Proven Delivery Models for LED Public Lighting:

Super-ESCO Delivery Model Case Study

EESL in Vizag, India

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Standard ESMAP text placeholder

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Acronyms and Abbreviations

AP	Andhra Pradesh
BEE	Bureau of Energy Efficiency
CCMS	central control and monitoring system
CRI	color rendering index
DPR	detailed project report (detailed energy audit)
€	Euro
EESL	Energy Efficiency Services Limited
ESCO	energy service company
GDP	gross domestic product
GVMC	Greater Visakhapatnam Municipal Corporation
HPS	high-pressure sodium
LED	light-emitting diode
MoP	Ministry of Power
MOU	memorandum of understanding
NMEEE	National Mission of Enhanced Energy Efficiency
Rs	Indian Rupee
TFL	tubular fluorescent lamp
ULB	urban local body
US$	US Dollar
Vizag	Visakhapatnam
BIS	Bureau of Indian Standards
CFL	compact fluorescent light
ESMAP	Energy Sector Management Assistance Program
GENDR	Environment and Natural Resources Global Practice
GSURR	Urban, Rural, and Social Development and Resilience (Global Practice)
kWh	kilowatt-hour
LDC	local distribution companies
MC	municipal corporation
RFP	request for proposals
W	watt

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Super-ESCO Delivery Model Case Study

EESL in Vizag, India

City name	**Visakhapatnam, India**
Project dates	**November 2014 – February 2015**
Project size	**91,775 points of light**
Implementing agency	**Greater Visakhapatnam Municipal Corporation (GVMC) and Energy Efficiency Services Limited (EESL)**
Funding mechanism	**ESCO with annuity-based deemed savings model**
Implementation/procurement process	**Installation and 7-year maintenance by EESL**
Expected energy savings	**50–55%**

Introduction

Visakhapatnam (also called Vizag, for short) is the largest and most populous city in the Indian state of Andhra Pradesh (AP) and, with over 2 million people, the 15th most populous city in India. It is a port city located on the southeast coast of India on the Bay of Bengal. It is the administrative headquarters of Visakhapatnam district, one of nine districts in Andhra Pradesh, and also the financial capital of the state. A cosmopolitan city with people from different parts of India, Vizag is a commercial hub of Andhra Pradesh with a GDP of US$26 billion and major economic contributions from heavy industry, tourism, industrial minerals, fishing, and information technology.

The Vizag municipality was formed in 1858, and converted to the Visakhapatnam Municipal Corporation in 1979. On November 21, 2005, the government of Andhra Pradesh released a Government Order establishing the Greater Visakhapatnam Municipal Corporation (GVMC) comprising the Visakhapatnam municipality, the Gajuwaka municipality, and 32 villages.

In 2014, Cyclone Hudhud hit Andhra Pradesh with heavy rains and winds up to 180 kilometers per hour, devastating many areas. It caused power disruptions by damaging and uprooting much of the infrastructure including street lighting poles, telephone poles, and the electrical grid system. The cost to the Eastern Power Distribution Company of Andhra Pradesh—including distribution disruptions and damage to transmission lines and poles—was estimated at Rs 400 billion (US$6 billion). Total economic losses were estimated at around Rs 700 billion (US$11 billion).

The government of Andhra Pradesh undertook several emergency measures in the affected areas to restore power, telecommunications and other infrastructure. In Vizag city, only 10,000 of the 91,000 street lights were still functional, with negative consequences for public safety and security. The Andhra Pradesh government decided that all GVMC street lights should be upgraded and replaced with energy efficient LED lighting.

The AP government and GVMC engaged Energy Efficiency Services Limited (EESL) to undertake this infrastructure upgrade. Established by the Ministry of Power (MoP) of the government of India, EESL is a joint venture company of several public sector units of the MoP: the National Thermal Power Corporation, the Power Grid Corporation of India, the Power Finance Corporation, and Rural

Electrification Corporation Limited. EESL is a super-ESCO that is defined as an ESCO: (a) established by the government; (b) serving as an ESCO for the public sector; (c) supporting capacity development and activities of other ESCOs; and (d) facilitating access to project financing.[1] As a super-ESCO, EESL has a strong public sector mandate: to lead the market development and implementation functions of the National Mission of Enhanced Energy Efficiency (NMEEE), which seeks to unlock the energy efficiency market in India. More specifically, EESL:

- Creates markets for private and public facilities through information sharing and capacity building of facility owners;
- Develops projects that address specific market barriers;
- Designs strategies to mitigate technical, financial and regulatory risks;
- Aggregates projects to generate economies of scale for its clients;
- Develops model templates of the agreements, payment security, memorandums of understanding, and so on that are necessary for project implementation;
- Disseminates best practices in order to encourage replication; and
- Provides transaction support to facility owners.[2]

Additionally, EESL has experience designing, implementing, monitoring and financing energy efficiency and conservation projects on behalf of public and private sector clients in the industrial, commercial and institutional fields.

EESL and GVMC signed an agreement for the installation, operation, and maintenance of LED street lighting throughout Vizag city over a period of seven years. Because of the damages to Vizag's street lighting infrastructure, EESL initiated the massive revamp of Vizag's public lighting on an emergency basis. EESL mobilized over 100 teams to remount street lighting poles and install 91,000 street lighting fixtures, putting the entire public lighting system back into operation in just 45 days. EESL financed the entire project, and GVMC is repaying it out of its electricity cost savings accruing over the seven-year contract period. The total project cost was approximately Rs 650 million (US$10.5 million). This street lighting upgrade results in annual savings of 24 gigawatt-hours to the government of AP and GVMC.

Context

Vizag at night is illuminated with 91,000 street lights that owned by GVMC. Before Cyclone Hudhud, most of the street lights used high-pressure sodium-vapor (HPS) or tubular fluorescent lamp (TFLs) technologies. Within GVMC's jurisdiction, there are 8 zones made up of 72 wards and approximately 4,000 manual points to switch the streetlights on and off. Maintenance was outsourced, with operation and replacement of street lights handled through a dedicated customer-care service center. Registered complaints were forwarded to the assistant engineer of the respective ward or zone and generally attended within 72 hours. Table 1 provides the distribution of various types of light sources that were being used in street lighting prior to LED installation.

[1] Dilip Limaye, "Scaling-Up Energy Efficiency: The Case for a Super-ESCO," presentation at Asia ESCO Conference 2010, New Delhi. http://www.asiaesco.org/pdf/presentation/2-2.pdf
[2] EESL Toolkit: http://www.eeslindia.org/writereaddata/EESL%20Toolkit%20final.pdf

Conventional Light	Replacement Light (LEDs)	Quantity
40 watt TFL	20 watt	60,395
70 watt HPS	40 watt	4,084
150 watt HPS	70 watt	18,392
250 watt HPS	120, 140, 150, and 160 watt	8,778
400 watt HPS	210 watt	126
Total		**91,775**

Table 1: Street lighting sources prior to and after LED installation

The replacement of HPS and TFL lamps with LED lamps resulted in energy savings of more than 50 percent, along with improvements in road illumination levels. In addition, a central control and monitoring system (CCMS) has been installed that can control the LED street lights remotely, reduces the time for fault detection, and provides better control of switching and dimming to reduce energy consumption. The CCMS in Vizag is a "smart" system, with information on each light available to be viewed and reported easily via a web-based tool. Vizag also uses the CCMS to measure energy savings, providing the municipality with much more information than they had previously about the energy consumption of their street lights.

The benefits of LED street lights to GVMC and the residents of Vizag include:

- Improved light quality that enhances safety, security and visual comfort in the city;
- Modernization of the street lighting system, with a CCMS monitoring the condition and energy consumption of each luminaire and reducing the time required for fault detection; and
- Improvements in lighting that influence the public's overall perception of municipal services.

Annuity-Based Deemed Saving Model

India's Bureau of Energy Efficiency (BEE)[3] and EESL have been working with various municipalities throughout India to mainstream energy efficiency in the governance of ULBs.[4] Energy efficient street lighting has been identified as an important ULB role requiring a major overhaul in terms of how services are operated and run in order to provide better and more efficient services to citizens. Under BEE's Municipal Energy Efficiency program, detailed energy audits have been conducted for ULBs, resulting in the development of detailed project reports (DPRs)[5] for municipalities across the country. This initiative has encouraged ULBs to undertake energy efficiency programs for street lighting.

However, previous ESCO-based projects based on guaranteed or shared savings have not been successful. These models require an accurate baseline, sufficient energy consumption data, and installed equipment that meets the required national standards. With little data available for

[3] The Bureau of Energy Efficiency (BEE) is a statutory body under the Ministry of Power responsible for spearheading the improvement of energy efficiency of the economy through various regulatory and promotional instruments.

[4] ULBs are the local bodies, such as state public works departments, municipalities, and corporations, who manage the public utility services in each state.

[5] Detailed Project Reports are also known as detailed energy audits

determining a baseline, limited understanding of the actual energy consumption of street lighting, and installed equipment that does not always meet national standards, it is extremely difficult for an ESCO to meet the predetermined guaranteed savings expected by municipalities.

To overcome these challenges, BEE and EESL designed an annuity-based deemed savings model designed to encourage investments in energy efficient street lighting and prepare the market in India for more street lighting projects. In this model, LED technologies are demonstrated in a designated area, and calculations are made based on those measurements to determine overall energy savings per measure. This method requires fewer resources for validation, since the demonstration usually takes about one month as compared to three to six months in a shared savings model. EESL provides the capital investment and replaces the existing street lights with LEDs (without any need for municipalities to invest). The consequent reduction in energy and maintenance costs to the municipality is used to recover EESL's costs over a period of time. The contracts between EESL and a municipality are typically of seven years' duration, and they guarantee a minimum energy savings (of typically 50 percent) as well as provide free replacements and maintenance of lights at no additional cost to the municipality. This service model enables the municipalities to install advanced street lights with no up-front capital cost—with repayments to EESL that are within the present level of expenditure. In this way, there are no additional expenditures required for the municipality to upgrade to energy efficient LED street lights.

EESL has successfully implemented the annuity-based deemed savings model in several states, and used it to design the GVMC street lighting upgrades.

EESL Energy Efficient Street Lighting Project: Methodology

Implementing the EESL approach to energy efficient street lighting projects normally requires eight steps. These are laid out in detail in the *EESL Toolkit for Street Light Energy Efficiency*, which EESL created as part of its mandate to develop the EE market and standardize process.[6] Because of the need to accelerate this process in the case of Vizag, EESL and GVMC skipped the first five steps and started by signing an implementation agreement (step 6).

1. **Memorandum of understanding (MoU) between the municipality and EESL**. EESL enters into an MoU with the municipality to provide a framework within which EESL will implement energy efficiency measures in street lighting, a role that is in the jurisdiction of the municipal corporation. (*This step was skipped in Vizag's case*.)
2. **DPR validation and joint verification.** EESL re-validates the DPRs of municipalities where they are already available, or prepares a fresh DPR where they are not. This includes physical verification of the number, type, and rated wattage of existing fixtures on a sample basis. (*This step was skipped in Vizag's case*.)
3. **Technology demonstration.** Working in a demonstration area designated by the municipality, EESL undertakes the retrofitting of existing (HPS/TFL) street lights with energy efficient LED street lighting fixtures. The actual consumption data are collected and analyzed against the

[6] The *EESL Toolkit for Street Light Energy Efficiency* is available online at: http://www.eeslindia.org/writereaddata/EESL%20Toolkit%20final.pdf

baseline, and the difference is the savings agreed for the entire municipality. (*This step was skipped in Vizag's case*.)

4. **Determination of annuity.** The annuity to be paid to EESL depends upon several parameters, including the capital cost of installed equipment and infrastructure; energy savings validated by the technology demonstration; total savings to the municipality in terms of electricity payments, operations, and maintenance; and project management charges (limited to 2–4 percent of the project's capital cost). (*This step was skipped in Vizag's case*.)
5. **Technical specifications.** To ensure that installed LED fixtures comply with Bureau of Indian Standards (BIS) requirements, products must meet a set of minimum technical specifications, including the following:

    - LED chips with a minimum efficacy of 125 lumens per watt
    - Luminaire efficiency of at least 80 lumens per watt
    - Average rated lifetime of 50,000 hours
    - Color rendering index (CRI) greater than 70
    - Five-year warranty, including free replacement for technical defects

    (This step was skipped in Vizag's case.)

6. **Implementation agreement.** After the demonstration of technology and determination of energy savings and annuity payments, EESL enters into an implementation agreement that includes the following:

    - Warranty to the products supplied will be throughout the contract period and cover any manufacturing defects.
    - If the luminaire fails to meet the agreed specification, EESL shall rectify or replace it at its own cost throughout the contract period, or payments will be reduced proportionately.
    - EESL shall ensure that at least 90 percent of the streetlights installed are operational, or payments will be reduced.
    - EESL will install centralized monitoring and control to optimize operational efficiency.
    - The municipality will pay the annual consideration in respect of the above supplies in every month as per the agreed schedule.

7. **Defining a payment security mechanism.** To ensure that EESL recovers its capital investment, a robust payment security mechanism is put in place. EESL requires each municipal corporation to have a bank guarantee covering the capital cost of the project. If the MC is unable to provide the guarantee, either a tripartite implementation agreement or a state government guarantee is required. In addition to either of these guarantees, the implementation agreement has provisions for mitigating defaults by having escrow arrangements.
8. **Selection of an implementation partner.** After the previous steps are completed, EESL selects an implementing partner, usually through an open competitive bidding process. However, because of the emergency situation in Vizag and the short timeline for street lighting

upgrades, implementing partners were limited to approved companies that had previously met a set of qualifying requirements.

Tracing the Implementation Process

The implementation process in Vizag is summarized in Figure 1:

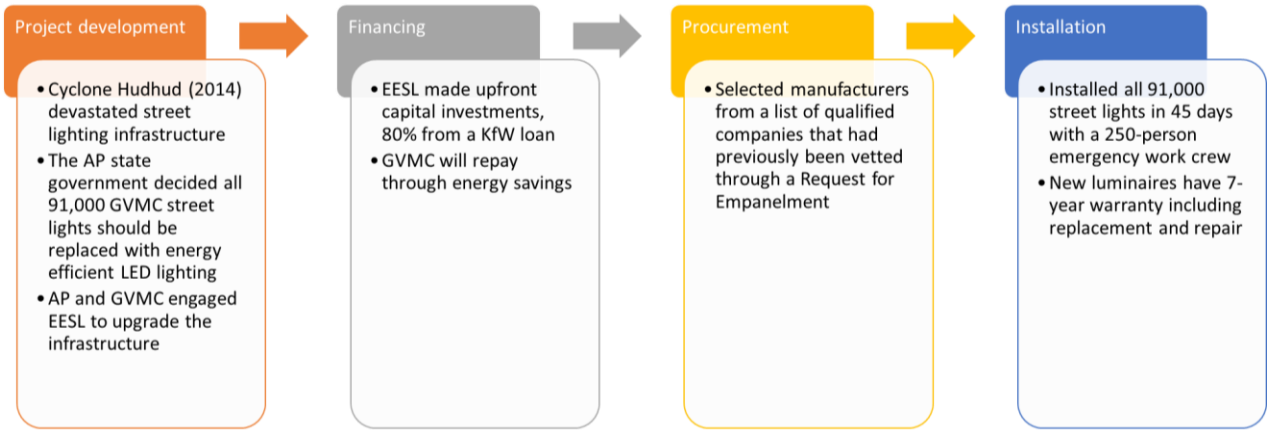

Figure 1: Summary of the implementation process in Vizag

Project Development

Due to the devastation of Vizag's infrastructure by Cyclone Hudhud, the usual project development steps were skipped to accelerate the emergency installation of energy efficient street lights. The AP government and GVMC, having decided to rebuild the public lighting infrastructure using more-efficient LED luminaires, engaged EESL.

Financing

EESL received a €50 million (US$54.6 million) loan from KfW, the German government–owned development bank based in Frankfurt, in order to support energy efficiency projects such as the street lighting upgrades in Vizag. The loan is meant to fund energy efficiency projects in energy intensive sectors such as municipal infrastructure, agricultural pumping, or industries with high energy consumption. It is aimed at supporting the establishment of a viable ESCO operation within EESL with the objective of building and institutionalizing its capacity to develop, structure and implement performance-based energy service projects in various public and private end-use sectors.

In Vizag, EESL made the up-front capital investment of Rs 650 million (US$9.8 million) without any investment from GVMC. Eighty percent of the capital cost was paid from the KfW funds, and the remaining twenty percent was paid by EESL. The guarantee was provided by the AP government. Over the seven-year leasing contract, GVMC will pay EESL a sum of Rs 185 million (US$2.8 million) every year, which reflects an interest rate of 10 percent. The annuity payments will come from the energy savings, which are expected to be between 50 and 55 percent of the

baseline. GVMC's overall costs savings will be Rs 310 million (US$4.7 million) annually. Once the leasing contract expires and all terms are met, ownership of the luminaires will be transferred to the GVMC.

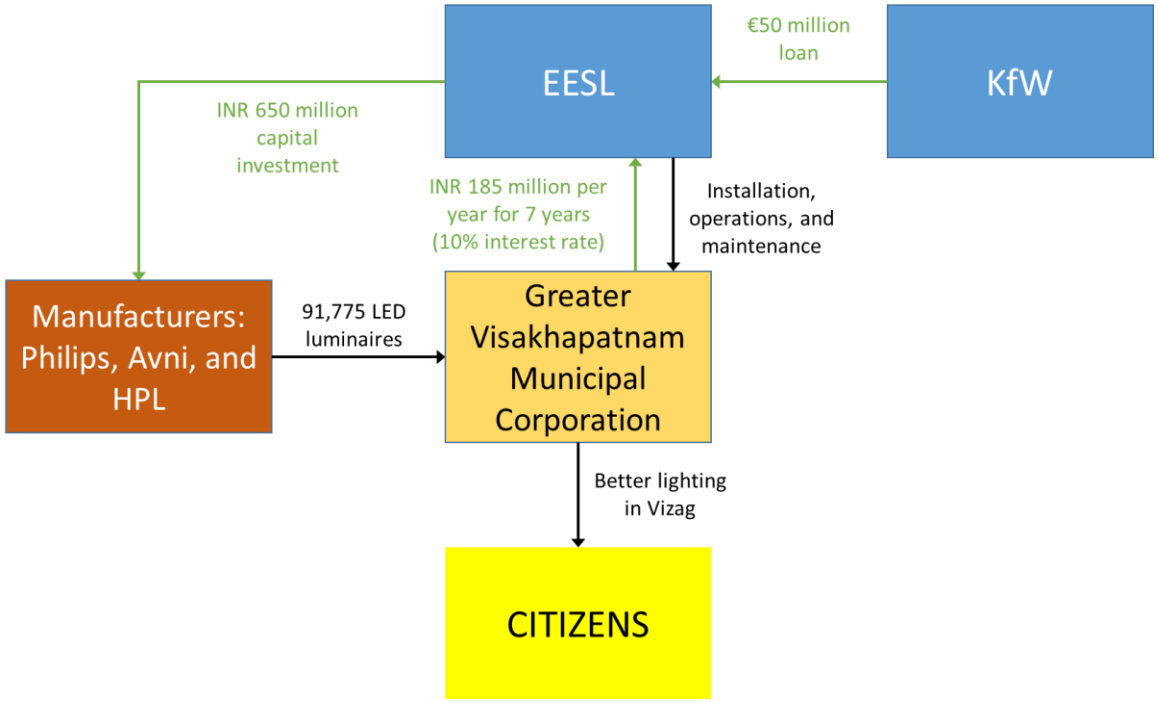

Figure 2: Notional flows for the street lighting retrofit in Vizag

Procurement Process

EESL usually selects LED suppliers through a transparent and competitive bidding process, with a tender document advertised in national daily newspapers and posted on the EESL website. Bid submission is generally required three to four weeks from the date of bid publication. Technical evaluation is performed first by an evaluation committee, followed by the opening of financial bids. Because of the accelerated timeline in the case of Vizag, manufacturers were selected from companies that had already been vetted through a Request for Empanelment. Three manufacturers—Philips, Avni, and HPL—were the successful bidders selected through this process to supply the LED lights in Vizag.

Installation

EESL, GVMC, and the selected LED manufacturers organized approximately 250 people to work on an emergency basis to restore the city's street lights, with team sizes varying by zone based on the number of lights. EESL appointed a project team with the primary responsibility of overseeing and supervising the quality of work, the installation timelines, and compliance with the specified standard. EESL organized daily meetings with GVMC and manufacturers to plan the project execution phases and to solve any field problems. The project timeline was monitored in accordance to the flow of equipment stock, manpower, vendor management, and high-voltage–line clearance. Figure 3 summarizes the respective responsibilities of EESL and GVMC in Vizag.

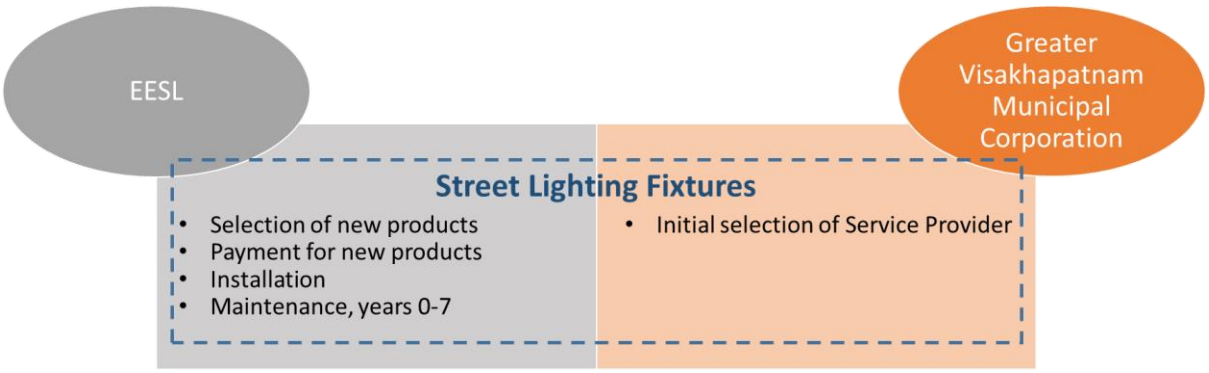

Figure 3: Responsibilities for upgrading street lights in Vizag

EESL provides GVMC with a seven-year warranty on the street lights for technical defects and maintenance. Overall, this will reduce GVMC's maintenance costs by about Rs 60 million (US$900,000) per year. Maintenance components that will either be significantly reduced or eliminated include scheduled luminaire replacement, night surveys for outage identification, and fault repairs. In addition, maintenance inspections for condition and cleaning can be extended to 10-year intervals, with only one such inspection required during the expected life of the asset. The upgrade to LED street lights has also improved the power factor of the street light system from 0.4 to 0.97, meaning that the percentage of power supplied to the street lights that is used to create light has increased from 40 percent to 97 percent. This leads to additional energy savings for the power distribution companies and GVMC, on top of the 50 percent energy savings from the electricity consumption of the street lights.

Lessons Learned

Local success can lead to national implementation

The Vizag street lighting project is the largest LED street light initiative in India thus far. The project's success is due to high-level commitment from the governments at the national, state, and municipal levels, each of which provided a major political push to implement the street light upgrades. The GVMC achieved a savings of 43 percent[7] in its electricity bills—about Rs 50 million (US$750,000)—from January to July 2015 compared to the same period in 2014. Noting the significant savings in electricity and costs, the Indian government is now keen to replicate the Vizag LED street lighting model in 100 major cities across the country and has launched a new National Programme for LED-based Home and Street Lighting.[8] As many as 90 municipalities have finalized agreements under the programme for the replacement of street lights with LED technologies.

The right methodology can reduce the cost of monitoring and verification

[7] http://www.thehindu.com/news/national/telangana/led-streetlighting-vizag-model-to-be-replicated-in-100-cities/article7552820.ece

[8] http://www.thehindu.com/news/national/telangana/led-streetlighting-vizag-model-to-be-replicated-in-100-cities/article7552820.ece

EESL's methodology is intended to increase confidence among investors about the capability of ULBs to design and implement similar projects. This approach reduces the costs associated with monitoring and verification by using a simple and effective means of determining the baseline and energy savings: only technology demonstration and validation of energy savings in a designated area are required, complemented by on-site inspections.

A super-ESCO can provide critical support that makes LED street lighting possible where ESCOs would have been hesitant

When Cyclone Hudhud destroyed street lighting infrastructure in Vizag, the GVMC was able to turn to EESL for a solution. Thus, the establishment of EESL as a super-ESCO allowed Vizag to recover quickly from a natural disaster while simultaneously upgrading its municipal infrastructure. The presence of support from an ESCO with a public mandate for energy efficiency made the installation of LED street lighting possible in Vizag when it likely would not have otherwise been considered.

Political buy-in is critical

In the case of Vizag, there was immediate political buy-in at all levels of government—national, state, and local—in the aftermath of a natural disaster that devastated the local infrastructure. For many municipalities in India, however, one of the major challenges during the implementation of such projects is the political setup of the ULBs. The ULBs are elected bodies that contain council members from different political parties, and this can lead to difficulties in building consensus—and thus delays in decision making.

In-depth technical knowledge and political-buy in is necessary for success

A number of issues arose during project execution that could have caused major delays in a situation with less political buy-in. Having the appropriate support to resolve these issues was key to keeping the Vizag street lighting replacement project on its accelerated schedule. These issues included:

- **Line Clearance Management.** Private power distribution companies grant power line clearances, and getting such clearance can cause significant delays. The ULB or municipality is responsible for getting line clearance, generally a day ahead of new street light installation for any high voltage transmission line. The strong political buy-in helped in securing line clearances.
- **Uneven Pole Height.** Due to overhead high voltage lines, pole mounting height was not uniform on several roads, and this resulted in uneven distribution of light across the road. Installing poles in the median or on both side of the roads often caused delays, but was required in order to meet the national lighting code. This required good technical understanding in order to find the solution given the high-voltage line constraints.

Infrastructure upgrades provide opportunities for reduced indirect costs

In addition to the cost savings Vizag achieved by reducing the energy consumption of its street lights and reducing the operations and maintenance costs; the upgrading of street lighting infrastructure has led to additional savings. For instance, the improved power factor of the newly installed LED street lights has led to huge cost savings for the power distribution company and GVMC.

Series of Case Studies on Public Lighting Delivery Models

"Super-**ESCO Delivery Model Case Study; EESL in Vizag, 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:

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