Proven Delivery Models for LED Public Lighting:

ESCO Delivery Model Case Study

Asian Electronics Ltd., India

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Standard ESMAP text placeholder

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Acronyms and Abbreviations

AEL	Asian Electronics Limited
BEE	Bureau of Energy Efficiency
BIS	Bureau of Indian Standards
BOOT	build-own-operate-transfer
CDCF	Community Development Carbon Fund
CDM	Clean Development Mechanism
CER	Certified Emission Reductions
CFL	compact fluorescent light
EOI	expression of interest
EPC	energy performance contract
ESCO	energy service company
ESMAP	Energy Sector Management Assistance Program
GENDR	Environment and Natural Resources Global Practice
M&V	measurement and verification
MC	municipal corporation
O&M	operation and maintenance
RFP	request for proposals
UIT	Urban Improvement Trust
ULB	urban local body

Acknowledgements

This case study was written by Pedzi Makumbe, Debbie K. Weyl, Andrew Eil, and Jie Li, with funding from the World Bank's Energy Sector Management Assistance Program (ESMAP) and the Community Development Carbon Fund (CDCF), both of which are multi-donor technical assistance trust funds administered by the World Bank. The work was led by ESMAP in close collaboration with the Social, Urban, Rural, and Resilience Global Practice (GSURR) and the Environment and Natural Resources Global Practice (GENDR) of the World Bank Group. The authors would like to thank Naman Shah, AEL Managing Director; Manoj Panchakshari, Super Wealth Financial Enterprises Pvt. Ltd., V. Baraneedharan, Consultant; Aditya Dhar, International Finance Cooperation; Neeraj Gupta, Principal Investment Officer, International Finance Corporation; and W. Nick Bowden, Carbon Finance Specialist, World Bank

The report benefited tremendously from support and comments by Rohit Khanna, ESMAP Practice Manager, World Bank. It also significantly benefited from comments by Wendy Hughes, Lead Energy Economist, ESMAP, World Bank; Ivan Jaques, Senior Energy Economist, ESMAP, World Bank; Martina Bosi, Senior Energy Economist, ESMAP, World Bank; Ashok Sarkar, Senior Energy Specialist, World Bank; and Luiz Maurer, Principal Industry Specialist, International Finance Corporation.

ESCO Delivery Model Case Study

Asian Electronics Ltd., India

City name	**Nine urban local bodies (ULBs): Latur, Akola, Pune, Ajmer MC, Ajmer UIT, Bikaner, Alwar UIT, Alwar MC, and Indore**
Project dates	**2005–22**
Project size	**121,365 lighting points in nine Indian municipalities**
Implementing agency	**ESCO: Asian Electronics Limited (AEL) in central and northwestern India**
Funding mechanism	**Carbon finance (via the Community Development Carbon Fund managed by World Bank); domestic Indian bank loans accessed by AEL**
Implementation/procurement process	**One co-financed by carbon finance and AEL; the rest financed by AEL. Nine distinct municipal energy performance contracts between AEL and nine Indian urban local bodies (ULBs)**
Expected energy savings	**50%**

Introduction

Population in cities in India is rapidly expanding and putting a strain on municipal services. Street lighting is one such service; though widely valued, it is often poorly provided. There are over 3 million municipal streetlights in India, and 5–10 percent are either over-designed or under-designed, resulting in inefficient and/or inadequate street lighting.[1] Many use fairly old technology and are often poorly maintained. Thus the quality of public lighting is often low, and municipal governments are motivated to both provide better lighting and expand coverage.

However, costs often get in the way. Although just 1.5 percent of electricity consumption in India is due to municipal street lighting, street lighting electricity and maintenance costs can consume 5–10 percent of municipal budgets in large cities, and up to 20 percent in villages. Moreover, the cost of electricity has been rising to the point of accounting for over 80 percent of all expenditure on street lighting, and municipalities are struggling to pay their lighting costs. Thus the need to find cost-effective, efficient solutions for street lighting is acute.

In the context of these challenges, energy service companies (ESCOs) have emerged offering fully-financed shared-savings energy performance contracts (EPCs) at little or no up-front cost to cities. This case study centers on how the confluence of the challenges and the ESCO opportunity led to the efficient lighting project in India starting with the nine municipalities of Latur, Akola, Pune, Ajmer MC,

[1] Infrastructure Development Department, Government of Karnataka, June 2012. "Pre-Feasibility Document: Energy Efficiency Project Energy Efficiency in Street Lighting through ESCO's at Hubli-Dharwad." (http://www.iddkarnataka.gov.in/docs/81_DMA_PFR_EnergyEfficiencyinStreetlightingatHUbli_final.pdf); Hyperion Green Energy India LTD, "Municipal DSM: The LED Alternative," http://tinyurl.com/qepgy9u.

Ajmer UIT, Bikaner, Alwar UIT, Alwar MC, and Indore. The project benefited from carbon finance through the sale of Certified Emission Reduction Credits (CERs) to the World Bank-managed Community Development Carbon Fund (CDCF), a donor-supported fund purchasing carbon credits for projects in developing countries with social benefits for the host communities.[2]

The projects were implemented on a build-own-operate-transfer (BOOT) basis through an ESCO shared-savings model. "Shared savings" means that the ESCO and the municipality shared performance risk: each would receive a fraction of the savings from the investment (as opposed to a guaranteed payment for either party). Asian Electronics Limited (AEL) was the World Bank's implementing partner as well as the energy services provider, compact fluorescent lights (CFL) manufacturer, and now LED luminaires provider.

The projects emerged from a 2005 partnership between AEL and Econoler, a Canadian company with carbon finance expertise, to develop a strategy in India for municipal street lighting with carbon finance incentives. Once the methodology had been developed and tested, AEL and Econoler approached the World Bank Carbon Finance Unit regarding a purchase agreement for carbon credits. Beginning in 2006, the World Bank and AEL began working on the project. Between 2005 and 2009, AEL signed up nine urban local bodies (ULBs), or municipal government entities,[3] to street lighting energy performance contracts.

As of April 2015, six years after signing up the last of the nine ULB clients to the World Bank carbon finance project, AEL had nearly 20 municipal street lighting clients, and was seeking to expand to Tamil Nadu state. The company had switched its entire manufacturing line from T-5 CFLs to higher-efficiency LEDs. AEL learned through experience how best to structure contracts to protect itself from risks out of its control, such as poor infrastructure, disputes over actual savings, and non-payment. Likewise, the Indian municipal street lighting market is transitioning from CFLs to LEDs. As LEDs have plummeted in cost and increased in reliability and market accessibility, a number of municipal corporations, including Pune and Indore, have switched over to LEDs. 121,000 luminaires have been switched to more efficient lighting.

Context

The project covers seven cities, encompassing nine urban local bodies (ULBs): seven municipal corporations (MCs) and two urban improvement trusts (UITs). The ULBs are responsible for infrastructure improvements in the cities. The cities are spread across three states in central and northwestern India: Rajasthan, Madhya Pradesh, and Maharashtra. They range in size from 260,000 (Alwar) to 2.6 million (Pune), with most in the range of 300,000 to 500,000 inhabitants.

Institutionally, municipalities in India are under little regulatory obligation to improve lighting quality to meet standards. India's Code of Practice for Lighting, created in 1970 by the Bureau of Indian Standards (BIS) to establish lighting standards for categories of streets and roads, had not been updated since 1981. Further, as USAID report from 2010 notes, "since these guidelines are not

[2] World Bank CDM PDD, 2012. *World Bank Project Information Document*, April 2009.

[3] ULBs are local bodies—such as state public-works departments, municipalities, and corporations—that manage the public utility services in each state.

enforced by any regulatory authority, it is common for municipalities to be unaware of the standards, and many fail to comply."[4] Consequently, project upgrades are not driven by regulatory compliance but by municipalities' initiative to save operating funds on electricity and maintenance, and to improve street lighting quality.

From AEL's perspective, opportunities for sound investments arose from three innovations:

- The advent of energy performance contracts (EPCs), allowing cash-strapped municipalities lacking access to debt capital to fund street lighting retrofits through savings shared with private contractors;
- Significant improvement in lighting technology from incandescent to more efficient LEDs; and
- The possibility of partnering with Econoler to tap into carbon offset markets for emissions reduction credits.

At the outset of the project in 2008–09, because no Clean Development Mechanism (CDM, the United Nations system for international carbon crediting) methodology for municipal street lighting efficiency yet existed, this approach represented an innovative test case. The CDM allows emission reduction projects in developing countries to earn certified emission reduction (CER) credits, which can be traded and sold; these are used by industrialized countries to meet their emission reduction targets under the Kyoto Protocol.[5] The CER payments represented an additional financial incentive to AEL and the municipalities because the project offered "additional" reductions in emissions: the baseline technology was incandescent lighting, which consumes more electricity and thus produces more emissions.

Regulatory and Policy Environment

Because most Indian municipal corporations are not creditworthy, they have limited options for raising capital for energy-efficient streetlight investments through debt issuance. Therefore, energy performance contracts (whether for guaranteed, shared or deemed-savings) have become the predominant model for financing public lighting in India.

Under the National Energy Conservation Act of 2001, the Bureau of Energy Efficiency (BEE) established guidelines for the energy efficiency performance contracting process. However, since 2005–09, when the suite of AEL projects commenced, these guidelines had not been promulgated and officials in municipalities such as Akola MC had to develop their own bidding process.[6] Despite the absence of national standards, however, there was a generally accepted set of municipal energy performance contracting practices. These included shortlisting ESCOs using the expression of interest

[4] USAID, 2010. *Guidelines: Energy Efficient Street Lighting* (New Delhi: USAID ECO-III Project). https://beeindia.gov.in/sites/default/files/ctools/Energy%20Efficient%20Street%20Lighting%20Guidelines.pdf
[5] CDM, https://cdm.unfccc.int/about/index.html
[6] ESMAP. "Good Practices in City Energy Efficiency: Akola Municipal Corporation, India - Performance Contracting for Street Lighting Energy Efficiency." ESMAP, Energy Efficient Cities Initiative. October 2009. https://www.esmap.org/sites/esmap.org/files/CS_India_SL_Akola_020910.pdf

(EOI) process, issuing the RFP, evaluating and selecting the ESCO, negotiating the contract, and conducting measurement and verification (M&V).[7]

In India, the street lighting infrastructure tends to be owned by municipal corporations and urban infrastructure trusts rather than the electric utilities, which facilitates the coupling of equipment supply (including luminaires) with maintenance contracts. Consequently, AEL signed two parallel contracts with its client local governments: one for design, supply and installation, and another for maintenance. This approach allowed AEL to create incentives for ongoing payment for operations and maintenance, and commit municipalities to pay for capital expenditures for lighting supply. AEL implemented these measures because securing payment is a challenge with many municipalities. In the case of maintenance contracts, AEL as service provider retains the ability to withhold services in the case of non-payment.

In AEL's experience, these contracts tended to provide a strong incentive to pay because the municipal governments generally lacked capacity for adequate maintenance at the outset of the projects. In most cases, municipalities paid their pre-agreed monthly payments within 2 to 12 months of invoicing. Payments were generally calculated on the basis of deemed savings (the model evolved from shared savings to a deemed/guaranteed savings model in later projects) determined during the auditing and pilot phases. Most public lights in India are not metered.

Tracing the Implementation Process

The implementation process from the city perspective is summarized in Figure 1.

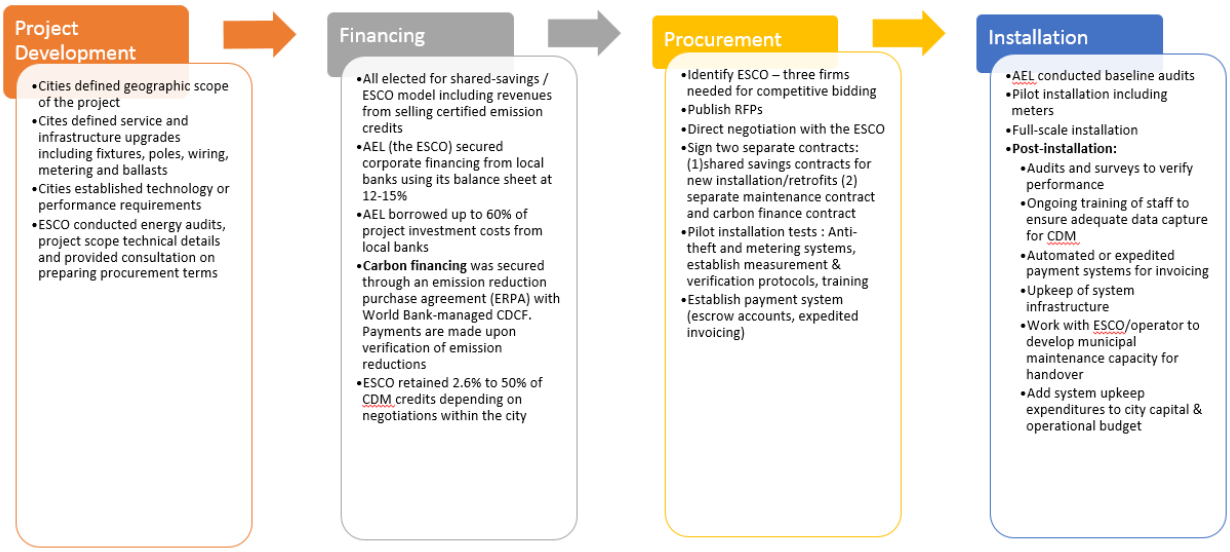


Figure 1: Summary of the implementation process for the AEL projects

[7] Jas Singh, Dilip R. Limaye, Brian Henderson, and Xiaoyu Shi. *Public Procurement of Energy Efficiency Services: Lessons from International Experience* (Washington, DC: IBRD/The World Bank), 2010. http://tinyurl.com/nd2undy

Project Development

In most of the cities in which AEL ultimately secured contracts, the firm would first approach city leaders with a project proposal. To secure interest and facilitate tendering, AEL would assist municipal governments by conducting an initial energy audit, developing the project's scope, and consulting the authority on the preparation of appropriate procurement terms. In some cases, metered energy efficiency pilots were even conducted prior to bidding. In this way, AEL enabled cities to understand the scale of the opportunity and the potential to achieve savings without up-front capital investment. (In all cases, AEL won contracts through competitive procurement with a minimum of three bids. The energy audit and pilot installation could come before, during, or after the contractor's selection, depending on the procurement terms.) The cities provided input into the project development process by defining geographic scope, desired service and infrastructure upgrades, and technology requirements based on standards.

Financing

In India, municipal corporations are greatly restricted in terms of access to debt capital. They do not have full autonomy over their finances, and often require state-level approval to borrow funds. Further, for a variety of reasons, many cities are not currently creditworthy. These problems are particularly acute in smaller second- and third-tier cities,[8] which formed the client base for the AEL street lighting project. As a result, all up-front costs were entirely covered by AEL, rather than by the municipalities.

The World Bank estimates that the projects collectively had a combined capital cost of US$5.83 million. These projects were implemented on a build own operate transfer (BOOT) basis through an ESCO shared savings approach. The World Bank Community Development Carbon Fund (CDCF) made no advance payments to AEL, and AEL used its AAA credit rating to secure corporate bank loans at rates of 12–15 percent. As a large-scale lighting manufacturer, AEL was more readily able to raise capital than many ESCOs, which often lack bankable assets and deep balance sheets. However, AEL reports that government contracts from client ULBs with strong credit ratings also assisted in securing loans,[9] indicating there is increasing recognition among financial institutions of municipal EPC contracts as viable collateral. AEL estimates that 10 percent of the cost of all its municipal street lighting EPC projects goes to financing.

As it signed on municipalities to street lighting energy performance contracts, AEL also negotiated ancillary CDM revenue-sharing clauses as part of the shared-savings agreements, promising to pass along 50–97.4 percent of carbon credit proceeds (each city negotiated a different rate, which AEL attributes to the wide range in monitoring and compliance costs in each municipality). AEL is responsible for monitoring the CERs for the entire CDM crediting period.

Following the experience of the pilot project in Indore, where it took an extra year for the city to provide payment for services after the end of the three-year project, AEL, working with the World

[8] India classifies its cities into six "tiers" on the basis of population; Tier 2 is 50,000–99,999 and Tier 3 is 20,000–49,999.

[9] Written correspondence, Naman Shah, August 2015.

Bank, designed a mechanism to receive expedited payment for installation and maintenance of LED lighting systems out of savings. Measures to expedite payments—such as pre-calculated payments, automatic payments, and expedited government approvals—helped to shorten and limit arrears, though they did not eliminate them entirely.

Figure 2 shows a simplified illustration of the project's structure.

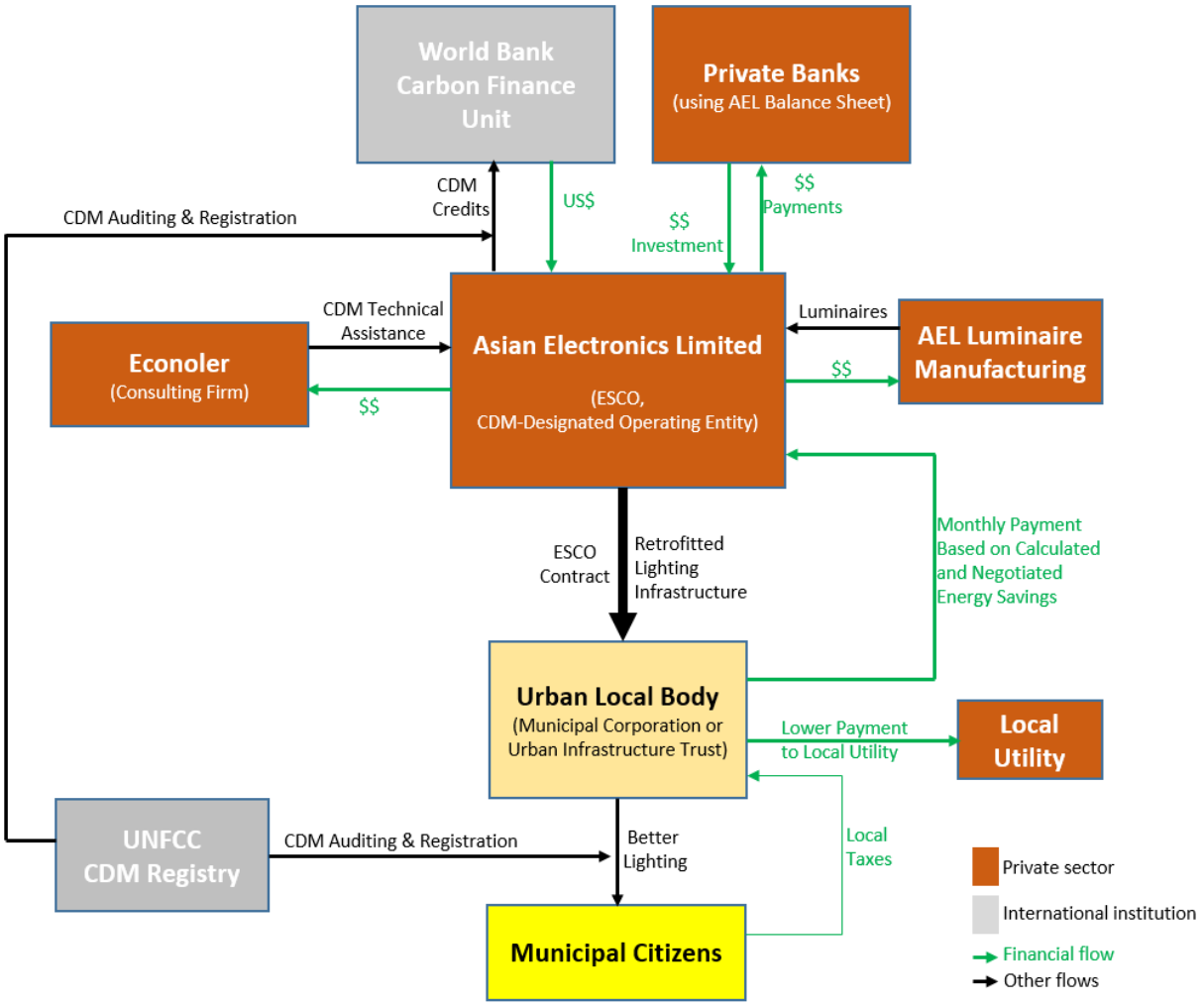


Figure 2: Notional flows in the AEL project

Procurement Processes

The cities involved in these nine projects procured AEL independently and one at a time over four years from 2005 to 2009. Latur became the first city to contract with AEL, with its project commencing in December 2005, followed by Pune in January 2006 and Akola in September 2006. Subsequent cities were able to benefit from learning about the existing projects, which facilitated the spread of municipal street lighting EPCs throughout India.

However, in the absence of national guidance, each ULB developed its own procurement process. To take one example, in 2006, Akola MC called for competitive bids to implement a street lighting retrofit project within their service territory, encompassing 13,003 luminaires, roughly 70 percent of them 40-watt CFLs (the remainder being high-pressure sodium and mercury high-impact discharge fixtures).[10] Bidding parameters included maintaining luminance levels on the street to 20–30 lux,[11] as per Indian Road Congress standards for street lighting.[12] Bidding documents were designed by city officials. An analogous process was repeated in the other eight ULBs, with AEL often providing templates for bidding document design since municipalities were not familiar with energy performance contracts when AEL started.[13] Though the process was not formally standardized, AEL reports that it used almost identical contracts with all client cities.[14]

Included in AEL's package of goods and services were financing, technology, lighting products, and maintenance. The energy savings accrued from these investments were quantified and shared between AEL and each city in pre-agreed ratios for a period of 5 to 7 years. Generally, AEL negotiated payment of 80 percent of electricity savings to cover its capital, operating, and up-front financing expenditures; in the case of Akola, AEL captured 95 percent of electricity savings, and in Alwar MC, 87.5 percent. This is relatively high because AEL provided the full amount of up-front capital, which is quite expensive in India, and spent significant resources upgrading associated ancillary infrastructure. These costs were rolled into the shared-savings contracts, and taken at AEL's risk. Additionally, the real benefit to the cities was not savings but rather improvement in lighting services, which the cities did not have the money to invest in themselves.

In later years AEL began to separate capital improvements (luminaire replacement and infrastructure upgrades) from service contracts, and to secure guaranteed payback for those capital improvements independent of shared savings stemming from operations and maintenance. Ostensibly this separation did not change the terms or structure of the EPC (and thus was not challenged by municipalities), yet this practice helped to ensure collection of payments by AEL. Separate installation and maintenance contracts also allowed for flexibility in negotiating the extent and terms of maintenance. In Akola, in addition to electricity savings, the municipal corporation paid AEL a share of savings from reduced costs of maintenance, amounting to Rs 8.25 (US$0.17) per lighting fixture per year. Akola MC further paid AEL a fixed fee for annual operations and maintenance (O&M) expenditures, totaling Rs 1.1 million (about US$23,000).[15] The city benefited by getting an upgraded public lighting system (and with it an improved sense of safety, enhanced aesthetics, and so on) as well as reduced volatility in its lighting bill.

[10] World Bank CDM Project Design Document.
[11] *Lux* is the International System unit of illumination; it is equal to one lumen per square meter.
[12] ESMAP. "Good Practices in City Energy Efficiency: Akola Municipal Corporation, India - Performance Contracting for Street Lighting Energy Efficiency." World Bank, October 2009.
[13] AEL helped cities get interested in and design street lighting services procurement. When AEL first approached them, municipal street lighting contracts were nearly unknown in India, so AEL helped to create the market. The templates did not give AEL any special advantage when it came to bidding for the work, and as the market matured, cities no longer needed templates from AEL.
[14] Written correspondence, Naman Shah, August 2015.
[15] ESMAP, "Good Practices in City Energy Efficiency" (2009).

By all reports, the projects were deemed a success by both the ULB administrations and by AEL itself. Significant energy savings were achieved in all nine locations. An independent consultant who monitored the project reported that the local authorities were quite satisfied with the energy and cost savings, the improvement in maintenance, and the resulting improvement in performance. AEL provided reliable maintenance for many years, often significantly upgrading degraded street lighting infrastructure, and ensuring that upwards of 90 percent of luminaires were in operation at all times. The installed CFLs achieved reductions in monthly bills of up to 30–40 percent.[16] Electricity savings across the nine ULBs were estimated at 47,000 megawatt-hours from December 2012 to September 2014.[17] Furthermore, at the end of the day, AEL was able to secure payment from the municipalities (though not without challenges, as described later). Because the ULBs made no up-front payments (for either installation or maintenance), AEL borrowed up to 60 percent of entire project costs up front from private banks.

Installation

AEL signed design, supply and installation (DSI) contracts with nine municipal governments to replace baseline lighting with more efficient lighting. (Maintenance contracts were signed separately.) The seven municipal corporations (MCs) and two urban improvement trusts (UITs) at the outset of the project in 2008–09 included a sum total of more than 121,000 luminaires. This total included all municipal roadway luminaires in all MCs and UITs except for that of Pune, for which 13,970 out of the city's roughly 100,000 roadway luminaires were included. The number of luminaires per municipality ranged from 4,700 to 26,000, with an average of roughly 13,000 per municipality.

From the date on which the municipality issued the work order, it would take AEL one month to complete the initial baseline audit, followed by a pilot installation complete with metering. Once the pilot proved successful based upon metered savings, AEL would proceed with the complete installation of streetlights, which, for the larger cities, would take two to three months. This included wiring, and often replacement of poles and other defective equipment. In some cases, a reengineering and redesign of lighting was necessary. AEL estimated that 5–10 percent of streetlights were "over-designed" (with wattage too strong, too many luminaires, or placed too close together), while 1–3 percent were under-designed.[18] AEL also ensured remote monitoring at "nodes," or switch points, that controlled blocks of lights, to track electricity usage and monitor performance. However, an operations audit showed that in most locations, only about 5–10 percent of switch points were equipped with functioning meters.[19] In Akola, the selection of 10 percent of lights for monitoring was explicitly defined in the terms of the contract.[20]

[16] Interview, V. Baraneedharan, April 2015.
[17] World Bank, Implementation Status and Results Update No. 3, March 2015.
[18] Interview with Naman Shah, AEL, April 2015.
[19] V. Baraneedharan, "Annual Survey of Lamp Performance (2013) for CDM project 'Bundled street lighting energy efficiency projects implemented by AEL in India,'" February 2014.
[20] ESMAP, "Good Practices in City Energy Efficiency" (2009).

Performance Monitoring and Assurance

For each city AEL hired a project manager responsible for maintenance and for ensuring adequate resources and equipment were available. Due to adverse conditions (e.g., variable voltage and blackouts, poor infrastructure quality) and stiff penalties for low burning efficiency (i.e., low luminaire performance rate), AEL instituted a practice of always carrying a local inventory of replacement bulbs equivalent to 1 percent of the total number of luminaires in use. Furthermore, AEL instituted proactive, preventive replacement of bulbs prior to the expiry of their expected lifetimes. In fact, AEL sometimes replaced bulbs preventively every 90 days, or after roughly 1,000 hours, regardless of the status of the bulbs.[21] AEL's status as a CFL/LED manufacturer facilitated aggressive luminaire sourcing and replacement.

By the end of 2013, in keeping with the 5- to 7-year maintenance schedules agreed at the outset, five of the nine urban local bodies (ULBs) were still contracting AEL for service and maintenance. Four others had assumed their own maintenance following the expiration of the AEL service contract. The first annual performance survey, as required by the CDM Project Design Document (PDD), conducted by a World Bank consultant, revealed that more than one-third of all luminaires were not functioning across the nine cities surveyed – a dramatic increase from the roughly 5 percent non-functioning fixture rate established in the contracts for AEL's maintenance period (see Table 5).

No.	Name of location	Maintenance status, Jan. 2014	Number of CFL lamp fittings surveyed	Number of CFL lamp fittings in operation	Percentage of lamp fittings in operation
1	Bikaner	**AEL**	360	246	**68%**
2	Alwar MC	**AEL and subcontractors**	367	265	**72%**
3	Alwar UIT	**AEL and subcontractors**	398	248	**62%**
4	Ajmer UIT	**AEL**	412	261	**63%**
5	Ajmer MC	**AEL**	373	295	**79%**
6	Indore	**Municipal Corp. (as of 9/13)**	336	241	**72%**
7	Akola	**Municipal Corp.**	348	227	**65%**
8	Pune	**Municipal Corp.**	345	155	**45%**
9	Latur	**Municipal Corp.**	320	177	**55%**
	Total	**AEL**	1910	1315	**69%**
	Total	**Municipal Corp.**	1349	800	**59%**

Source: Adapted from V. Baraneedharan, "Annual Survey of Lamp Performance (2013) for CDM project 'Bundled street lighting energy efficiency projects implemented by AEL in India'", February 2014.

Table 1: Summary of January 2014 lamp performance survey in each project location

As the table shows, lamp performance varied considerably—from 45 to 79 percent per surveyed location. Satisfactory performance per contract terms is 95 percent, which AEL claimed to be meeting and exceeding when payments from the cities were current. In project locations where AEL was

[21] Interview with Naman Shah, April 2015.

providing maintenance during the survey period, higher lamp performance was observed (79 percent in Ajmer MC and 72 percent in Alwar MC); where AEL was not providing it, lower lamp performance was recorded (45 percent in Pune and 55 percent in Latur). Overall, AEL-maintained networks have maintained a rate of performance at least 10 percent greater than that of cities maintaining their own networks (69 percent vs. 59 percent) – but still well below target, contracted levels.

There are a number of possible explanations for this discrepancy. Most prominently, the methodologies for CDM performance and for fulfilment of municipal contracts are different. CDM methodologies measure the performance of each luminaire (bulb), whereas ULB contracts with AEL mandate performance of fixtures, which are considered to be performing if any bulb in a multiple-luminaire fixture (e.g., four bulbs) is functioning. This means that AEL could consider a fixture with some functioning and some non-functioning luminaires to be "operational," whereas the CDM would not.

There are two other possible explanations. First, the first project audit that discovered these performance levels surveyed both metered and non-metered fixtures. It is possible that AEL maintained 90 percent performance only for metered switch points and associated fixtures. Second, AEL withheld maintenance in at least one city where payments were significantly delayed, leading to a rapid deterioration in performance rates. Thus it is paramount to design contracts with the right measurement and verification protocol.

Main Challenges and Solutions

Table 6 lists a number of the problems related to implementation that arose, and summarizes how AEL and the cities sought to solve them.

No.	Problem	Solution
1	**Establishing a baseline.** Generally, luminaire performance rates rose from 65% to 80% at the outset to greater than 95% (of *fixtures* and not *luminaires* as seen above) under AEL's maintenance. Increased functioning lights increased electricity consumption, reducing savings by up to 30%. Cities would often blame AEL for lower-than-expected savings.	AEL began to calculate baseline and savings both on an initial sampling basis and actual functioning basis simultaneously. AEL added provisions in the contract to ensure that savings calculations would be adjusted to take into account higher overall operational efficiency (i.e. more functioning luminaires compared to the baseline), reflecting savings per functioning fixture or luminaire block rather than absolute system-wide electricity use reductions.
2	**Proper streetlight design**. At least 5–10% of city street lights are not planned effectively—overdesigned or under-designed, resulting in inefficient and/or inadequate street lighting.	AEL included in the project the capability to undertake "lightscaping," or street lighting redesign, in the project scope, and adjusted baseline electricity use calculations and capital expenditures accordingly.
3.	**Delays in payment.** Since the municipal governments are generally cash-strapped and payment approvals face bureaucratic inertia, there may be delays in receivables. AEL regularly experienced 60–90 day delays in the approval and transfer of monthly payments.	AEL set aside adequate resources to maintain streetlights irrespective of delayed payment. Also, AEL increasingly separated maintenance and supply into two discrete contracts, allowing AEL to recover the supply-related income notwithstanding potential non-payment for maintenance. Also, the government clients pre-approved a significant share of payments due to AEL, and instituted expedited payment approval procedures.

4.	**Electricity theft**. Theft, particularly in second- and third-tier cities, is a major concern which can result in reduced savings resulting in cities' defaulting on the payment as agreed in the contract.	Utility companies, client and AEL worked together to implement measures such as concealing the supply points, putting up tamper-proof meters, etc. Increased up-front expenditures for electronic metering, tamper proof seals, and Load Management Systems with GSM technology were adopted by AEL in later projects to curtail theft.
5.	**Asymmetrical balance of risk borne.** Maintenance contracts generally place all performance risks on the ESCO, yet AEL does not control voltage quality, electricity reliability, and other infrastructure concerns that impact luminaire performance. Furthermore, the penalties borne by AEL due to nonperformance are large: up to 50 rupees (US$0.79) per day per light.	To ensure 100% client satisfaction and maximum burning efficiency, AEL adopted preventive maintenance practices. If a tube rod CFL has a life of 5,000 hours, the ESCO will initiate replacement upon completion of 4,900 hours of burning so as to reduce the down-time at minimal possible levels. Also, AEL maintained a minimum 1% inventory at the site to ensure timely replacement. AEL also began negotiating inclusion of incentives necessary to offset high costs of keeping performance above the 90% contracted threshold. One method employed was the inclusion in AEL's contracted services of more extensive up-front infrastructure investment to ensure lighting performance and upkeep.
6.	**Savings distortions due to non-performance of lights.** Non-performing luminaires due to outages and failures may also result in lower utility bills.	Installation of Load Management Systems (LMS) with capable GSM technology enables AEL and municipal client to monitor streetlights functionality. Any major variance in load indicates non-functioning street-lights or theft. GSM technology would work on real time basis and point the direction of location wherein the variance is experienced.

Source: Adapted from ESCO brief, drafted by AEL.

Table 2: Summary of problems and solutions during implementation

These problems – particularly higher-than-expected maintenance costs, disputes over actual savings, and payment delays—tended to eat into AEL's profits and, according to AEL, made some of its first contracts not profitable until proper remediation and improved contract design corrections were made. Specifically, to secure more timely payment, AEL (a) began separating payment for infrastructure ("supply") from operations and maintenance; and (b) invested more up front in improved infrastructure for performance, metering, and theft prevention. Generally, clients were pleased with performance. Akola MC, which signed a six-year maintenance contract upon installation in 2007, experienced 2.1 million kilowatt-hours (56%) in annual energy savings and Rs 6.4 million (US$133,000) in cost savings in the first year, providing full payback in 11 months.[22]

Lessons Learned

Adequate protocols for establishing data collection systems are necessary for effective monitoring, reporting and verification (MRV).

A key drawback of the project was the lack of compatibility between the monitoring required by AEL's business practices and contracts with its client cities, on one hand, and CDM monitoring requirements on the other. Because AEL's energy performance contracts with Indian ULBs were based primarily on deemed rather than metered savings, AEL was ill-equipped to meet the rigorous metering and

[22] ESMAP, "Good Practices in City Energy Efficiency" (2009).

monitoring requirements of the CDM. Should CDM or other carbon revenues be part of municipal street lighting projects in the future, these monitoring practices and requirements should be synchronized or the more rigorous (CDM in this case) would need to have a mechanism in place.

Difficulty establishing appropriate baselines for the projects from which to account for savings.

India's rapidly growing, poorly managed municipal street-lighting networks create numerous challenges for establishing the proper baseline. Streetlight network expansion as well as the increase in electricity use due to improved maintenance (i.e., greater numbers of functioning luminaires) necessitate calculations of expected "rebalancing" as well as regular, real-time updating of appropriate baselines at monthly or quarterly intervals. Such appropriate baselines may also be impacted by deferred ESCO maintenance due to non-payment by the municipal client.

Mechanisms for securing payment of the ESCO by the municipal corporation are critically important.

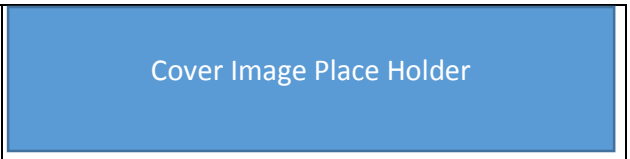
AEL did not use secured escrow contracts or automatic payment mechanisms. Initially, delays resulted from bureaucratic challenges regarding disputed savings, and municipal government cash-flow problems. In later projects, AEL redesigned contracts to expedite and automate payment approvals, anticipate contingencies in cases of disputed savings, and reserve the right to withhold maintenance in the case of non-payment (which AEL did for one municipal corporation). Such barriers to prompt payment should be addressed at the project design stage to ensure the financial and operational viability of the ESCO model in India; AEL is already addressing them in more recent street-lighting ESCO projects.

Provisions are needed to address issues over which the ESCO has no control.

Although ESCOs have little to no ability to control irregular voltage, blackouts, electricity theft, vandalism, and poor infrastructure quality and maintenance—none of which fall under their contractual obligations—they are sometimes held accountable when things go wrong. Energy performance contracts should make specific provisions absolving ESCOs of responsibility for such issues. Even better, mechanisms should be established to allow municipal governments, ESCOs, and other key stakeholders (such as state regulatory bodies and distribution companies) to address them.

Series of Case Studies on Public Lighting Delivery Models

"**ESCO Delivery Model Case Study; Asian Electronics Ltd., India**" 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 synthesize 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:

	
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	Public-Private Partnership Delivery Model Case Study; Birmingham, United Kingdom
URL	URL
	
Super-ESCO Delivery Model Case Study Energy Efficiency Services Limited, Vizag, India	Joint Procurement Delivery Model Caser Study Ontario, Canada
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	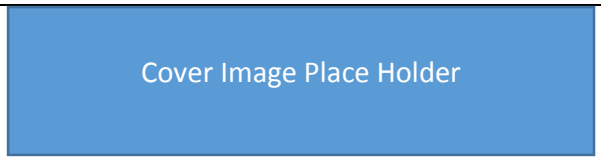
Municipal Financing Delivery Model Case Study Quezon City, Philippines:	Lease-to-Own Delivery Model Case Study Guadalajara, Mexico:
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