

# Proven Delivery Models for LED Public Lighting

Public-Private Partnership Delivery Model Case Study  
Birmingham, United Kingdom

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## Acronyms and Abbreviations

BCC	Birmingham City Council
Capex	Capital expenditures
CDCF	Community Development Carbon Fund
CIP	Core investment period
CMS	Central Management System
ESMAP	Energy Sector Management Assistance Program
GENDR	Environment and Natural Resources Global Practice
GIS	Geographic information system
GSURR	Social, Urban, Rural, and Resilience Global Practice
HMMPI	Highway maintenance and management private financing initiative
HPS	High pressure sodium
ILE	Institution of Lighting Engineers
LED	Light-emitting diode
Opex	Operational expenditures
P3 or PPP	Public private partnership
PFI	Private financing initiative
SPV	Special purpose vehicle
SSD	Street Services Division
UK	United Kingdom

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# Public-Private Partnership Delivery Model Case Study

## Birmingham, United Kingdom

<b>City name</b>	<b>City of Birmingham, UK</b>
<b>Project dates</b>	<b>2007–35</b>
<b>Project size</b>	<b>97,000 points of light (57,000 from 2010 to 2015; 40,000 from 2015 to 2035)</b>
<b>Implementing agency</b>	<b>Birmingham City Council (BCC)</b>
<b>Funding mechanism</b>	<b>Public-private partnership (PPP)</b>
<b>Implementation/procurement process</b>	<b>An SPV manages and delivers contract requirements overseen by the Birmingham City Council</b>
<b>Expected energy savings</b>	<b>50%</b>

### Introduction

With a population of 3.7 million people in England’s West Midlands region, the metropolitan area of Birmingham is the United Kingdom’s second most populous urban region after London. Birmingham spawned many science, technology, and manufacturing innovations during the Industrial Revolution; today, with manufacturing declining, Birmingham is reinventing itself and becoming an important international commercial and service center. However, like many former industrial city powerhouses, Birmingham’s industrial tax revenue base has eroded over the years while its expenses have increased. Thus, the city has struggled to properly maintain its aging public infrastructure, postponing needed maintenance and upgrades year after year.

Birmingham has approximately 2,500 kilometers of streets, roads, and urban highways, as well as 850 bridges, tunnels, and related transportation structures. At night the city is illuminated by 97,000 street lights that are owned by the city. In the past, most of these were HPS, MV, and MH lamps. Before the LED program, many of Birmingham’s street lights were old and in need of replacement. In 2000–01, the Birmingham City Council (BCC) conducted a Best Value Review of highway maintenance in an attempt to solve some of the challenges identified above. That review, and a subsequent review by BCC’s Audit Commission, concluded that City staff would be unable to carry out a step-wise improvement in the highway assets, and a cash infusion was needed to bring the asset to a reasonable standard.<sup>1</sup> The Commission recommended that plans be drawn up for a Private Financing Initiative (PFI)—a public services contracting model in the United Kingdom based on the public-private partnership (P3 or PPP) model—in order to capitalize upgrades and modernization of streets, roads, tunnels, street lighting, and related assets. PFI contracts are:

*“Long-term contracts (typically 20–35 years) where the private sector constructs the project’s assets (for example a building) and raises the required funding, usually on a project finance basis (i.e. where contractual payments from the public sector represent the primary security for funders)... By contracting*

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<sup>1</sup> Birmingham City Council, *Highways Management and Maintenance PFI*, Report to City Council from the coordinating Overview and Scrutiny Committee dated October 12, 2004, pp. 10–11.

*in this way, the aim is to ensure that whole-life costs associated with such assets are minimized and required associated services are provided competitively. Wherever possible, contracts specify the outputs rather than the inputs associated with a particular project.*

*Under PFI, a private sector firm creates and/or maintains the asset at its own cost. The public sector counterpart agrees to cover these costs over time, including the cost of capital, which is typically higher than if the public sector had funded the project itself. As long as the higher cost of capital is offset by greater efficiencies elsewhere, such projects still offer value for money for the public sector.”<sup>2</sup>*

The key advantage of PPP contracts from a municipal government point of view is the source of capital, which is typically the private sector. National governments may also incentivize PPP contracts by offering supplementary grants. Hence, there is no need for the municipality to raise up-front capital. It is not surprising that the PPP approach strongly appealed to cash-strapped Birmingham’s City Council.

Another appealing innovation of PPP contracts is that they shift technology and performance risk to the private sector. Payments can be withheld until an asset is refurbished or built to a specific performance standard. The government can impose strict penalties for poor performance during the operations and maintenance period. The arrangement is attractive to the private sector looking to add that asset class to its portfolio as well. Thus both the public and the private sector benefit from the PPP.

The BCC therefore adopted a PFI contract approach to access significant private investment alongside national government support to fund the backlog of necessary maintenance, to upgrade key assets such as lighting to a higher standard, and to maintain these assets over the next 25 years. Using the PFI framework, Birmingham contracted with a private service provider, Amey plc, to repair, modernize, and maintain these assets over a 25-year period. The value of the total contract is £2.7 billion (US\$4.2 billion) of which US\$117 million is for lighting.<sup>3</sup> The whole contract covers a step-improvement in the highways network, the removal of the works backlog, and the maintenance and management of 2,500 kilometers of roads, 4,200 kilometers of footways, 97,000 street lights, 76,000 street trees, 1,100 traffic light signals and over 850 bridges, tunnels and highway structures. The small but integral street light component of Birmingham’s PFI was Europe’s first LED street light retrofit project financed through a PPP. At the time of procurement, LED technology was not a widely used technology in the UK. However, it was clear to the service provider that LED street lighting could offer substantial cost savings and was firmly on the ascendant, so Amey made a business decision to deploy it where appropriate.

Another driver of the LED program for efficient street lighting was the BCC’s Sustainable Community Strategy, *Birmingham 2026*, which was endorsed in 2008. This plan aimed for Birmingham to become the best place in the UK to live, learn, work, and visit, “with a low-carbon energy infrastructure and well prepared for the impact of climate change.”<sup>4</sup>

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<sup>2</sup> European PPP Expertise Centre, June 2012. *United Kingdom – England: PPP Units and Related Institutional Framework*. [http://www.eib.org/epcc/resources/publications/epcc\\_uk\\_england\\_public\\_en.pdf](http://www.eib.org/epcc/resources/publications/epcc_uk_england_public_en.pdf)

<sup>3</sup> <http://www.birmingham.gov.uk/highwayspfi>

<sup>4</sup> Birmingham City Council, *Birmingham 2026: Our vision for the future*, September 2008: [http://www.bebirmingham.org.uk/documents/Final\\_Sustainable\\_Community\\_Strategy-Birmingham\\_2026.pdf](http://www.bebirmingham.org.uk/documents/Final_Sustainable_Community_Strategy-Birmingham_2026.pdf)

Under the PFI, Birmingham’s street lights are being modernized in two stages, as follows.

- **Stage One** is the five-year Core Investment Period (CIP), 2010–15, which officially concluded June 7, 2015. During this stage, 57,404 street light luminaires were replaced on 35,804 columns with a combination of 21,402 Philips Indal Stela LED luminaires, 14,204 conventional HPS luminaires, and 198 other types of luminaires. The LED luminaires range in size from 10 to 52 watts, with the most common luminaires using 36 to 44 watts and producing about 5,000 initial lumens output. Installations are spread across Birmingham’s residential areas to ensure that all 10 parliamentary constituencies and 40 municipal wards benefit from the improved lighting. In addition, adaptive controls and sensors manufactured by Telensa were installed in the LED luminaire casings, establishing the capacity for trimming<sup>5</sup> and further dimming to save more energy. The capital cost of the initial five-year tranche of the street light retrofit was approximately £72 million (US\$113 million), or £171 (US\$268) per unit. Most of the capital expenditure (Capex) was deployed during the CIP, from June 2010 to June 2015. It focused on “tackling the worst, first,” including:
  - Improving the average condition of roads, carriageways and sidewalks, especially those in an extremely poor condition;
  - Replacing upwards of 41,000 antiquated street lighting columns, including upgrading the equipment in the columns to permit monitoring and more effective energy management;
  - Refurbishing the three main City Centre tunnels with modern safety equipment;
  - Strengthening bridges, so that roads in the city are capable of carrying 40 metric tons live loading; and
  - Renewing the large number of old traffic-signal controllers while improving the capability to link traffic management systems with other agencies.
- **Stage Two** is the 20-year operational expenditures (Opex) period, 2015–35, during which the aim is to maintain the higher performance standards reached by 2015. During this stage, the balance of the city’s street lights, approximately 40,000 luminaires, will also be gradually upgraded. Meanwhile, some remaining assets will become due for replacement over the next 20 years, and they will be upgraded by 2035. Final decisions on technologies and products have not yet been made on this second stage.

With the CIP stage of the PFI contract now concluded, Amey has exceeded its target of upgrading half of the city’s street lights. Birmingham staff report that only limited testing has been done so far to confirm lighting performance of the new LED luminaires. However, visual inspection by staff indicates that the new LED lighting is providing a much better level of illumination than the older lamps that were replaced. The only technical issues that have arisen so far are general faults that Philips has

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<sup>5</sup> *Trimming* involves turning on street lights later in the evening and switching them off earlier in the morning. This is possible because LED street lights reach their required light output very quickly.

addressed under the warranty.<sup>6</sup> Meanwhile, illumination on the streets has attracted strong positive public feedback, with only a few public complaints.<sup>7</sup>

## Context

Birmingham's LED street lighting project is a small but integral component of a larger, innovative public-private infrastructure modernization effort—the Birmingham Highway Maintenance and Management PFI (HMMMPFI)—which the BCC signed with Amey on June 7, 2010. The modernization is being done under the PFI framework, which was created by the UK government to increase the availability of private financing for capital projects, and to transfer risk to the private sector through joint ventures and leasing agreements. The government has put in place a clear framework and tools around the PFI in England, including a standard form contract (the Standardization of PFI Contract, or SoPC) that is mandatory for public sector use when creating PFI contracts. There are institutional structures within Her Majesty's Treasury in a body called Infrastructure UK (IUK) that support PFIs. IUK includes four teams that help raise private sector capital, track existing projects, support clients, publish papers about the benefits of the PFI, provide assurance that deals are well-structured, and support infrastructure delivery and finance.<sup>8</sup>

In the case of Birmingham, the private and public sectors came together in a partnership using private money to fund construction upgrades of the city's infrastructure system according to set specifications. The partnership also included maintenance of the infrastructure for the remainder of the contract. Since the infrastructure is operational in this case, Amey is responsible for managing and maintaining the infrastructure portfolio at the same time as the firm undertakes rehabilitation works to upgrade the infrastructure. Other entities, such as utilities, continue to have access to the asset to maintain their specific infrastructure within the PPP.

The timeline for the PFI in Birmingham is summarized in Figure 1.

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<sup>6</sup> Private communication (August 20, 2015).

<sup>7</sup> Private communication. Amey is compiling a public survey for later publication.

<sup>8</sup> European PPP Expertise Centre, 2012. *Ibid.*

[http://www.eib.org/epec/resources/publications/epec\\_uk\\_england\\_public\\_en.pdf](http://www.eib.org/epec/resources/publications/epec_uk_england_public_en.pdf)

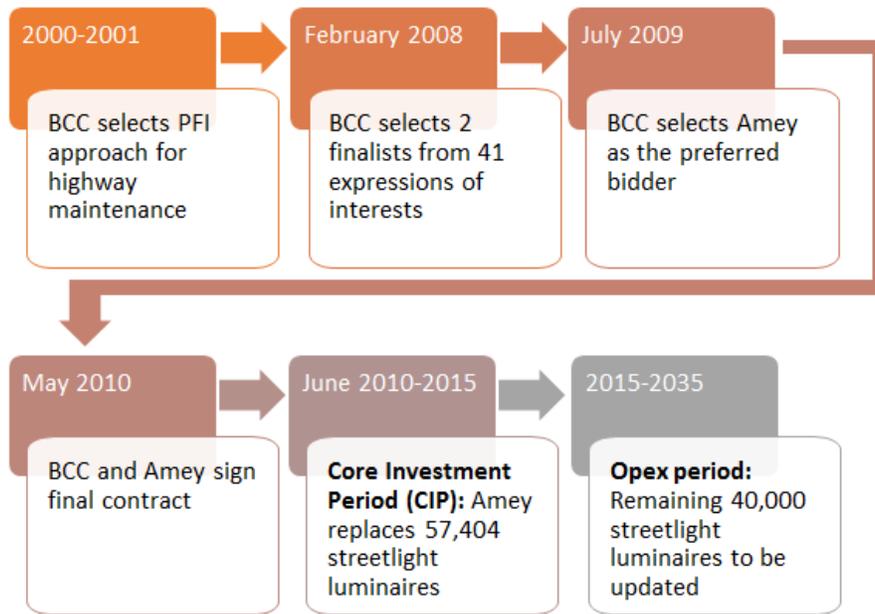


Figure 1: The timeline in Birmingham for retrofit of street lights

## Tracing the development and implementation process in Birmingham

Figure 2 summarizes the project implementation process in Birmingham.

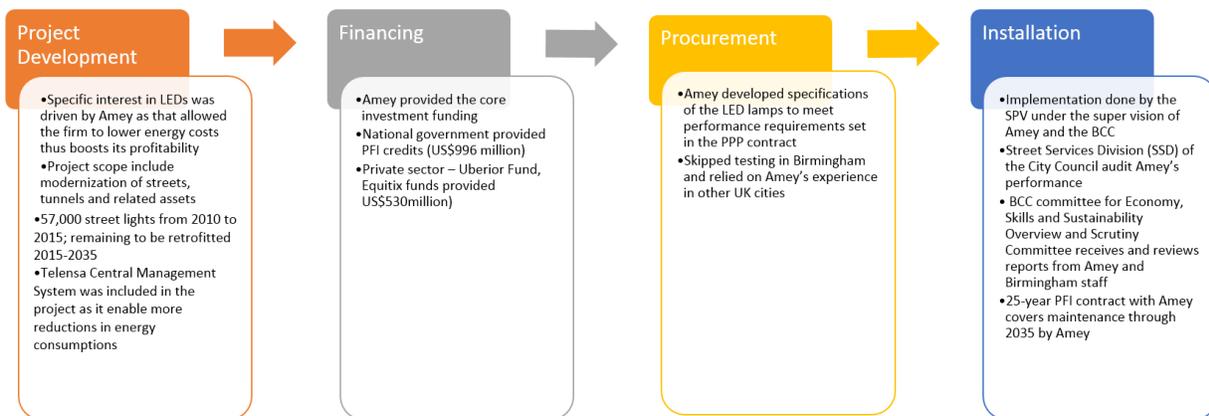


Figure 2: The implementation process in Birmingham for retrofit of street lights

## Project Development

Decisive interest in LED street lighting came from Amey, prompted by the firm’s positive experience with LED luminaries in other UK cities. Within the PPP contract, Amey is responsible for complying with Output Specifications that meet specific lighting design standards set by the national government.<sup>9</sup> Thus energy consumption is Amey’s risk, and all energy savings accrue to Amey’s

<sup>9</sup> These are based on ILE TR27 and British standards BS EN 13201:203 and BS 5489:2003. Birmingham City Council, *Highways Maintenance and Management Service PFI* (PROC/0091), Appendix B to Part 1 of Schedule 2: Specific Lighting Design Standards (2010).

*bottom line.* The contract also allowed for Amey to install LED lighting by providing incentives for both the Service Provider (Amey) and City Council to investigate advances in lighting technology, and subject them to further analysis in terms of life cycle costs and possible implementation. Therefore, while the contract does not require periodic technology upgrades, there is a general requirement that the Service Provider actively seek and investigate innovations across the full range of transportation infrastructure assets.

The potential benefits of efficient street lighting also appealed to politicians and city staff because they would simultaneously address two imperatives: improving quality of life and reducing the carbon intensity of the energy infrastructure. The expected benefits were as follows:

- Improved light quality from LEDs would enhance visibility and overall road safety by reducing accidents, crime, light pollution and “sky-glow.”
- High operating and light delivery efficiency, reliability, and long operating lifetimes would generate energy savings and carbon dioxide reductions of 50 percent or more.
- Modernization of the street lighting systems with controls, creating a Central Management System (CMS), would enable engineers to maximize energy savings.
- The ability to adjust the LED luminaires’ drive current over time would reduce heat build-up and extend the lifetime of the LED devices.
- Improvements in lighting would be highly visible and influence the public’s overall perception of highways and maintenance;
- The CMS would enable proactive programmed installation and maintenance work, thereby replacing reactive work.

The project scope as it relates to public lighting was fairly broad. It covers not only 97,000 street light luminaires, but also the upgrade of associated street infrastructure such as columns. This allowed for LED luminaires to be assessed using a full lifecycle model as part of the modernization of the large lighting system. The scale of the project also gave engineers the opportunity to incorporate a wireless Telensa CMS for the street lights.

These controls will enable the LED luminaries to be operated in the most energy efficient manner across a range of situations and over their full operating life. For instance, luminaires produce slightly less light output over time, decreasing to 70 percent of the initial light output by the end of the luminaire’s lifetime (referred to as “L70”). With a CMS, the luminaires’ light output will initially be dimmed to just meet British roadway lighting standards for residential streets, producing additional energy savings for Birmingham. Then, input current will be increased gradually over time to maintain the same level of light output throughout the luminaire’s lifetime.

This complete LED system approach has enabled Amey to maximize energy savings, as well as trim current levels to the LED devices whenever appropriate, thus reducing heat build-up and extending the lifetime of the LED devices. The CMS will also allow engineers to trim light output in response to

varying levels of traffic or pedestrian flow. Following existing guidance and standards,<sup>10</sup> Birmingham opted to dim light output between midnight and 4 a.m. on certain traffic routes.

## Financing

Amey was able to consider costs and revenue over the entire 25-year PFI contract, thereby applying a total cost of ownership model to the Indal LED solution for Birmingham. Some of the assumptions and stipulations underlying their analysis were as follows:

- LED luminaire lifetimes will be greater than 100,000 hours or about 24 years; that is, until that time the light output of the luminaires should achieve at least 70 percent of its initial output (“L70”).
- Amey guarantees light output to 85 percent of the luminaires’ initial output through a “maintained Illuminance” warranty.
- Energy cost savings is predicted to be 50 percent, or up to £2 million (US\$3.2 million) annually.

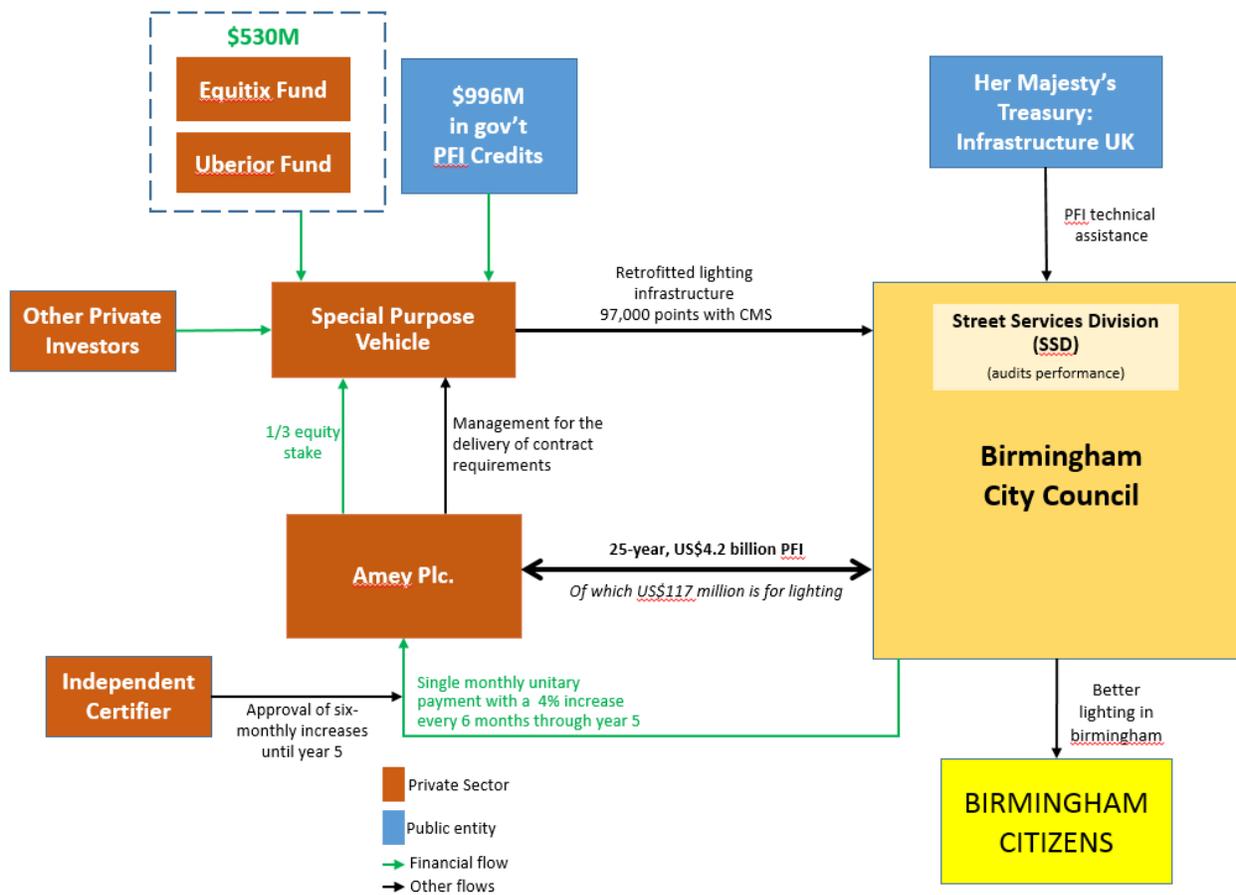
The PFI’s total project value of £2.6 billion (US\$4.2 billion) is spread over 25 years, which includes £620 million (US\$996 million) in PFI credits in the form of a grant from the UK government. Birmingham’s special purpose vehicle (SPV), created to manage and deliver the contract requirements with oversight by BCC and Amey, has so far attracted an injection of £330 million (US\$530 million) from the Uberior Fund (part of Lloyds Banking Group) and the Equitix Investment Fund.<sup>11</sup> To date, additional investment has resulted in Amey holding a one-third stake in the SPV, with private investors and banks holding the remainder.<sup>12</sup> (See Figure 3.)

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<sup>10</sup> Guidance includes the Institution of Lighting Engineers *Technical Report 27* (ILE TR27, Code of Practice for Variable Light Levels for Highways) and British standard BS 5489.

<sup>11</sup> <https://www.amey.co.uk/media/1068/42060-amey-annual-report-15.pdf>

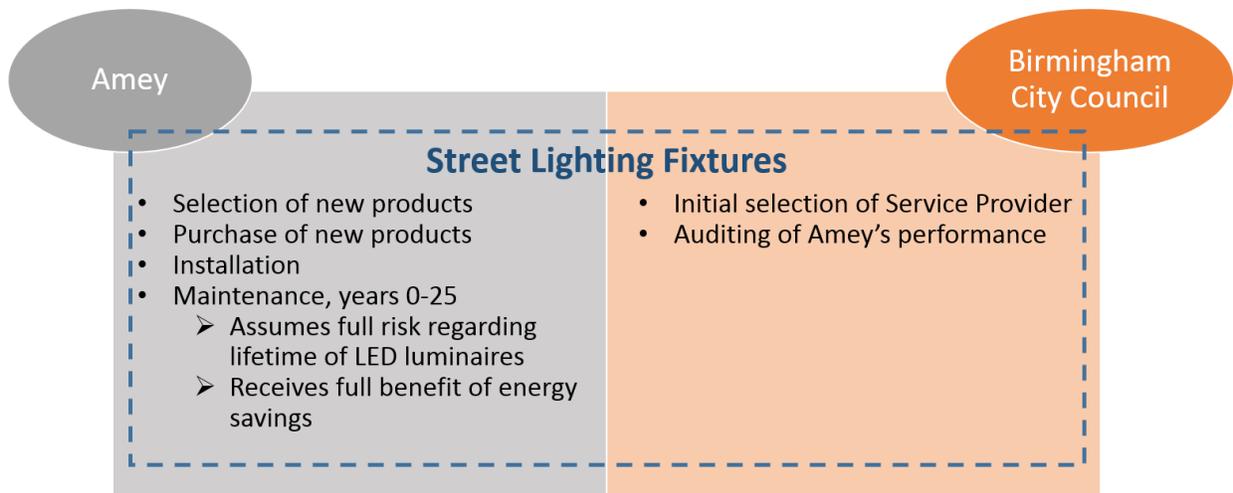
<sup>12</sup> A consortium of lenders included the Bank of Ireland, Dexia Group, Lloyds Banking Group, Nationwide, Natixis and NIBC Bank: [http://www.wragge.com/wragge\\_news\\_6024.asp](http://www.wragge.com/wragge_news_6024.asp)



**Figure 3: Notional flows for the street lighting retrofit in Birmingham**

Under the HMMPFI, the BCC receives, in the case of lighting, a modernized street light system that will be operated and maintained over 25 years. Amey, as the service provider, determines what products are procured and funded. Under the PFI, Amey receives a single monthly “unitary”<sup>13</sup> payment from BCC with certain deductions allowed. Any energy savings that Amey realizes in the lighting scheme accrue to its benefit. However, Amey also assumes full risk regarding the potential maintenance costs and lifetime of the Indal LED luminaires. Figure 4 summarizes the responsibilities of the different stakeholders for the installation and maintenance of street lights in Birmingham.

<sup>13</sup> The PFI contract bundles the payment to the private sector as a single “unitary” charge for both the initial capital spend and the ongoing maintenance and operation costs.



**Figure 4: Responsibilities for upgrading street lights in Birmingham**

Every six months, an independent certifier approves a step-up of the monthly unitary charge by about 4 percent until the end of year 5 of the contract. This unitary charge then continues for the life of the contract. The program of modernizing street lighting and other transportation assets is deliberately frontloaded to bring these assets up to standard as rapidly as possible.

Meanwhile, in order to raise debt and secure investor confidence, Amey required a revenue stream to balance their investment commitments. Thus Amey needed clearly defined contract delivery requirements and performance targets with scope for profit. The private funding banks and investor stakeholders needed to ensure that the investment could provide them with a sufficient return on investment, with low risk and high security over time and a security of return.<sup>14</sup>

### Procurement Process

The PFI procurement method, developed by the UK government in 1992, taps private sector investment and expertise to deliver public services and capital financing of public infrastructure projects. It offered BCC a mechanism for standardization, specification, and long-term management and maintenance of its street and road network and associated assets.

Once the BCC decided to undertake a PFI, the bid for the contract was publicly advertised, as required by national legislation, in the *Official Journal of the European Union* and in other media outlets such as the *Birmingham Post*, *Contract Journal*, and *Construction News*. Forty-one companies submitted expressions of interest, and the list was narrowed down to two finalists that were asked to produce best and final offers in February 2008. In July 2009, the BCC selected Amey as the preferred bidder for the contract. On May 6, 2010, the final contract was signed by both parties.

A number of early concerns for the BCC surfaced during the Birmingham PFI tender and bid process. Namely, there was a perceived loss of control of the city's highway assets, concerns from union and staff members around their "buy-in", and a necessity to "ring fence" BCC revenue and part of the

<sup>14</sup> With long projects, there are additional underlying concerns of subsequent government reviews or changes in law that may impact the contract over the 25-year period.

authority's capital budget. Many of BCC's highway staff were required to change roles, with many moving to work within the SPV/Amey organizational structure. However, Amey reports that 300 net jobs have been created for the whole contract. Addressing the above concerns required significant consultations and reviews over the two-year bidding process between the staff and Council of Birmingham and Amey. The final contract (for the whole US\$4.2 billion PPP) approaches 1,000 pages in length.

## Installation

After the BCC gave a green light to the Amey PFI contract in May 2010, an SPV was created to manage and deliver the contract requirements, overseen by BCC and Amey. The contract transferred project responsibility, risk and delivery management to the SPV and Amey. BCC created a new Street Services Division (SSD) to audit Amey's performance and manage the activities retained by the Council, such as statutory functions, drainage, and emergency planning.

In terms of oversight of the HMMPFI, BCC's Economy, Skills and Sustainability Overview and Scrutiny Committee receives and reviews reports from Amey and Birmingham staff regarding the progress of the PFI. The most recent comprehensive report was published January 10, 2012.<sup>15</sup> There are over 1,200 performance indicators for the overall PPP derived from Output Specification clauses in the contract. Each item must be tracked and audited over 25 years.

## Lessons Learned

The Birmingham LED street light project is one of the very first worldwide to utilize a public services contracting model to tap significant private financing to capitalize a large public LED street lighting retrofit. In this case, BCC used a private financing initiative (PFI) in the UK based on the public-private partnership model.

The decision of BCC and Amey to partner in the upgrading and maintenance of a large urban transportation system over a 25-year period has relieved the municipal government of the need to raise up-front capital from its own taxpayers. Whether the LED technology chosen for the HMMPFI can achieve a lifetime of over 100,000 hours remains to be seen, but the total systems approach taken by BCC and Amey represents an excellent chance to successfully address the identified performance and operational risks with such a new technology. In large metropolitan areas in the developing world where national policies strongly support PPP solutions, the Birmingham Highways Maintenance and Management PFI offers a potential model for implementation.

The key challenge in PFI contracts—apart from the negotiation of a lengthy, complex agreement that may take several years to finalize—is to ensure that the requirements and needs of the various stakeholders are met over the term of the contract. BCC and the UK Government are ultimately responsible for the delivery of efficient public services in Birmingham, ensuring quality and value for money. The tendering and procurement process must be highly visible and responsive to public scrutiny. (UK watchdog groups have roundly criticized the lack of accountability in PFIs.)

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<sup>15</sup> Birmingham City Council, *Highway Maintenance and Management Services in Partnership*, a report from the Overview and Scrutiny Committee (January 10, 2012).

Three key transferable elements of this contracting approach are:

- The use of a full-lifecycle costing model that measures financial costs and benefits over the lifetime of the service;
- The innovative use of CMS technology to maximize energy savings, extend the lifetime of the LED luminaires, and create new opportunities to adapt the level of illumination on specific streets or neighborhoods to their particular uses and needs;
- The shift of LED performance risks away from the municipality to the private sector entity (in this case Amey, the service provider).

The BCC was faced with the problem of how to address the deterioration of its highways and street lighting. The PFI allowed the city to redress the lack of past public investment, and offered a mechanism for standardization, specification, and long-term management and maintenance of its street and road network and associated assets within the Council's jurisdiction, including street lighting. The PFI also enabled BCC and Amey to consider the lifetime affordability and performance benefits of replacing conventional 250-watt high-pressure sodium bulbs with a new, more efficient and reliable LED lighting system.

Finally, in the UK as in many countries, local authorities are typically risk averse and there is considerable reticence towards the adoption of new technologies such as LEDs. The transfer of technical risk to a service provider such as Amey, therefore, has clear attractions for the local authority.

In terms of the implementation of the HMMPFI, a number of more specific lessons emerge from this case study that municipalities in developing countries may wish to consider.

*A national framework is needed to smooth the process*

Birmingham's PFI was enabled by a framework of national institutional policies and subsidies, dating back to 1974, aimed at shifting public services to the private sector. Public institutions and private firms in the UK have had long experience with this financing model and have honed transaction processes and documents to facilitate partnerships. In countries where such experience is lacking, special consideration will need to be given to providing external technical assistance and firm guarantees that can assure private firms that the deals they fashion will be honored over time. Some of the associated risks can be included in the contracts for what is known as "management by contract."

*Precision, communication, and feedback channels are key to minimizing conflicts*

Even with many years of experience with PFIs in the UK, friction and conflicts emerged between Amey and BCC regarding the implementation of the HMMPFI. Such disputes may be minimized if the existing infrastructure covered by the PFI is accurately and precisely detailed in the PFI documentation, so the private firm knows exactly what will be expected over the term of the contract and can budget accordingly. Meanwhile, communication channels and processes need to be well designed and thoroughly implemented so that each party is fully aware of progress, problems, and issues arising as construction and refurbishment proceeds.

*Periodic review of selected technologies can lead to greater energy savings and lower costs*

PFI contracts should incorporate provisions that require the private firm to periodically investigate and analyze the LED technologies used in the street light retrofit. LED technology is evolving rapidly, and prices are declining equally rapidly; given the lengthy time of PFIs, significant technology advancements and price reductions are likely. Such a provision might also call for a periodic procurement “refresh” undertaken by the private firm to identify the best available technology applicable for the streets and roads of its city partner.

*Ensure the scope of the project is clear and the required outcomes are clearly defined*

PPP contracts are complex, and changes during the contract period can be costly and time consuming. Thus, there is need for a fully funded and well-staffed government oversight of contract implementation. It is important to be sure that the location, wattage, and current repair of street light assets are accurately described to prevent any surprises once installation crews are replacing luminaires. A complete up-to-date geographic information system (GIS) database of street lights can be particularly helpful.

## Series of Case Studies on Public Lighting Delivery Models

“Public-Private Partnership Delivery Model Case Study; Birmingham, United Kingdom” is one in a series of seven knowledge products produced by ESMAP in an attempt to help cities work through the challenges associated with implementing LED programs. The publications include six case studies and a synthesis report which summarizes and synthesizes the case studies. Each case study describes the context in which decisions were made, then recounts the problems encountered and solved in order to realize the implementation of the programs. The challenges include real-life examples of cities managing to attract private sector participants to provide necessary financing and technical expertise; examples of programs implemented in municipalities that are not creditworthy and have limited policy and institutional support; examples involving small municipalities of about 2,500 residents as well as cities with several million residents; examples of cities managing the perceived risk; and finally, examples of cities effectively handling the measurement and verification of electricity savings accruing from the implementation of more efficient LEDs. These case studies are available online:

Cover Image Place Holder	Cover Image Place Holder
Proven Delivery Models for LED Public Lighting: Synthesis of Six Case Studies Illustrating ESCO, Joint Procurement, PPP, Lease-to-Own, Municipal Financing, and Super-ESCO Models	ESCO Delivery Model Case Study; Asian Electronics Ltd., India:
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Super-ESCO Delivery Model Case Study Energy Efficiency Services Limited, Vizag, India	Joint Procurement Delivery Model Case Study Ontario, Canada
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