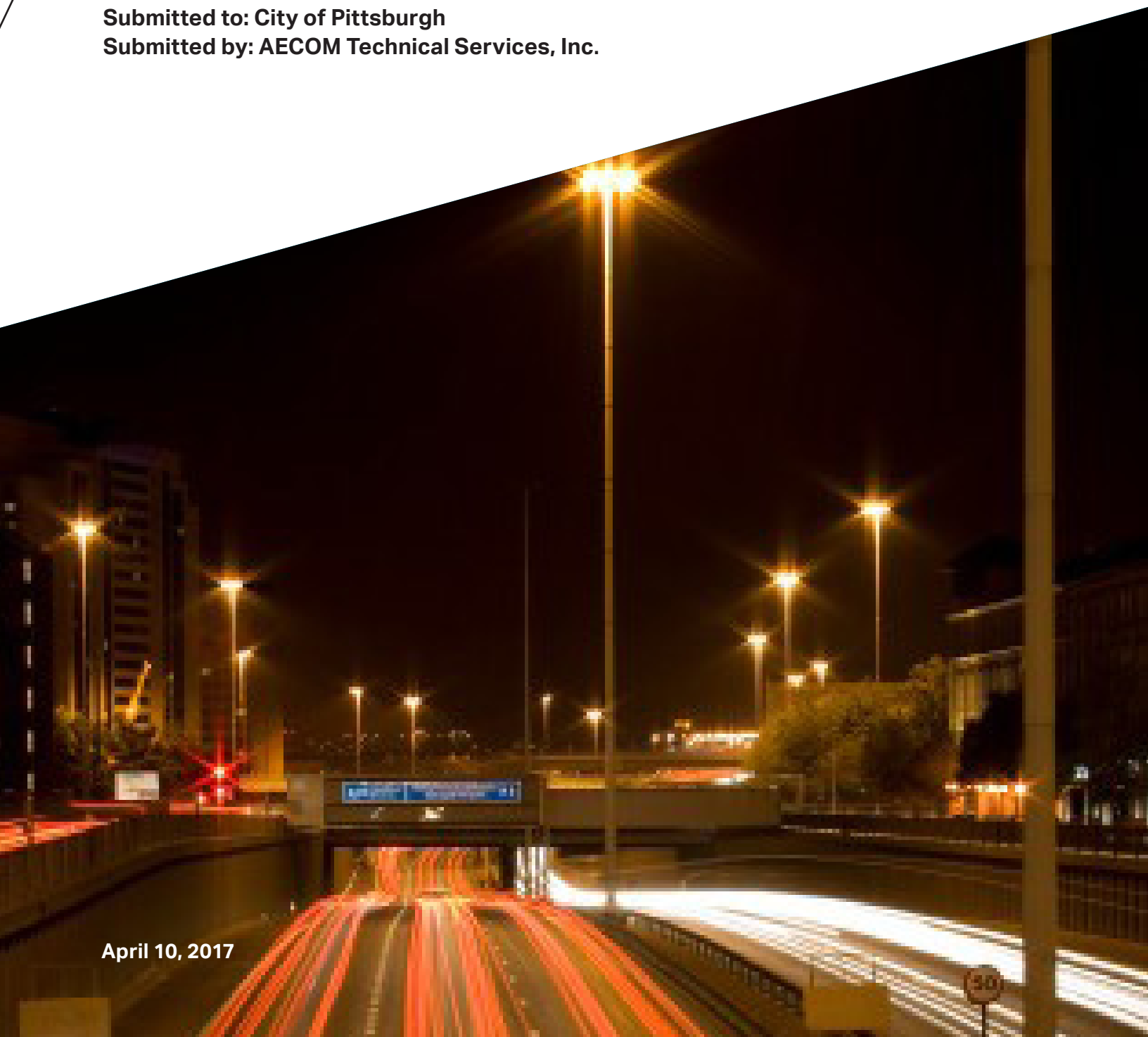
AECOM

Smart Streetlights

Submitted to: City of Pittsburgh
Submitted by: AECOM Technical Services, Inc.



April 10, 2017

AECOM

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April 7th, 2017

Attention: Thoryn Simpson
Senior Procurement Analyst
Office of Management and Budget
City-County Building, Room 502
Pittsburgh, PA 15219

Re: Request for Information (RFI) for Smart Streetlights RFI No. 2017-0001

Dear OMB RFI Coordinator:

AECOM is pleased to submit this response to the City of Pittsburgh for its Smart Streetlights request for Information dated March 2nd, 2017.

AECOM is one of the largest Architectural and Design firms in the World and the US. AECOM is ranked #1 in the ENR Top 500 Design firms and #1 in Transportation and Highway Design.

We have a strong local presence with a large number of experienced professionals in our Pittsburgh and Philadelphia offices. AECOM has a track record of working with Pennsylvania Department of Transportation on many projects throughout Pennsylvania and within the Metropolitan Pittsburgh and Philadelphia.

We look forward to participating in this exciting opportunity.

Sincerely,
AECOM

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Firm’s Qualifications

AECOM Firm Description

AECOM is a premier, fully integrated infrastructure firm, with a broad range of markets, including energy and transportation. AECOM is built to deliver a better world. We design, build, finance and operate infrastructure assets for governments, businesses and organizations in more than 150 countries. As a fully integrated firm, we connect knowledge and experience across our global network of experts to help clients solve their most complex challenges. From high-performance buildings and infrastructure, to resilient communities and environments, to stable and secure nations, our work is transformative, differentiated and vital.

Relevant Experience and Qualifications

AECOM is a leader in integrated planning and engineering solutions for a sustainable energy future. The company’s mission is to help its clients reduce energy and water consumption, develop renewable sources, cut carbon emissions, and improve infrastructure and community resilience.

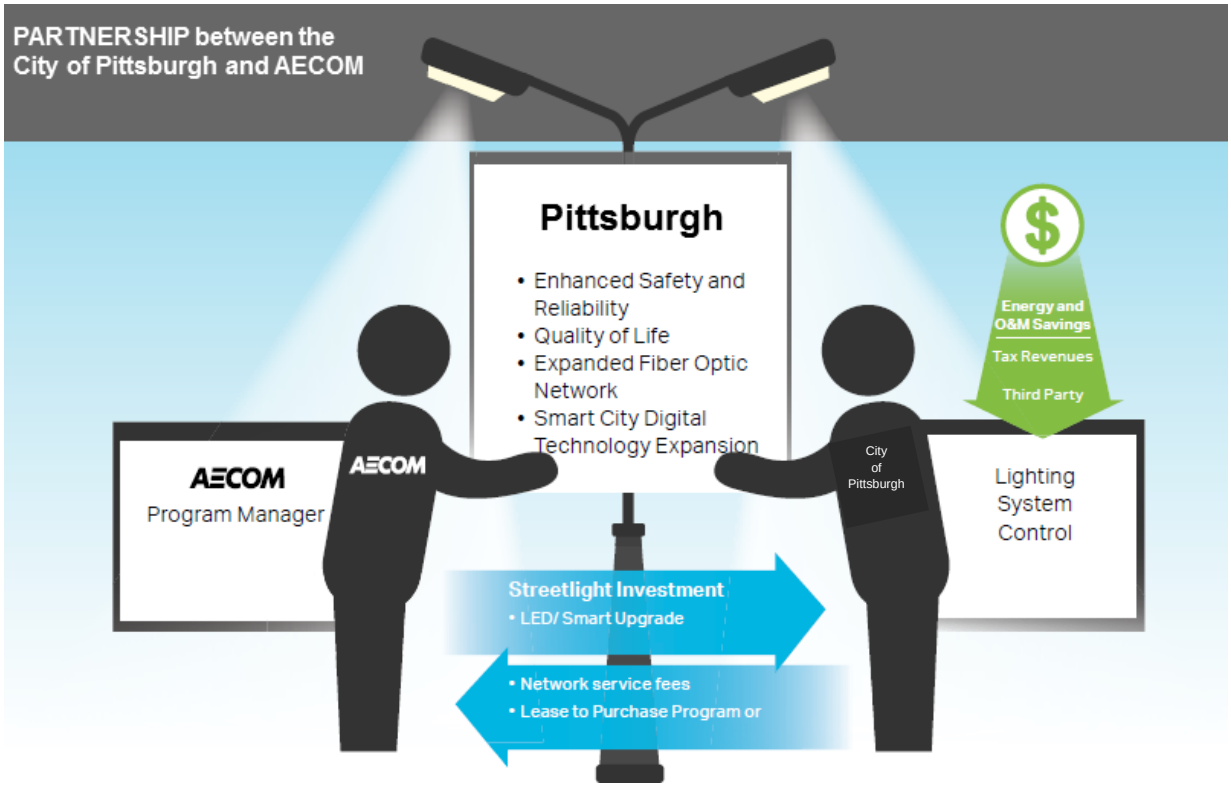
AECOM’s comprehensive suite of integrated infrastructure services drives performance and produces innovative solutions. We provide economic analysis, planning, and implementation services with the goal of helping our clients and partners achieve triple bottom line returns on investment: social, ecological and financial. We focus on three primary areas:

- **Economic policy, sustainable infrastructure, and community resilience analysis.** Projects include integrated smart infrastructure plans, utility system modeling, community resilience, socioeconomic impact evaluations, green premiums, Triple Bottom Line (TBL) modeling, and direct and indirect benefit-cost analyses of different policy and investment actions.
- **Feasibility analysis and economic development strategies.** Projects include market and financial feasibility analyses, business case development and practical implementation plans to promote sustainable business activity, attract new investment, and unlock development opportunities that meet social, fiscal, and environmental goals.
- **Planning and community development.** Projects include economic and fiscal impact analyses supporting the full range of planning efforts from focused specific plans for small areas to large, multi-phase master plans. This area also encompasses community development sustainable infrastructure studies, plans, and strategies.

Project Overview

The City of Pittsburgh through Office of Management & Budget on behalf of Department of Innovation & Performance has issued a Request for Information of (RFI) regarding a comprehensive streetlight modernization program. While its primary intent is to improve performance and savings through the conversion of 40,000 existing outdoor lights to LEDs, the City also seeks to light roadways that remain unlit with LED fixtures and the requisite infrastructure, as well opportunities to implement a centralized lighting management system, upgrade legacy lighting infrastructure, and leverage the streetlight network to deploy cost effective digital technologies that provide public benefit and create additional city revenues.

The result of the AECOM project team solutions can potentially reduce energy costs as much as 60 percent and create over $3 million in potential revenues from smart city features. This savings would benefit the City of taxpayers by reducing the City's cost burden and potentially freeing up funds that would be spent on the energy bill to fund streetlight infrastructure improvements.



Deployment Plan

The City has conducted extensive research on LED fixture replacement analysis[1] and has completed a streetlight modernization pilot project. Lessons learned from these studies as well as the Smart PGH initiative serve as valuable data points in developing an effective deployment plan. AECOM plans to analyze and build upon that information and recommends development of a proof of concept deployment plan and technology conversion at a mutually agreeable location in the City of Pittsburgh to confirm the most efficient deployment of the smart lighting solution in an urban environment. The proof of concept technology deployment will be conducted in neighborhoods with various socioeconomic, demographics, businesses, and pole types.

AECOM recommends deployment planning using geospatial mapping and a multivariable optimization model. Our initial analysis showed that the team may be able to rollout of the LED conversion under a maximum three-year plan. This duration can be adjusted in our optimization model. The order of installation would begin with neighborhoods with the most poles that most easily facilitate the conversion. Installations would be distributed throughout the 90 neighborhoods with multiple crews working across the City rather than being concentrated on adjacent neighborhoods. Though slightly less efficient than concentrating on one segment of the City at a time, this allows the City to show widespread distribution and investment in multiple neighborhoods, their commitment to the community by creating new jobs and fueling economic activity and growth.

AECOM will leverage the City of Pittsburgh's robust GIS database to create an optimization model to assist the City in the deployment of the smart technologies to achieve optimal revenue and maximize social benefit. Each neighborhood's socioeconomic, crime and revenue earning potential will be analyzed to facilitate a data driven approach to determine where and when to deploy streetlights. This data will also be utilized to determine the smart city features that will go in which neighborhoods, in order to optimally make investments and generate the best socioeconomic benefits for the city of Pittsburgh. The approach can also be used to engage stakeholders to ensure that smart features are tied to and address community priorities. The following smart features are considered:

Smart Feature	Description
Energy Outage Information	Smart sensors monitoring residential energy use to detect electricity and other utility outages instantly, as well as monitor status of city assets such as manholes and stop signs.
Wifi Connection	WIFI routers mounted to light poles to provide internet access throughout the city.
Traffic Management	Light pole sensors monitoring traffic flow to relay information to the cloud, which could intelligently set traffic signals to reduce congestion. This would be built to enhance the existing Smart Spine Network.
Gunshot Notification	Acoustic sensors on streetlights to determine location of gunshots in high crime neighborhoods.
Parking Management	Sensors monitor parking spot openings and relay information in real time to drivers looking for parking.
Disaster management Solutions	Sensors to provide data to optimize deployment of an emergency response team.
Environmental Sensors	Sensors to provide hyper-local information on weather, air quality and stormwater levels.
Urban Information Systems	A platform to aggregate city data and distributes it to 3rd party developers.
Air Quality Measurement and Monetization	Net reduction in Criteria Pollutants from Mobility and Energy Efficiency Gains.
Electric Car Charging	Electric vehicle charging stations could increase viability of electric cars by reducing mileage in between charging.
Solar Installation	Solar panels on streetlights to offset power consumption of streetlights.

Smart Feature	Description
Advertising	Smart billboards hanging from streetlights to provide an untapped revenue stream to the City.
Location Based Data Mining	Targeted services and marketing provided to people near retail environments.
Wireless Energy	Wireless charging stations could be set up in City transit stops to charge personal electronic devices and near parking spots to wirelessly charge electric vehicles.

In each of the neighborhoods, LED conversion work would initially begin in the alleys. Crews would be dispatched upon initiation of the project, allowing program management efforts and site condition surveys to be conducted concurrently. Upon completion of the alleys, work would progress on poles based upon the amount of potential complications they may incur.

The LED streetlights would be deployed in the following order:

1. Pilot
2. Alleys
3. Residential Poles
4. Arterial Poles
5. Downtown Poles
6. New Poles

Technical Specifications

Mesh Network

Wireless mesh network has a relatively stable topology with ease of deployment. The network will provide two-way wireless communication to effectively blanket all of Pittsburgh, allowing it to be leveraged for Smart Streetlights and other similar technologies. The network will be based on the IEEE 802.15.4 future proof IPv6 communication protocol. All the devices in the network are authenticated via certificates (X.509) and the end-to-end communication is encrypted using AES. The mesh network provides a node-to-node transport that could be utilized for numerous functions.

The implementation of smart lighting controls based on a mesh network enables the city to remotely monitor the power consumption, track outages, and control individual fixture light levels (dimming). Upgrades to the Smart Lighting Control Node firmware for future upgrades or bug fixes can be done over the air via the mesh network. This will avoid the need to physically go back to the pole to access the Node. The data from the Nodes is aggregated at the Gateway or Access Point via the mesh network and then transmitted to a lighting controls Central Management system using Cellular or Wire line (Fiber) back haul.

Streetlight Control Node

The Smart Photocell/Streetlight Control Node makes a typical street light luminaire ‘smart.’ It is a node that resides on the top of the fixture with an embedded GPS chip that enables things such as auto commissioning, maintenance, and asset management. The nodes allow for monitoring and collecting electrical data (voltage, current, energy) for the respective fixture, and send this information to the Central Management Server (CMS) via the mesh network. The fixtures can be remotely configured, monitored, and controlled by sending commands through the CMS. Dimming schedules can be pre-programmed and downloaded into each node over the air via the mesh network. In addition, real-time “Alerts” can be sent to maintenance or responsible personnel in case of any failures such as a day burner (luminaire on during the day) or a dark night (luminaire not producing any light), or if there is an under or over voltage situation.

Intelligent City Features

The foundation of an intelligent city begins with the city’s assets. Many suppliers sell individual sensors for individual applications, which results in network redundancy and expensive capital expenditure for the city, prohibiting the ability to create a truly integrated Smart City. Why install new single-use infrastructure, when you can leverage what’s already available? All across Pittsburgh is a ubiquitous network of streetlights. These streetlights leverage the existing height and power source to easily deploy an intelligent digital infrastructure.

A primary goal of the project will be to select a commercially viable product that will provide a secure digital infrastructure that lays the foundation for innovation and solution development throughout the city. There are products that are built specifically to host large scale industrial data collected from any existing data sources collected from other sensors already deployed in the city as well as sensors that will be deployed in the future. A key benefit of these products is the open and interoperable nature of the platform. This allows the city to both collect and control its data without limiting application development and creativity. The data platform should work with Shot Spotter (SST) for gunshot detection and optimization of emergency response.

Endless applications may be built by entrepreneurs, application vendors, consultants, and local universities as part of an ever-growing ecosystem of partners working towards making the city a better place to live, work and play. To foster increased cooperation within the developer community, the the city should consider engagement strategies like live local hack-a-thons. These hack-a-thons encourage broad participation to further promote economic development in the city. They can focus on critical needs such as traffic, pedestrian planning, public safety, and intelligent buildings. The benefits of these hack-a-thons stimulate a thriving local

app development and data analytics community which can lead to acceleration of technology acceptance and adoption, improvement of quality of life and city services.

This new digital infrastructure enables access to data that can be used to develop revenue generating applications, create new innovative citizen services as well as provide opportunities to reallocate resources in more cost effective and efficient ways.

Firmware and Software Upgrades

To add new features, fix any reported bugs and to continuously improve the performance of the system, the firmware (embedded software) inside the lighting control node or the intelligent fixture node can be upgraded over the air. This will avoid the hassle of physically accessing the Nodes for upgrades. Adding new features fix any reported bugs and to continuously improve the performance of the system, the Lighting controls software can be upgraded by downloading and installing a new version in the server.

Lighting Controls

With the many diverse components of a smart lighting project, their ability to communicate with each other is critical for reliable functionality. Identifying and setting a standard lighting control protocol (i.e. TALQ consortium) and establishing the Lighting Controls Central Management system can support an interface with other third party systems such as work order management.

Approach to Security

Our team’s approach to security is multifaceted. In a time of increased weather volatility and security threats, AECOM is leading the way in innovation to increase grid security and resilience. AECOM has significant systems and processes in place to provide for grid security in the face of cyber threats. We have a robust, seasoned team of Cyber Security professionals who constantly monitor for potential cyber threats -- including malware, spyware, viruses -- to our system on multiple levels.

Recognizing security spans across the value chain, the project team starts with a trusted supply chain to secure hardware and boot. This carries forward with trusted OS and hypervisors in order to secure communications, services, and applications across the network.

By combining our deep domain expertise in operational technology (OT) and information technology (IT), the lighting central management system and the cloud has the most advanced protocols available boasting industrial-grade security and compliance.

The lighting control CMS is protected by AES security encryption and a central management server offers a secure login portal to manage user access.

For Intelligent fixtures, we recommend secure boot of the operating system. The system offers two-way Transport Layer Security (TLS) for transmitting MQTT messages between the fixture and the cloud. It also offers a two-way fixture to cloud authentication based on the fixture certificate. Finally, data from sensors is encrypted while it’s queued on the device and when transmitted to the cloud.

Operational Considerations

Product Lifespan

While we propose to partner with the collaborators mentioned throughout this response, this proposal from AECOM keeps the options open for product selection, so that together with the City of Pittsburgh we can evaluate the top performing, most reliable, most durable, and most weather-resistant components to procure for the system. The primary elements to install are the LED fixtures, the Streetlight Photocells/Control Nodes, and the Network Interface Cards that allow for communications with the AMI network.

- The typical LED fixture lifespan for many products is a 100,000 hour rated life.
- Typical street light photocells have a lifespan of over 25 years.
- Network Interface Cards have a useful life of 20 years.

Maintenance

The city of Pittsburgh would retain ownership of the streetlighting system, and thus would be responsible for the maintenance of the streetlights.

Business Model / Financing

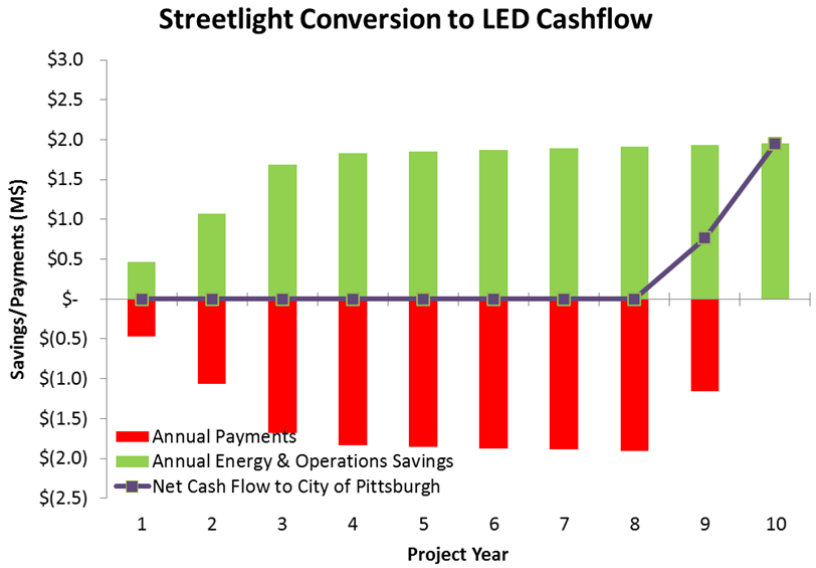
The City RFI indicates that it will consider a full range of funding models, one of which is an Energy Savings Performance Contract (ESPC). Below are three models including ESPC that may be applicable to that the City may wish to consider. Each has differing benefits, risk sharing schemes and revenue potential.

- **Energy Savings Performance Contract (ESPC):** ~15+ yr financing lease for LED, low cost Wifi equipment, renewals/electric work on City controlled/owned poles
  - Guaranteed savings cover CAPEX and OPEX (audit required for savings guarantee)
  - Savings guarantees supports lease financing
- **~15-20+ yr Design Build Finance Operate Maintain (DBFOM) with Availability Payments**
  - Contractor takes on asset financing, long term performance risk and ensures service controlled/owned poles performance Codified KPIs, penalty regime for service not being PC compatible" per KPIs
    - Contractor does not take revenue risk. O&M, debt service, cost of equity are reimbursed by Owner
- **~ 30+ Lease/ 40-50 year Revenue Concession**
  - Contractor leases lighting infrastructure and network to enable a complete solution OR
  - Contractor leases lighting infrastructure and gets long term access to network
  - Exclusive right to earn advertising revenue and rent access capacity on leased assets
  - KPIs to meet City services and needs

AECOM has constructed a sample model of the project finances utilizing a standard financing structure for energy savings performance contract to demonstrate the potential financial benefits of the project. The finance model assumes that the project will be funded over three distinct stages, with a new wave of financing for each stage. The stages of the project are described in the deployment plan. Each year for the first three years, the city will enact a purchase of the streetlights required for that year.

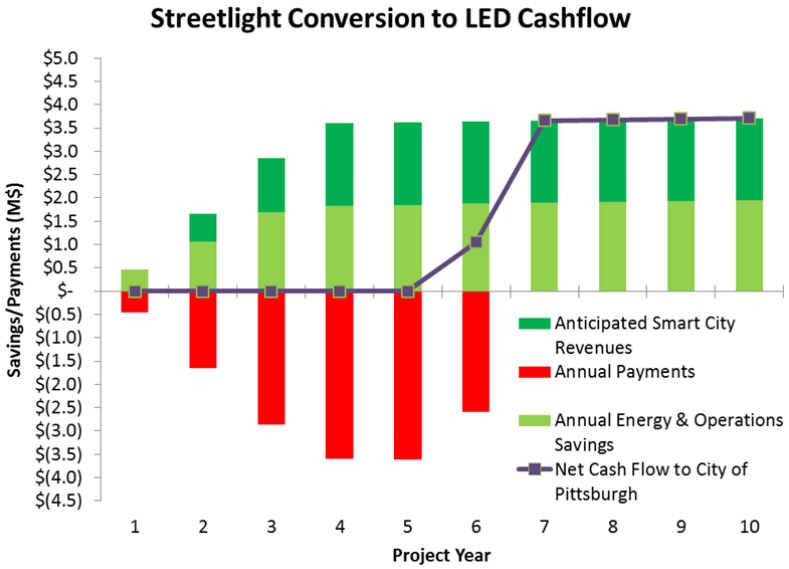
The project was modeled in two separate scenarios under current market conditions for feasibility and a three year deployment. The following cash flow was obtained by using a 10 year loan term, while assuming that any excess cash generated by energy savings or smart city revenues would be used to pay down the loan. The model assumed monthly compounding of interest. The payments slowly ramp up, as more energy, operations & maintenance (O&M) savings, and smart city revenues become available.

In the first, more conservative financial scenario, the project team assumed that there would be no revenues from smart cities applications. The only cash in-flows would be from energy savings and O&M savings. In the model, the City of Pittsburgh has zero net cash flow from the project until year eight. At that point, the loan is paid off and the energy and operations savings generate a positive cash flow.



The model above does not consider any new revenue streams that would materialize from the implementation of smart city technologies.

In the second scenario, the potential impact of smart city applications is included. The AECOM economics team separately researched the impact of smart city technologies and applications for the City of Pittsburgh. Following the installation of additional hardware and networking equipment, smart city technologies such as parking management and smart advertising could generate revenues in the range of one to three million dollars per year. The payback period of the loan is reduced to a 6 year payback. AECOM recommends installing these technologies throughout Pittsburgh, with a particular focus on the downtown area.



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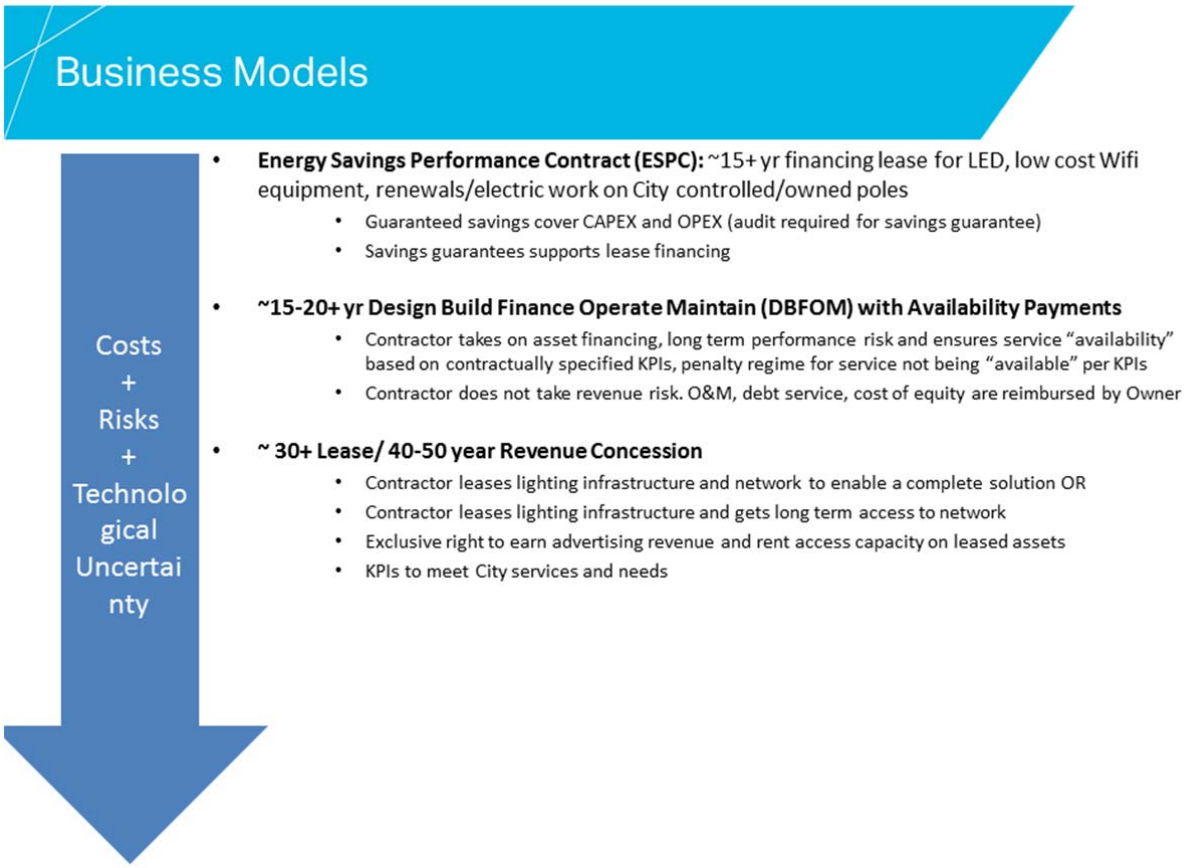

Evaluation

Project Evaluation

AECOM would work with the City and its partners to create an evaluation and implementation plan. The project team will investigate possible funding sources, along with energy, O&M savings and rebates to help fund the deployment period. Once the initial smart infrastructure is in place, the partnership will seek to capitalize on creating new revenue streams. Proceeds from the new revenue streams will help accelerate the remaining system improvements including capital reinvestment into the modernization of the existing lighting system on a schedule agreed to by the City and new streetlight. Our initial analysis shows that the City can potentially deploy the streetlight modernization and smart city features at close to net zero cash outlay.

The project effectiveness evaluation should be based on cost/benefit analysis through the Triple Bottom Line (TBL) model. The model will evaluate the consequences of different microgrid urban place types. The model establishes a set of social, environmental, and financial performance metrics to compare the potential set of options and pre/post implementation of LED and smart city features. The analysis can be used to describe both the negative and positive externalities based on a preexisting set of indicators. The outputs easily communicate the consequences and will be utilized to help disseminate information to gauge the effectiveness and civic value of the project.

About AECOM

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A Fortune 500 firm, AECOM had revenue of approximately $17.4 billion during fiscal year 2016. See how we deliver what others can only imagine at aecom.com and @AECOM.

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