make energy efficiency upgrades and install lights in under lit areas around the city. These increases in energy efficiency are expected to lower streetlight operations costs, allowing the rate of the streetlight fee to fall over time. Tualatin provides an example of a successful capital improvement fee and the flexibility it affords the city in provision of services. The rate of a capital improvement fee is more difficult to calculate but will positively address the public “buy in” problem that cities face in implementing and operating a fee system for streetlights.

Acquisition of Salem Option A Lights

Based on the expected annual savings of $12,400 associated with the acquisition of Salem Option A lights, we recommend that the city consider purchasing these lights from Salem Electric now, for $90,356. This investment meets the positive NPV test and has the highest NPV among the current alternatives. Another aspect of this opportunity that bears consideration is that it might not be available in the future. The research team expects this investment to produce positive returns after 8.79 years. Additionally, the city may regard the

Salem Electric Option A acquisition as a long-term investment enabling future upgrades to LEDs; which would be under city control only through ownership.

Postpone LED Upgrades for the PGE Option C Segment

While the increased efficiency of LED lighting is indisputable, other factors such as high acquisition costs, escalating LED failure rates beyond the warranty period, and unproven LED service lives limit the expected benefits for the city. With a discounted payback period of 21.5 years, the city would never recover an investment in LEDs if their maximum expected service life is only 11.41 years. Finally, with a negative NPV of $28,439, the city should table any plans for LED streetlight upgrades until prices come down to more acceptable levels. The downward trend in LED fixture prices is expected to continue.

Further technological advances are in development that will allow for greater energy savings than the 35% rate currently obtainable. According to Kelly Fough of Holophane, the next wave of LEDs will be individually programmable, allowing the Department of Public works to dim illumination at desired intervals (Personal Communication, April 21, 2011). This coming innovation holds the potential for sufficient additional energy savings to further offset acquisition costs, lower the discounted payback period, and shift the current negative NPV to positive NPV.

All underlying assumptions, computations, and financial analyses in Appendices C1, C2, D, E, and F can be updated at future intervals to reassess the investment potential of LED upgrades and further innovations, and assure that only positive NPV investments are made.

Additional Considerations

The above recommendations represent the research team's conclusions about the most cost-effective and equitable steps available to Salem. When considering the implementation of our recommendations, the city should keep in mind the implications of levying a new tax on its residents. We recommend that the city consider these aspects when evaluating alternatives and deciding to act on the research team's recommendations.

The Price of Government

As with any government expenditure, public works spending is subject to a certain level of scrutiny from both the public in general and taxpayers in particular. While streetlight costs are a small portion of any individual's total tax burden, Salem should acknowledge that any increase in costs passed on to community members comes with a degree of public resistance.

In The Price of Government (2004), David Osborne and Peter Hutchinson state that the total amount a community is willing to spend on government services is constrained within a narrow range. This means that any significant increase in one area of fee or tax collections needs to be offset by a corresponding decrease in another area. For example, Oregonians have voted repeatedly to limit base property taxes levels, but there has been a gradual increase in the amount of income tax collected. The Oregon Business Council has calculated that the total "price" of government Oregonians have supported has remained remarkably consistent over the past 30 years when measured as a percentage of personal income (Oregon's Challenge, 2011). Any new fee collected for streetlights will add to the current burden Salem residents must pay. While the fee is a small portion of average household income, it is reasonable to expect some degree of backlash from residents and business owners.

The Opportunity Cost of Government

The Public Works Department is not alone in their financial challenges. The city as a whole faces extremely limited resources, and it is important to consider the financial implications of diverting resources to streetlight funding on all other city departments and functions. While the Public Works Department has identified streetlight operations as their preferred means of addressing budgetary concerns, the needs of all projects and all departments must be considered. This idea is important because taxpayers have a tax cap, or a limit, on how much they are willing to spend for public goods (Browning, 1976).

The Nature of Public Goods

According to economic theory, streetlighting is a pure public good. The use of a streetlight by one individual does not preclude another's use (it is non-rival), nor is it possible to limit the benefits to only those individuals who have paid for them (it is non-excludable) (Stiglitz and Walsh, 2002). When individuals cannot be prevented from enjoying the benefits of a good, there is little incentive for private provision. Consequently, the provision of streetlighting falls within the scope of city government.

When considering the implementation of a new streetlight funding mechanism, the city must consider its authority and responsibility to provide public goods. While economic theory concerning public goods will not prevent public resistance to new fees or taxes to support public streetlighting, it is unlikely that one could expect private provision of these services absent a legal or regulatory requirement to do so. (Note that this applies to public streetlighting but not necessarily private lighting, such as that found in shopping centers, industrial parks, and other non-public areas.)

Conclusion

Several funding, ownership, and efficiency mechanisms are available to Salem to increase the sustainability of its streetlighting system. Through qualitative and financial analysis, the research team identified three recommended actions Salem can take at this time:

- Implement a direct “streetlight fee.”
- Purchase Salem Option A lights.
- Postpone investments in LED or other energy efficiency technology.

Although the City of Salem has a unique finance and ownership structure, this report highlights decision-making calculus that can be applied to numerous other municipalities facing similar problems. The recommendations made throughout the report serve to answer the underlying research questions established by the University of Oregon students and the City of Salem.

Appendix

Appendix A: Public Works reports to City Council

FOR COUNCIL MEETING OF: December 14, 2009
AGENDA ITEM NO.: 7 (c)
PUBLIC WORKS FILE NO.:

TO: MAYOR AND CITY COUNCIL
THROUGH: LINDA NORRIS, CITY MANAGER
FROM: PETER FERNANDEZ, P.E., PUBLIC WORKS DIRECTOR
SUBJECT: SALEM AREA STREET LIGHTING INFORMATION

ISSUE:

How are street lights installed, managed, and maintained in the City of Salem?

RECOMMENDATION:

Information only.

BACKGROUND:

This report has been prepared in response to a City Council request for more information regarding the costs of the City's street light system. There are two electric utilities in the Salem area with a combined total of 10,473 street lights within the Salem city limits. There are 2,168 street lights within the Salem Electric service area. That area includes most of West Salem, a portion of the northwest corner of downtown, and the Northgate and Highland neighborhoods in north/northeast Salem. Portland General Electric (PGE) has 8,305 street lights within its service area, which encompasses the rest of Salem.

There are three ownership options for the street lights in the PGE service area:

- Option A - PGE owns and maintains the street light fixture, mast arm, and pole. The City is billed a rental rate for the whole street light system and for electricity costs. There are 2,773 PGE street lights in this option.

- Option B - The City owns the street light system and PGE maintains the system. The City is only billed for maintenance of the system and electricity costs. There are 4,865 PGE street lights in this option.

- Option C - The City owns and maintains the street light system. The City is only billed for electricity costs. Many of these lights are City-owned because they are of a type and design not approved for maintenance by PGE. There are 667 PGE street lights in this option. Of that number, 474 PGE street lights located on traffic signal poles were required to be converted from Option B to Option C in 2009 by the utility.

For both Option B and C, the City must pay for replacement of system components as they age (end-of-life). Electricity costs for all options are billed separately.

There are also three ownership options for street lights in the Salem Electric service area:

- Option A - Salem Electric owns, maintains, and provides electricity for the street lights. There are 538 street lights and 130 poles in this option.

- Option B - The City owns the street lights and systems. Salem Electric provides maintenance and electricity. There are 1,624 street lights in this option.

- Rental - Salem Electric owns and maintains the street light equipment. The City pays for electricity. There are only six street lights in this option.

For Option B, the City must pay for replacement of system components as they age (end-of-life).

FACTS AND FINDINGS:

1. How are new street lights acquired and paid for?

It is a City code requirement (SRC 63.245) that all new street lights installed within a subdivision or with a street improvement project are Option B street lights.

Maintenance and electricity costs for street lights are funded with the City's allocation of the State Highway Fund (gas tax) revenues. In FY 2008-09, the City received $5,910,000 in State Highway Fund revenues. Twenty percent of those revenues were used to pay for street lights ($1,152,600 plus ODOT pays an additional $70,000 for street lights on highways in the City).

2. Would there be cost savings if the City owned all of the street lights?

In 2000, a *Feasibility Study: Municipal Street Light Acquisition* was prepared for the City by R. W. Beck. This study compared operation and maintenance costs for the three ownership options. The study determined that it would cost approximately $1 million to purchase the Option A street lights (3,445 street lights) from the utilities. Based on the results of the study, there were three recommendations:

a. At that time, the City would realize a cost savings by acquiring the street light systems.

b. The City should evaluate all of its street light options. For the short term, the easiest option would be to continue to have the utilities maintain the systems as Option B street lights. City staff maintenance or contractor maintenance may be a better long-term option.

c. The City should monitor activities at the Oregon Public Utilities Commission regarding electric utility issues that may impact the City.

Since 2000, the number of street lights in the City has increased from 6,879 to 10,473; a 52 percent increase.

PGE System

Using 2009 rates for maintenance and electricity, the City will pay PGE approximately $372,000 for Option A lights, approximately $537,000 for Option B lights, and approximately $72,000 for Option C lights.

It should be noted that, since the 2000 Feasibility Study, PGE is no longer willing to sell its Option A lights. This changed the cost/benefit ratio considerably.

The only option available for the City to potentially save costs would be to take over maintenance responsibility by converting the Option B lights to Option C lights. The savings in maintenance costs from PGE would be approximately $172,200 per year. However, there are offsetting costs to do this conversion:

1. PGE requires circuit disconnects on all of the Option B lights before they could become Option C lights. To physically convert all of the PGE street lights from Option B to Option C could cost up to $1,459,000. if every Option B pole needed a disconnect.

2. The City would need to be able to maintain the additional 4,865 street lights. That could be done by either hiring more staff, or by using an electrical contractor of record:

   a. If the City were to use its own staff, the following expenditures would be required:[1]

Item	Annual Cost
Hire an additional electrician.	$90,000
Purchase and fleet rental of a bucket truck	15,000
Bulb and photo cell replacement	31,200
Fixture replacement	73,000
Pole replacement	121,500
Total	$330,700

   b. If the City were to use an electrical contractor of record, assuming a five-year relamping, the following expenditures would be required:

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Item	Annual Cost
Labor and equipment	$65,000
Bulb and photo cell replacement	31,200
Fixture replacement	73,000
Pole replacement	121,500
Total	$290,700

Based on PGE's economy of scale, both of these options are more expensive than the status quo.

Salem Electric

Using 2009 Salem Electric rates for maintenance and electricity, the City will pay Salem Electric approximately $76,900 for Option A street lights, approximately $159,000 for Option B street lights, and approximately $570 for Rental street lights.

Salem Electric will allow the purchase of the 538 Option A street lights and 130 street light poles for $80,440.28. This represents a depreciated book cost based on an estimated life value of these facilities of ten years on a 25-year full life value.

It is estimated that the City would save approximately $26,200 in maintenance costs per year converting Option A street lights to Option B. However, the City would now be responsible for end-of-life replacement costs of these street lights. The annualized replacement cost would be approximately $13,800 over the 25-year life span that Salem Electric uses.

Based on the cost of the purchase and replacement costs, verses the yearly savings in maintenance payments to Salem Electric, the City would realize a combined savings of $12,400 per year by purchasing the Option A street lights. This action would pay for itself after 6.5 years.

Mark Becktel, AICP
Parks and Transportation Services Manager

Attachment: Purchase quote from Salem Electric
Wards: All

Prepared by: Kevin Hottmann, City Traffic Engineer

[1] Some of these expenditures are annualized for comparison.

KH:AB/JP:G:\GROUP\DIRECTOR\ANN\COUNCIL 09\REPORTS\2009DEC14\SALEMAREASTLIGHTINGINFO2.DOC

633 SEVENTH STREET NW / PO BOX 5588 / SALEM, OREGON 97304-0055 / 503 362-3601 / FAX 503 371-2956

Salem Electric
SERVING KEIZER AND SALEM

November 25, 2009

Mr. Kevin Hottmann
City of Salem
555 Liberty St. SE, Rm. 325
Salem, OR 97301

Dear Mr. Hottmann:

Per your e-mail request, I understand the City of Salem is interested in purchasing the Salem Electric-owned streetlights located within the City of Salem. We have provided most of the information requested by e-mail, but feel a written response is appropriate.

Salem Electric will sell these facilities to the City with the understanding that Salem Electric will provide the necessary maintenance and energy under Schedule 4, Street and Highway Lighting. Maintenance will be limited to replamping, cleaning, and PE cell replacement. A copy of this schedule is enclosed.

Our records indicate that the City rents 538 streetlights from Salem Electric (SE) with an average book cost of $223.56 per light. This is a 37% increase from the year 2000 quote since labor and material have increased an average of over 4% per year for the past 9 years. In addition to streetlights, the City rents 130 streetlight-only (SLO) poles from SE with an average book cost of $583.99. This represents an 18% increase from the year 2000 quote since its labor and material costs have also increased. SE will agree to sell these facilities at the depreciated book cost. It is estimated the remaining life value of these facilities is 10 years based on a 25-year full life value. The year 2000 quote used a remaining life value of 6 years. In the past 9 years SE has replaced many streetlights and poles reducing their system-wide average age. Therefore, after applying the depreciation, the average sale price is $91.66 per light and $239.44 per SLO pole. This results in a sale price of $80,440.28.

If you have any additional questions, please feel free to contact me.

Sincerely,

Roger Kuhlman, P.E.
Engineering & Operations Manager

dh
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633 SEVENTH STREET NW / PO BOX 5588 / SALEM, OREGON 97304-0055 / 503 362-3601 / FAX 503 371-2956

Salem Electric
SERVING KEIZER AND SALEM

March 7, 2011

Mr. Kevin Hottmann
City of Salem
555 Liberty St. SE, Rm. 325
Salem, OR 97301

Dear Mr. Hottmann:

I understand the City of Salem is once again interested in purchasing the Salem Electric-owned streetlights located within the City of Salem.

Salem Electric will sell these facilities to the City with the understanding that Salem Electric (SE) will provide the necessary maintenance and energy under Schedule 4, Street and Highway Lighting. Maintenance will be limited to replamping, cleaning, and PE cell replacement. A copy of this schedule is enclosed.

Our records indicate that the City rents 538 streetlights from SE with an average book cost of $250.20 per light. This is a 1% increase from the 2009 quote since labor and material have increased an average of over 4% per year for the past 10 years. In addition to streetlights, the City rents 130 streetlight-only (SLO) poles from SE with an average book cost of $611.49. This represents a 1% increase from the 2009 quote since its labor and material costs have also increased. SE will agree to sell these facilities at the depreciated book cost. It is estimated the remaining life value of these facilities is 11 years based on a 25-year full life value. Therefore, after applying the depreciation, the average sale price is $110.09 per light and $269.04 per SLO pole. This results in a sale price of $90,355.62.

If you have any additional questions, please feel free to contact me.

Sincerely,

Roger Kuhlman, P.E.
Engineering & Operations Manager

dh
Enc
WkuL

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Appendix B - Salem Electric Option A System Acquisition

NET PRESENT VALUES OF THE DISCOUNTED CASH FLOWS FOR A GIVEN PROJECT, AT VARIOUS POSSIBLE PROJECT LIVES, DISCOUNT RATES; AND INTERNAL RATES OF RETURN

		"Undiscounted" Simple Payback	Discount Rate (aka "opportunity cost of capital" and "hurdle rate"):									
		0%	**1.0%**	**2.0%**	**3.0%**	**4.0%**	**5.0%**	**6.0%**	**7.0%**	**8.0%**	**9.0%**	**10.0%**	**IRR:**
Project	**20**	132,844	112,983	95,546	80,188	66,620	54,595	43,907	34,377	25,856	18,214	11,342	**11.91%**
Life:	**19**	132,844	112,983	95,546	80,188	66,620	54,595	43,907	34,377	25,856	18,214	11,342	**11.91%**
	18	120,444	102,616	86,864	72,904	60,499	49,443	39,562	30,708	22,753	15,585	9,112	**11.60%**
	17	108,044	92,146	78,008	65,402	54,133	44,033	34,957	26,783	19,401	12,720	6,658	**11.22%**
	16	108,044	92,146	78,008	65,402	54,133	44,033	34,957	26,783	19,401	12,720	6,658	**11.22%**
	15	95,644	81,571	68,975	57,675	47,512	38,352	30,076	22,583	15,782	9,597	3,960	**10.76%**
	14	83,244	70,890	59,762	49,716	40,627	32,388	24,902	18,088	11,873	6,193	991	**10.20%**
	13	70,844	60,103	50,364	41,518	33,466	26,125	19,418	13,279	7,651	2,482	-2,274	**9.51%**
	12	58,444	49,207	40,779	33,074	26,019	19,549	13,604	8,134	3,092	-1,563	-5,866	**8.66%**
	11	46,044	38,203	31,001	24,377	**18,274**	12,644	7,442	2,628	-1,832	-5,971	-9,817	**7.58%**
	10	33,644	27,089	21,028	15,419	10,219	5,394	909	-3,263	-7,151	-10,777	-14,163	**6.21%**
	9	21,244	15,863	10,856	6,192	1,842	-2,219	-6,015	-9,567	-12,894	-16,015	-18,944	**4.45%**
	8	8,844	4,525	480	-3,311	-6,870	-10,212	-13,354	-16,312	-19,097	-21,724	-24,203	**2.12%**
	7	-3,556	-6,926	-10,103	-13,100	-15,930	-18,605	-21,134	-23,528	-25,797	-27,947	-29,987	**-0.99%**
	6	-15,956	-18,492	-20,898	-23,182	-25,353	-27,417	-29,381	-31,251	-33,032	-34,730	-36,350	**-5.28%**
	5	-28,356	-30,173	-31,909	-33,567	-35,153	-36,670	-38,122	-39,513	-40,846	-42,124	-43,350	**-11.37%**
	4	-40,756	-41,971	-43,140	-44,264	-45,345	-46,386	-47,388	-48,354	-49,285	-50,183	-51,049	**-20.32%**
	3	-53,156	-53,887	-54,595	-55,281	-55,944	-56,587	-57,210	-57,814	-58,400	-58,968	-59,519	**-33.99%**
	2	-65,556	-65,923	-66,280	-66,629	-66,968	-67,299	-67,622	-67,936	-68,243	-68,543	-68,835	**-55.46%**
	1	-77,956	-78,078	-78,199	-78,317	-78,433	-78,546	-78,658	-78,767	-78,874	-78,979	-79,083	**-86.27%**

Cash flow inputs:
-90,356
12,400

Simple Payback Period: **7.29 years (90,355.62 / 12,400 = 7.29)**
Discounted Payback Period: **8.79 years**
The Net Present Value rule: **"Only invest in projects with a positive net present value"**
The Internal Rate of Return rule: **"Only invest in projects where the internal rate of return exceeds the hurdle rate."**

Adapted from Brealey, R. A., & Myers, S. C. (2003) *Principles of Corporate Finance, Chapter 5: Why Net Present Value Leads to Better Investment Decisions.* New York: McGraw-Hill.

Appendix C1: LED Efficiency - A Current Investment Alternative and Two Future Scenarios

Pilot Proposition: Replace 131 250W HPS Luminaires with 120W LED Array Fixtures

	Current Infrastructure:	Upgraded Infrastructure:		
Luminaire Class:	**250W HPS LC 36**	**LED's @35% Energy Savings (Feasible Now)**	**LED's When 50% Energy Savings Becomes Feasible**	**LED's When 70% Energy Savings Becomes Feasible**
Wattage	250W Cobra	120W LED Array	Future LED	Future LED
Annual power (operating) cost per luminaire	$ 116.52	$ 75.74	$ 58.26	$ 34.96
Avg. annual replacement costs per luminaire	$ 21.02	$ 25.17	$ 25.17	$ 25.17
Avg. annual labor & related costs per luminaire	$ 36.27	$ 9.97	$ 9.97	$ 9.97
Total ann. op., labor & rel., & repl. costs per luminaire	$ 173.81	$ 110.88	$ 93.40	$ 70.10
Number of luminaires	131	131	131	131
Total ann. op., labor & rel., & repl. costs for 131	**$ 22,769.11**	$ 14,525.02	$ 12,235.40	$ 9,182.58
Net annual op., labor & rel., & repl. savings of LED Pilot:		**$ 8,244.09** (see appendix D)	**$ 10,533.71** (see appendix E)	**$ 13,586.53** (see appendix F)
Investment costs:				
LED cost per fixture	$ 600.00			
Labor & related costs per LED installed	$ 89.00			
Total investment cost per luminaire	$ 689.00			
Number of luminaires in pilot	131			
Total upgrade investment per class	**$ 90,259.00**			

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Appendix C2: Computational Notes and Assumptions Underlying Appendix C1
Pilot Proposition: Replace 131 250W HPS Luminaires with 120W LED Array Fixtures

250W HPS Historic Costs: Review period: 7/01/09 - 6/30/10

Option C LC	Lamp Type	KWH	Monthly Energy Cost	Cost/KWH	Owner	Maint	Segment Count	Annual power cost per 250W HPS luminaire:	Annual power billed by PGE x 131 250W HPS lumin's:	Average annual replace- ment costs = $21.02 x 131 250W HPS lumin's:	Average annual labor & related costs = $36.27 x 131 250W HPS lumin's:	Total annual operating, replace- ment, and labor & related costs for 131 lumin's:
36	250W HPS CC	102	$9.71	$0.10	CUST	CUST	131	$116.52	$15,264.12	$2,753.62	$4,751.37	$22,769.11

Projected Average Annual Replacement Costs of 131 LED's:

	Estimated # of LED failures per year:	Projected LED replace- ment cost per fixture	Cost to replace failed LED fixtures:	Adjust- ments for 5 yr. warranty	Net projected annual replace- ment costs	Projected annual labor & related costs	Total annual replace- ment, labor & rel. costs
Year 1	2	600	1,200	(1,200)	-	178	178
Year 2	3	560	1,679	(1,679)	-	275	275
Year 3	5	522	2,609	(2,609)	-	472	472
Year 4	7	487	3,406	(3,406)	-	681	681
Year 5	9	454	4,083	(4,083)	-	902	902
Year 6	11	423	4,654	-	4,654	1,135	5,789
Year 7	13	394	5,128	-	5,128	1,382	6,510
Year 8	15	368	5,518	-	5,518	1,642	7,160
Year 9	18	343	6,175	-	6,175	2,029	8,204
Year 10	22	320	7,037	-	7,037	2,555	9,592
Year 11	26	298	7,756	-	7,756	3,110	10,865
	131				36,268		
						14,360	
							50,627

/ 11 yrs. / 131 total luminaires = 25.17 per LED avg. ann. replacement. costs 25.17
/ 11 yrs. / 131 total luminaires = 9.97 per LED labor & related costs 9.97
/ 11 yrs. / 131 total luminaires = 35.13 per LED tot. labor and rel. & repl. costs **35.14**

Related underlying assumptions:

1) **Optimal expected service life of an LED is 50,000 hours; = 11.41 years.**
2) **The projected number of LED failures will increase annually; with the entire 131 LED Pilot inventory failing over 11 years.**
3) **The warranty period is 5 years, but replacement labor is not included.**
4) **An initial LED fixture cost of $600, that will decline by 6.75% per year; to $298 per unit in year 11.**
5) **A cost of skilled electrician labor and related expenses of $89.00 per hour that will increase by 3% per year; to $119.61 in year 11.**

Appendix D - Replace 131 250W HPS Luminaires with LED's at 35% Energy Savings

NET PRESENT VALUES OF THE DISCOUNTED CASH FLOWS FOR A GIVEN PROJECT, AT VARIOUS POSSIBLE PROJECT LIVES, DISCOUNT RATES; AND INTERNAL RATES OF RETURN

		"Undiscounted" Simple Payback	Discount Rate (aka "opportunity cost of capital" and "hurdle rate"):										
		0%	**1.0%**	**2.0%**	**3.0%**	**4.0%**	**5.0%**	**6.0%**	**7.0%**	**8.0%**	**9.0%**	**10.0%**	**IRR:**
Project Life:	**20**	74,623	58,510	44,544	32,392	21,781	12,481	4,300	-2,921	-9,317	-15,002	-20,072	**6.58%**
	19	66,379	51,754	38,996	27,828	18,018	9,373	1,730	-5,051	-11,086	-16,473	-21,298	**6.24%**
	18	58,135	44,930	33,337	23,126	14,105	6,111	-995	-7,331	-12,996	-18,077	-22,646	**5.85%**
	17	49,891	38,038	27,564	18,284	10,036	2,685	-3,884	-9,770	-15,059	-19,825	-24,129	**5.40%**
	16	41,646	31,076	21,677	13,296	5,804	-911	-6,945	-12,380	-17,288	-21,730	-25,760	**4.86%**
	15	33,402	24,046	15,671	8,158	1,402	-4,688	-10,190	-15,173	-19,694	-23,806	-27,554	**4.22%**
	14	25,158	16,945	9,546	2,867	-3,176	-8,654	-13,630	-18,161	-22,293	-26,069	-29,527	**3.46%**
	13	16,914	9,773	3,298	-2,583	-7,936	-12,818	-17,277	-21,358	-25,100	-28,536	-31,698	**2.55%**
	12	8,670	2,529	-3,075	-8,197	-12,888	-17,190	-21,142	-24,779	-28,131	-31,225	-34,086	**1.44%**
	11	426	-4,787	-9,575	-13,980	-18,037	-21,780	-25,239	**-28,439**	-31,405	-34,156	-90,259	**0.08%**
	10	-7,818	-12,177	-16,206	-19,935	-23,392	-26,600	-29,582	-32,356	-34,940	-37,351	-39,603	**-1.61%**
	9	-16,062	-19,640	-22,969	-26,070	-28,961	-31,661	-34,185	-36,547	-38,759	-40,834	-42,781	**-3.75%**
	8	-24,306	-27,178	-29,867	-32,388	-34,754	-36,976	-39,065	-41,031	-42,883	-44,629	-46,277	**-6.49%**
	7	-32,550	-34,791	-36,903	-38,896	-40,778	-42,556	-44,237	-45,829	-47,337	-48,767	-50,123	**-10.08%**
	6	-40,794	-42,481	-44,080	-45,599	-47,042	-48,415	-49,720	-50,963	-52,148	-53,277	-54,354	**-14.88%**
	5	-49,039	-50,247	-51,401	-52,503	-53,558	-54,566	-55,532	-56,457	-57,343	-58,192	-59,007	**-21.49%**
	4	-57,283	-58,091	-58,868	-59,615	-60,334	-61,026	-61,692	-62,335	-62,954	-63,550	-64,126	**-30.88%**
	3	-65,527	-66,013	-66,484	-66,940	-67,381	-67,808	-68,222	-68,624	-69,013	-69,391	-69,757	**-44.61%**
	2	-73,771	-74,015	-74,253	-74,484	-74,710	-74,930	-75,144	-75,354	-75,558	-75,757	-75,951	**-64.87%**
	1	-82,015	-82,097	-82,177	-82,255	-82,332	-82,407	-82,482	-82,554	-82,626	-82,696	-82,764	**-90.87%**

Cash flow inputs:		
-90,259	**Simple payback period:**	**10.95 years (90,259 / 8,244.09 = 10.95)**
8,244	**Discounted payback period:**	**21.5 years**
	The Net Present Value rule:	**"Only invest in projects with a positive net present value"**
	The Internal Rate of Return rule:	**"Only invest in projects where the internal rate of return exceeds the hurdle rate."**

Adapted from Brealey, R. A., & Myers, S. C. (2003) *Principles of Corporate Finance, Chapter 5: Why Net Present Value Leads to Better Investment Decisions.* New York: McGraw-Hill.

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Appendix E - Replace 131 250W HPS Luminaires with LED's at 50% Energy Savings

NET PRESENT VALUES OF THE DISCOUNTED CASH FLOWS FOR A GIVEN PROJECT, AT VARIOUS POSSIBLE PROJECT LIVES, DISCOUNT RATES; AND INTERNAL RATES OF RETURN

Project Life:	"Undiscounted" Simple Payback 0%	Discount Rate (aka "opportunity cost of capital" and "hurdle rate"): 1.0%	2.0%	3.0%	4.0%	5.0%	6.0%	7.0%	8.0%	9.0%	10.0%	IRR:
20	120,415	99,828	81,982	66,456	52,898	41,014	30,562	21,335	13,163	5,898	-580	9.91%
19	109,881	91,195	74,893	60,624	48,090	37,044	27,277	18,613	10,903	4,019	-2,145	9.64%
18	99,348	82,476	67,663	54,617	43,090	32,876	23,796	15,701	8,462	1,970	-3,868	9.33%
17	88,814	73,669	60,287	48,429	37,891	28,499	20,105	12,584	5,826	-263	-5,762	8.95%
16	78,280	64,775	52,765	42,056	32,483	23,903	16,194	9,249	2,979	-2,697	-7,846	8.51%
15	67,747	55,791	45,091	35,492	26,859	19,077	12,047	5,681	-96	-5,350	-10,139	7.98%
14	57,213	46,718	37,265	28,731	21,010	14,010	7,652	1,863	-3,417	-8,242	-12,660	7.34%
13	46,679	37,554	29,281	21,767	14,927	8,690	2,993	-2,222	-7,003	-11,394	-15,434	6.56%
12	36,146	28,299	21,139	14,594	8,601	3,104	-1,946	-6,593	-10,876	-14,830	-18,486	5.60%
11	25,612	18,951	12,833	7,205	2,021	-2,762	-7,181	-11,270	-15,059	-18,575	-21,842	4.41%
10	15,078	9,509	4,361	-404	-4,821	-8,920	-12,730	-16,275	-19,577	-22,657	-25,534	2.91%
9	4,544	-27	-4,280	-8,242	-11,937	-15,387	-18,612	-21,629	-24,456	-27,107	-29,595	0.99%
8	-5,989	-9,658	-13,095	-16,316	-19,338	-22,177	-24,847	-27,359	-29,726	-31,957	-34,062	-1.50%
7	-16,523	-19,386	-22,085	-24,631	-27,035	-29,307	-31,456	-33,490	-35,417	-37,243	-38,976	-4.81%
6	-27,057	-29,211	-31,255	-33,196	-35,040	-36,793	-38,461	-40,050	-41,563	-43,006	-44,382	-9.32%
5	-37,590	-39,134	-40,609	-42,018	-43,365	-44,654	-45,887	-47,069	-48,201	-49,287	-50,328	-15.63%
4	-48,124	-49,157	-50,149	-51,104	-52,023	-52,907	-53,759	-54,579	-55,370	-56,133	-56,869	-24.78%
3	-58,658	-59,280	-59,881	-60,463	-61,027	-61,573	-62,102	-62,615	-63,113	-63,595	-64,063	-38.50%
2	-69,192	-69,503	-69,807	-70,103	-70,391	-70,673	-70,947	-71,214	-71,475	-71,729	-71,977	-59.51%
1	-79,725	-79,830	-79,932	-80,032	-80,130	-80,227	-80,322	-80,414	-80,506	-80,595	-80,683	-88.33%

<u>Cash flow inputs:</u>

-90,259
10,534

Simple payback period: 8.57 years (90,259 / 10,533.71 = 8.57)

Discounted payback period: 13.54 years

The Net Present Value rule: "Only invest in projects with a positive net present value"

The Internal Rate of Return rule: "Only invest in projects where the internal rate of return exceeds the hurdle rate."

Adapted from Brealey, R. A., & Myers, S. C. (2003) *Principles of Corporate Finance, Chapter 5: Why Net Present Value Leads to Better Investment Decisions.* New York: McGraw-Hill.

Appendix F - Replace 131 250W HPS Luminaires with LED's at 70% Energy Savings

NET PRESENT VALUES OF THE DISCOUNTED CASH FLOWS FOR A GIVEN PROJECT, AT VARIOUS POSSIBLE PROJECT LIVES, DISCOUNT RATES; AND INTERNAL RATES OF RETURN

		"Undiscounted" Simple Payback	Discount Rate (aka "opportunity cost of capital" and "hurdle rate"):										
		0%	**1.0%**	**2.0%**	**3.0%**	**4.0%**	**5.0%**	**6.0%**	**7.0%**	**8.0%**	**9.0%**	**10.0%**	**IRR:**
Project Life:	**20**	181,472	154,917	131,900	111,874	94,386	79,059	65,577	53,677	43,136	33,766	25,411	**13.95%**
	19	167,885	143,783	122,757	104,352	88,186	73,939	61,341	50,166	40,221	31,342	23,391	**13.75%**
	18	154,299	132,537	113,431	96,604	81,737	68,562	56,851	46,409	37,072	28,700	21,170	**13.52%**
	17	140,712	121,178	103,918	88,623	75,030	62,916	52,091	42,389	33,672	25,819	18,726	**13.23%**
	16	127,125	109,706	94,215	80,403	68,055	56,989	47,045	38,088	30,000	22,680	16,038	**12.89%**
	15	113,539	98,119	84,318	71,936	60,801	50,765	41,697	33,486	26,035	19,258	13,081	**12.47%**
	14	99,952	86,416	74,223	63,215	53,257	44,229	36,028	28,562	21,752	15,528	9,829	**11.96%**
	13	86,366	74,596	63,926	54,233	45,411	37,367	30,018	23,292	17,126	11,462	6,251	**11.32%**
	12	72,779	62,658	53,423	44,981	37,252	30,162	23,648	17,655	12,130	7,030	2,315	**10.52%**
	11	59,193	50,601	42,710	35,452	28,765	22,596	16,896	**11,622**	6,735	2,200	-2,014	**9.51%**
	10	45,606	38,423	31,783	25,637	19,940	14,653	9,739	5,167	908	-3,065	-6,776	**8.22%**
	9	32,020	26,123	20,637	15,527	10,761	6,312	2,152	-1,740	-5,385	-8,804	-12,014	**6.54%**
	8	18,433	13,701	9,269	5,114	1,216	-2,446	-5,889	-9,130	-12,182	-15,060	-17,776	**4.33%**
	7	4,847	1,154	-2,327	-5,611	-8,712	-11,642	-14,414	-17,037	-19,522	-21,879	-24,114	**1.33%**
	6	-8,740	-11,519	-14,155	-16,658	-19,037	-21,298	-23,450	-25,498	-27,450	-29,311	-31,086	**-2.83%**
	5	-22,326	-24,318	-26,219	-28,037	-29,774	-31,436	-33,028	-34,552	-36,012	-37,412	-38,755	**-8.78%**
	4	-35,913	-37,245	-38,525	-39,757	-40,941	-42,082	-43,180	-44,239	-45,259	-46,242	-47,192	**-17.60%**
	3	-49,499	-50,301	-51,077	-51,828	-52,555	-53,260	-53,942	-54,604	-55,245	-55,867	-56,471	**-31.23%**
	2	-63,086	-63,488	-63,880	-64,262	-64,634	-64,996	-65,350	-65,694	-66,031	-66,359	-66,679	**-52.95%**
	1	-76,672	-76,807	-76,939	-77,068	-77,195	-77,319	-77,442	-77,561	-77,679	-77,794	-77,908	**-84.95%**

Cash flow inputs:
-90,259
13,587

Simple payback period: **6.64 years (90,259 / 13,586.53 = 6.64)**
Discounted payback period: **9.25 years**
The Net Present Value rule: **"Only invest in projects with a positive net present value"**
The Internal Rate of Return rule: **"Only invest in projects where the internal rate of return exceeds the hurdle rate."**

Adapted from Brealey, R. A., & Myers, S. C. (2003) *Principles of Corporate Finance, Chapter 5: Why Net Present Value Leads to Better Investment Decisions.* New York: McGraw-Hill.

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