

# Proven Delivery Models for LED Public Lighting:

Guadalajara, Mexico

Lease-to-Own

Delivery Model Case Study

Pedzi Makumbe, Debbie K. Weyl, and Andrew Eil, Jie Li

Standard ESMAP text placeholder

# Contents

- Figures ..... 4
- Acronyms and Abbreviations ..... 5
- Acknowledgements ..... 6
- Guadalajara, Mexico: Lease-to-Own Delivery Model ..... 7
  - Introduction ..... 7
  - Context ..... 8
    - The National Public Lighting Program ..... 8
  - Tracing the development and implementation process in Guadalajara ..... 10
    - Project Development ..... 11
    - Financing ..... 12
    - Procurement Process ..... 13
    - Installation ..... 15
  - Lessons Learned ..... 16

# Figures

- Figure 5: Responsibilities for each phase of CONUEE’s National Lighting Program ..... 10
- Figure 6: The implementation process in Guadalajara for retrofit of street lights ..... 11
- Figure 7: Notional flows for the street lighting retrofit in Guadalajara ..... 13
- Figure 8: Responsibilities for installation and maintenance of street lights in Guadalajara ..... 15

## Acronyms and Abbreviations

Banobras	<i>Banco Nacional de Obras y Servicios Públicos</i> (National Bank of Public Works and Services)
CFE	<i>Comisión Federal de Electricidad</i> (Federal Electricity Commission)
CONUEE	<i>La Comisión Nacional para el Uso Eficiente de la Energía</i> (National Commission for the Efficient Use of Energy)
Electrotec	<i>Electricidad y Tecnología SA de CV</i>
LED	Light-emitting diode
NOM	<i>Norma Oficial Mexicana</i> (Official Mexican standard)
SEAD	Super-efficient Equipment and Appliance Deployment <i>Proyecto Nacional de Eficiencia Energética en Alumbrado Público Municipal</i>
PNEEAPM	(National Public Lighting Program)

## 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 Ing. Héctor Ledezma Aguirre, Director of States and Municipalities, CONUEE, government of Mexico; Lic. Francisco Castillo, Secretary of Public Services, Municipality of Guadalajara; Ing. Alberto Arreola, Director of Street Lighting, Municipality of Guadalajara; and Ing. Sergio González Cota, Advisor to the Municipality of Guadalajara and Member of the Association of Electrical Engineers from the State of Jalisco.

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.

## Guadalajara, Mexico: Lease-to-Own Delivery Model

<b>City name</b>	<b>Guadalajara, Mexico</b>
<b>Project dates</b>	<b>2013–16</b>
<b>Project size</b>	<b>80,000 total points of light; 40,000 to be replaced</b>
<b>Implementing agency</b>	<b>Directorate of Public Lighting</b>
<b>Funding mechanism</b>	<b>Lease to Own; Financed with Energy Savings, 15% reimbursement from Banobras, and guarantee from State government</b>
<b>Implementation/procurement process</b>	<b>Installation by contractor, maintenance by Guadalajara</b>
<b>Expected energy savings</b>	<b>50–55%</b>

### Introduction

Guadalajara, with a population of approximately 1.5 million, is the fourth largest city in Mexico and is located in the country's central Pacific region. Until the implementation of the current street lighting retrofit project, the city's outdated street lighting infrastructure had not been renovated in over 30 years. Lighting crews could not keep up with outages reported by citizens, and there were many unlit areas around the city. This coincided with increasing crime rates, leading to an overall lack of safety in the city. The outdated infrastructure also required substantial spending on both maintenance and electricity for the street lights. Street lighting represented approximately 18 percent of electricity consumption, and paying for it was a significant component of the city's budget.<sup>1</sup>

To help Guadalajara and other cities address the problem, Mexico's national government established National Project for Energy Efficiency and Public Municipal Lighting (*Proyecto Nacional de Eficiencia Energética en Alumbrado Público Municipal*<sup>2</sup> (PNEEAPM - National Public Lighting Program.) The program provides a significant amount of technical assistance to cities embarking on LED public lighting projects. The cities also have an opportunity to obtain financing from the National Bank of Public Works and Services (*Banco Nacional de Obras y Servicios Públicos*, or Banobras) and to obtain rebates after verifying the energy savings from the investment. The technical assistance reduces the risk that municipalities associate with embarking on an LED street lighting project, and the rebate provides an additional incentive to retrofit outdated street lighting infrastructure.

Guadalajara initiated its LED street lighting program in 2013, soon after the city leadership entered office, in order to solve the problems described above and take advantage of the National Public Lighting Program. Although the city had previously considered upgrading street lights, previous mayors had deemed municipal resources insufficient to do so. Guadalajara now expects to achieve a fully operational street lighting system through this project. The city currently has approximately 80,000 street lights installed, all of them sodium-vapor luminaires; of these, half – 40,000 – will be

---

<sup>1</sup> "Mexico: Street Lighting Programme." Presentation at the World Bank International Conference on Energy Efficient Street Lighting in New Delhi, India. March 2014.

<sup>2</sup> *Proyecto Nacional de Eficiencia Energética en Alumbrado Público Municipal* - [http://www.conuee.gob.mx/wb/Conuee/\\_proyecto\\_nacional\\_de\\_eficiencia\\_energetica\\_en\\_alu](http://www.conuee.gob.mx/wb/Conuee/_proyecto_nacional_de_eficiencia_energetica_en_alu)

replaced with LEDs, in 200 districts and along 100 roads. The project will also use a portion of the removed stock of still-operational sodium-vapor luminaires to replace the out-of-service luminaires in other parts of the city.

## Context

### The National Public Lighting Program

Several national strategies and programs in Mexico have been created at different points in time focusing on energy efficiency as a way to address issues such as energy security (ensuring reliable and affordable energy supply for all) and environmental concerns (including reduction of greenhouse gases). One such program was Mexico's National Program for the Sustainable Use of Energy (2009–12). The program identified seven areas with the greatest potential for reducing energy consumption: transport, lighting, appliances, cogeneration, buildings, industrial motors, and water pumps.

In the case of lighting, one action item highlighted to increase lighting efficiency was to accelerate the implementation of energy efficiency in street lighting. To achieve this, Mexico's National Commission for the Efficient Use of Energy (*La Comisión Nacional para el Uso Eficiente de la Energía*, CONUEE) created and implemented the National Public Lighting Program to improve the efficiency and quality of street lighting in municipalities. This program is supporting economical projects that use energy savings as the source of repayment; thus municipalities do not have to commit resources to participate in the program.

The program brings together support from CONUEE, the Federal Electricity Commission (*Comisión Federal de Electricidad*, or CFE), and the state-owned Banobras to provide municipalities with guidance on implementation, verification, and financing of efficient street lighting projects. As one element of this support, CONUEE offers technical guidance regarding compliance with Mexican standards (*Normas Oficiales Mexicanas*, or *NOM*) for luminaires and systems,<sup>3</sup> including the energy efficiency standard for LED street lighting luminaires (NOM-031-ENER-2012<sup>4</sup>)—that Mexico adopted in 2012. CONUEE makes resources and tools available to help local officials in municipalities like

#### Challenges of the Mexico National Lighting Program

The national program in Mexico has achieved mixed results. Of the 15 proposals implemented, fewer than 10 have used the government subsidy. The program encountered several difficulties:

- Cities interested in participating cities had to secure collaboration and approvals from CONUEE, CFE, the Ministry of Finance, the Ministry of Energy and Banobras. This increased transaction costs and the amount of bureaucracy involved.
- Financing for the investments was fairly limited since many municipalities are not creditworthy. Guadalajara was one of the few cities that could obtain investment from the private sector.
- Although the government provided financial incentives, the timing was often a challenge. Incentives from Banobras were only available after verification of savings.

As result, the Mexican government developed a new program with the World Bank that provides financing while removing many of the bureaucratic challenges that have discouraged cities from investing in efficient public lighting.

<sup>3</sup> Secretaria de Energia, <http://tinyurl.com/p2s36fq>. Accessed October 2015.

<sup>4</sup> *Diario Oficial*, November 2012: <http://tinyurl.com/pz7d5ne>

Guadalajara to develop the necessary technical analysis to support the procurement of luminaires. These tools include:

- A *technical and economic tool* developed by CONUEE to assess the energy savings potential and financial impact of a transition to more efficient lighting;
- The *SEAD Street Lighting Tool*<sup>5</sup> which evaluates the light quality and life cycle costs of fixtures that are being considered for procurement or installation in a project; and
- A *certified product list*, updated monthly, which includes products that have passed 1,000- and 6,000-hour testing, certified products, and products that failed testing.<sup>6</sup>

Finally, CONUEE serves a role in vetting the technical aspects of municipal lighting programs. Before authorizing financing for new street lights, the Ministry of Finance (*Secretaría de Hacienda*) requests technical certification from CONUEE. This is a notable achievement for the program, as this vetting of the technical specifications and certifications by a third party reduces the risks to municipalities and financial institutions of investing in a new technology such as LEDs.

CONUEE is implementing the National Lighting Program in partnership with CFE and Banobras. While CONUEE provides implementation guidance, CFE's role is to measure the energy use from street lights before and after a project is implemented. Banobras' role is to review the financial viability of the project and, when requested, provide financing to the municipalities.

CONUEE's National Lighting Program has five main phases, detailed below and in Figure 1:<sup>7</sup>

1. *Plan Project*: The municipality prepares and submits a financing application and technical documentation to Banobras, which includes CFE's studies of public lighting energy usage.
2. *Technical Evaluation*: CONUEE and Banobras evaluate the technical and financial viability of the project.
3. *Secure Financing*: If required by the municipality, Banobras provides financing. The program does not require municipalities to finance their program through Banobras; they can finance the project using the mechanism most suited to the city's needs.
4. *Implementation*: The municipality implements the project.
5. *Savings Verification*: At the end of the project, CFE and CONUEE verify the energy savings of the retrofit. If targets are met, the municipalities receive a reimbursement of 15 percent of the total cost of the project (up to Mex\$10 million).

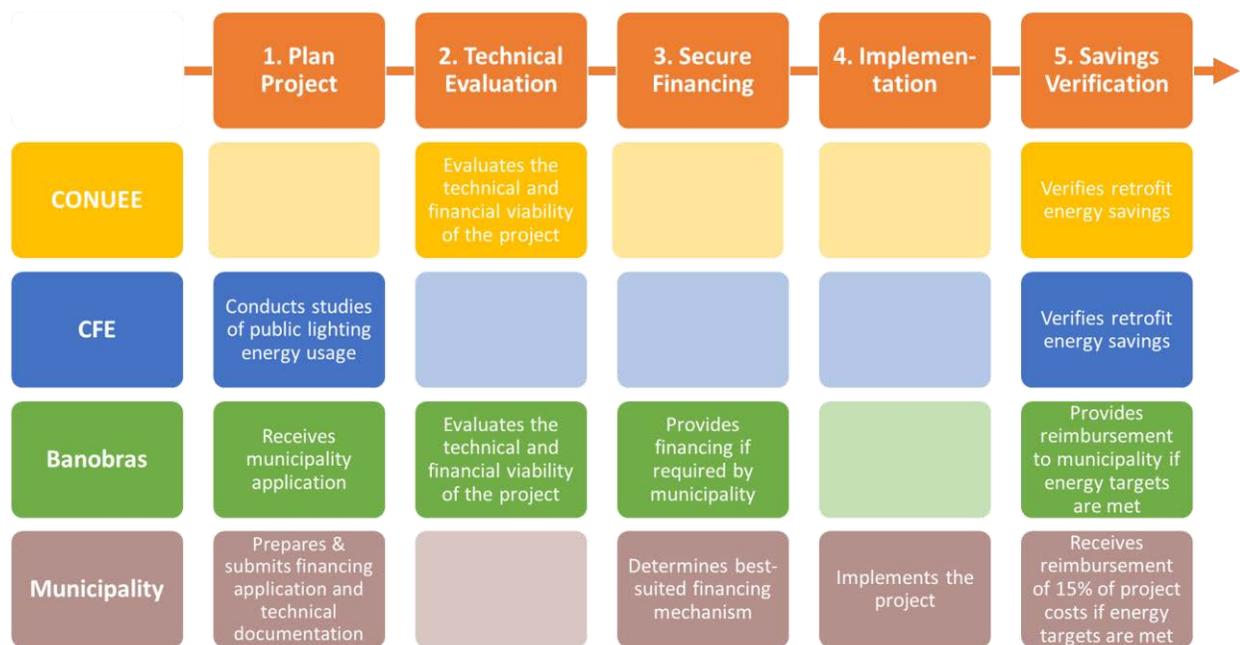
---

<sup>5</sup> The SEAD Street Lighting Tool provides a quick, free, and easy way for government procurement officials to evaluate the quality, efficiency, technical compatibility, and lifetime cost of different street lighting products. More information is available at [www.superefficient.org/sltool](http://www.superefficient.org/sltool). (The Super-efficient Equipment and Appliance Deployment (SEAD) Initiative is a voluntary collaboration among governments working to promote the manufacture, purchase, and use of energy-efficient appliances, lighting, and equipment worldwide.)

<sup>6</sup> The certification process is a result of NOM-031, which establishes a series of tests and two certification processes: (1) Testing for the first 1,000 hours – if light output levels are achieved, an initial certificate is given; and (2) Testing for another 5,000 hours (for a total of 6,000 hours) to measure if light output levels are maintained throughout the lifetime – if light output levels are maintained, a final certificate is given. Products that passed and failed these tests are available online on a PDF file that is updated regularly.

<sup>7</sup> [http://www.conuee.gob.mx/wb/CONAE/proyecto\\_nacional\\_de\\_eficiencia\\_energetica\\_en\\_alum](http://www.conuee.gob.mx/wb/CONAE/proyecto_nacional_de_eficiencia_energetica_en_alum)

The responsibilities of each key stakeholder are shown in Figure 1.



**Figure 1: Responsibilities for each phase of CONUEE’s National Lighting Program**

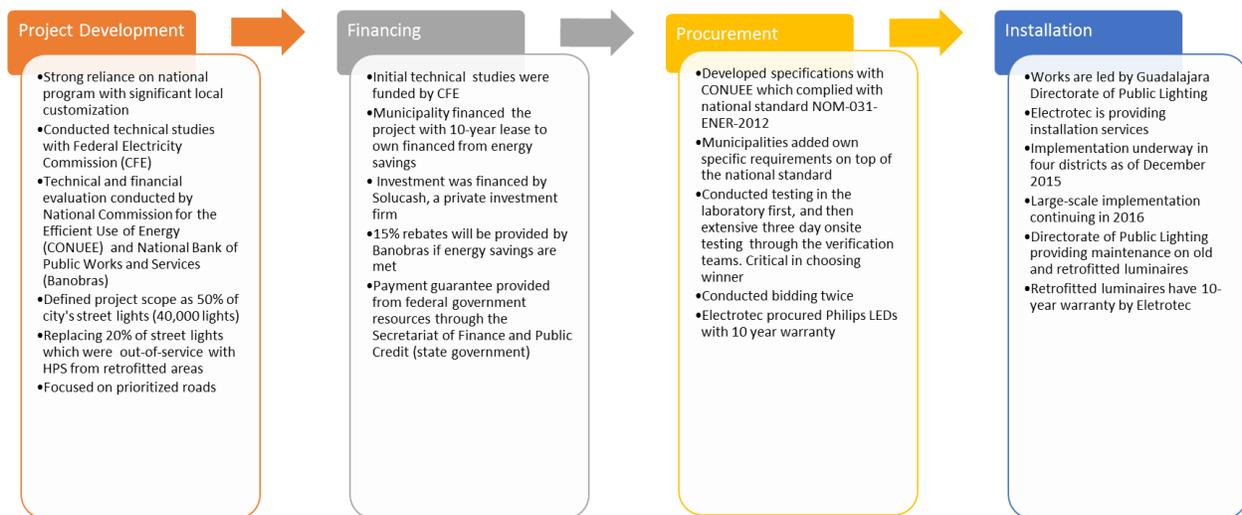
The reimbursement in the Savings Verification stage is an incentive for municipalities to join the National Public Lighting Program. It provides them with a clear financial benefit in case the social and environmental benefits are not sufficiently attractive to spur them to action on street lighting upgrades. After a municipality finishes luminaire installation and provides the required documentation, CONUEE has 20 business days to issue a final technical approval. After that, the reimbursement is provided to the municipality within 15 business days.

The resources for repayments come from the Fund for Energy Transition and Sustainable Energy Use (*Fondo para la Transición Energética y el Aprovechamiento Sustentable de la Energía*, or FOTEASE) of the Secretariat of Energy (*la Secretaría de Energía*, or SENER). This fund was created in 2009 to boost the national energy sector through projects, programs and actions that aim to achieve a greater use and development of renewable energy sources and clean technologies.<sup>8</sup>

### Tracing the development and implementation process in Guadalajara

The implementation process in Guadalajara is summarized in Figure 2.

<sup>8</sup> A. E. Guevara Sanginés and J. A. Lara Pulido, 2015. “Mitigación del cambio climático a través de un alumbrado público eficiente en México: superando los retos políticos en aras de la eficiencia económica y el equilibrio ambiental.” *Acta Universitaria* 25(1): 43-55. doi: 10.15174/au.2015.681



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

## Project Development

In the context of the National Lighting Program, Guadalajara conducted energy studies of public energy use in collaboration with CFE. The municipality then prepared and submitted a financing application and the technical documentation from CFE studies to Banobras and CONUEE for technical and financial viability evaluation. Additional preparatory work was done to define the current needs of the city's diverse districts (*colonias*), including assessing the characteristics of key roads to define lighting requirements. Field trials were also conducted on representative roads to verify compliance of certain luminaires and technologies with lighting specifications. Most of the existing lighting did not meet the national lighting standard.

The city used the following criteria to select the roads on which luminaires would be replaced:

- Roads that would benefit from the increased security that better street lighting would provide;
- Roads where out-of-service lamps had been reported through the city's website or hotline; and
- A cross-check between field visits and what was reported by the districts.

The project was high-profile, and important for the city. The main considerations during the design stage were:

- Assuring the specifications and program design responded directly to the city's needs, even though the project was part of a larger national program; and
- Awarding the contract for project implementation to a contractor that demonstrated a complete understanding of the technical requirements, and has the technical capability.

The project was scoped to retrofit 50 percent of the city's lights, and to replace the 20 percent of out-of-service lights using non-fully depreciated HPS luminaires from the stock of luminaires replaced by LEDs in retrofitted areas.

## Financing

The project is being self-financed through energy savings, which are expected to be 50 to 55 percent from the baseline after the installation is complete. The financing instrument is a 10-year leasing contract valued at Mex\$300 million (approximately US\$19 million). The contract is between the municipality and a partnership between *Electricidad y Tecnología SA de CV* (Electrotec), the installer, and *Solucash SA de CV SOFOM ENR* (Solucash), the financial institution. The municipality will pay an average of Mex\$4 million (approximately US\$250,000) per month to Solucash over the 10-year lease term, which reflects an interest rate of 6.7 percent.<sup>9</sup> After the leasing contract expires and all terms are met, ownership of the luminaires will be transferred to the municipality. The lifetime of the luminaires is 13 years.

Guadalajara's energy savings will be verified by the Directorate of Public Lighting, with the approval of CFE, and are expected to be around US\$500,000 a month. If Guadalajara is unable to make payments from the energy savings, as a guarantee they can allocate funds from a separate provision of federal government funding provided to municipalities to cover some operational costs. This critical guarantee is included in the master contract as follows:

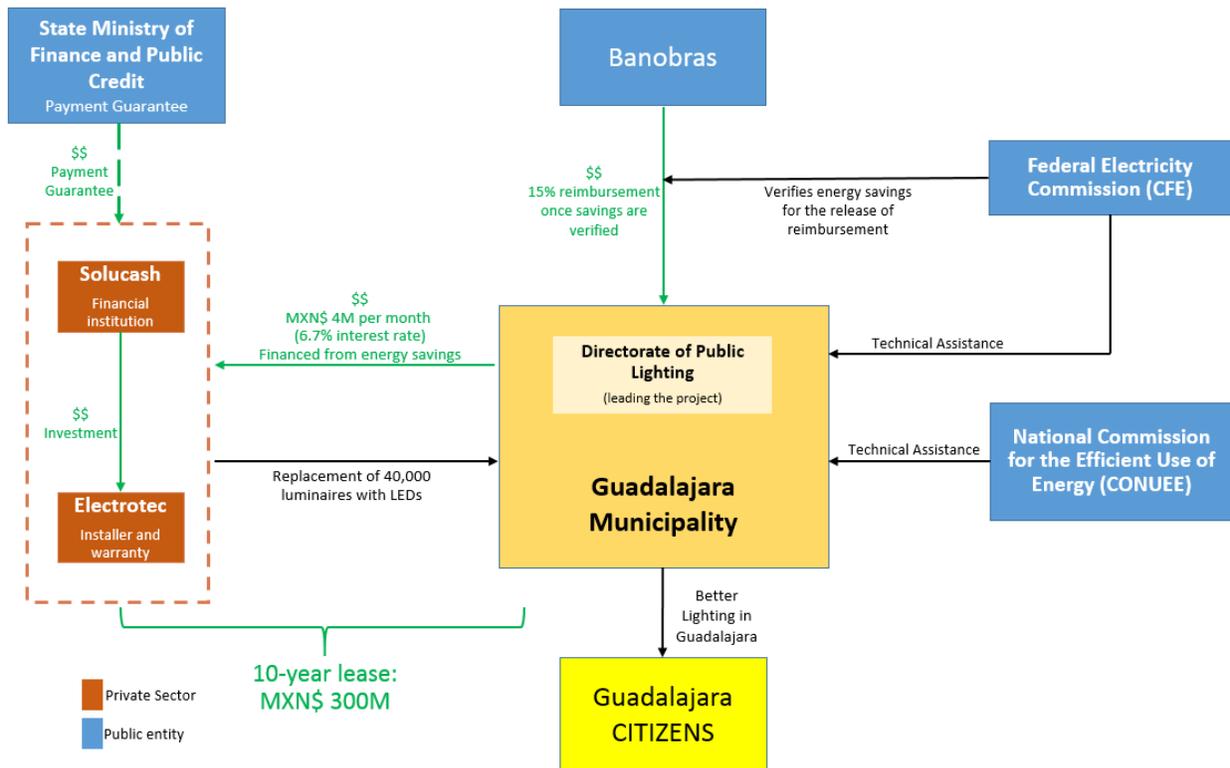
*Failure to make partial or complete payment of any of the periodic installments and in general of any obligation arising from the Master Contract or this Annex, [Guadalajara] establishes as a guarantee payment or alternate source of payment the federal holdings (Participaciones Federales), in which case [Solucash] will give notice to the State Ministry of Finance and Public Credit (Secretaría de Hacienda y Crédito Público) to make payment of the missing amount within 48 hours through federal contributions, otherwise penalty interest is paid.*

The city will continue to pay for electricity to CFE and new meters are planned for installation in some parts of the city. The city's electricity bill will be calculated using actual measurements for the street lights where meters are installed. Where meters are not installed, the electricity bill will be estimated by calculating the difference in wattage between the old sodium-vapor lamps and the newly installed LED luminaires. At the end of the project, CFE and CONUEE will verify the energy savings of the retrofit. If targets are met, Guadalajara will receive a reimbursement of 15 percent of the total cost of the project (up to Mex\$10 million).

Figure 4 summarizes the overall notional flows.

---

<sup>9</sup> Including interest, payments over the 10-year lease term will total Mex\$490.4 million (approximately US\$29 million).



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

### Procurement Process

CONUEE was critical in helping the municipality define its procurement specifications. There were more than 200 suppliers of efficient LED and metal-halide<sup>10</sup> street lights available when Guadalajara was beginning the procurement process, and the municipality did not have the technical capacity to develop the procurement specifications and evaluate products to ensure they complied with the most recent standards. The city sought assistance in these technical areas and CONUEE was able to fill these gaps, providing in-depth technical assistance from project inception through the final stages of implementation.

The bidding process was transparent, competitive, and open to all participants. An initial proposal for the bid requirements was presented to the city government using outputs from CONUEE’s financial analysis tool. Local stakeholders met with government officials to develop the procurement process and criteria. They agreed upon the following:

1. Products must comply with Mexico’s energy efficiency standard for street lighting luminaires—NOM-031-ENER-2012—and must have a 6,000-hour test certificate of compliance issued by CONUEE.

<sup>10</sup> CONUEE does not endorse the use of any particular technology, as each municipality has its own technical and financial constraints.

2. Compliance with lighting specifications for the relevant roadway types must be demonstrated through use of the SEAD Street Lighting Tool.
3. Applicants must provide equipment samples for testing in a laboratory and in the field (for the 12 types of roads identified in the project). Verification teams (*unidades de verificación*) would conduct on-site testing and measurement of the new equipment samples. Only products that passed field verification testing would be considered.
4. Applicants could submit proposals that included a combination of brands and models that best achieved project goals while complying with national standards.

The municipality initially proposed including two additional requirements: a minimum of 50 percent energy savings from the baseline, and lighting levels that exceeded the national requirements by at least 10 percent. After modeling scenarios using the SEAD Street Lighting Tool, it was clearly not feasible to achieve both requirements simultaneously. CONUEE therefore recommended that, in its tender, Guadalajara require 50 percent energy savings and compliance with national requirements at the current levels (rather than exceed the requirement by 10 percent).

The tender also required that all luminaires project white light, and that at least 50 percent of the fixtures (20,000 luminaires) use LED technology. The remainder of the luminaires could use either LED or metal-halide technology. The city required luminaires that project white light because it has been shown to improve safety by increasing visibility and color accuracy on roads, and most people find it more aesthetically pleasing than yellow light.<sup>11</sup> Guadalajara launched the open bid process in January 2015. When the call for tenders closed, CONUEE reviewed the provided documentation and certificates, and found that none complied with the technical specifications.

A second bidding process was launched on 2 March 2015, this time requiring at least 30,000 LED luminaires (75 percent of the luminaires to be installed). The 75 percent LED requirement indicated the city's interest in LED and willingness to invest in the same while the 50 percent requirement left the bidders unclear about the intentions of the municipality. The two leading candidates proposed installing 100 percent LED luminaires and complied with all technical specifications; both were also within the project's budget of Mex\$300 million (approximately US\$19 million).

The city conducted a three-day trial to test the luminaires' performance at various heights, distances, and street types. Five models within a range of wattages were tested per supplier. These technical trials were key in selecting the winning contractor, as the exercise provided useful information on the suppliers' claims and overall product quality. For example, although they did not assess the technical cause for this discrepancy, the city found that some products using imported parts no longer met quality specifications after local assembly. Ultimately, the contract was awarded to a partnership between *Electricidad y Tecnología SA de CV* (Electrotec) and *Solucash SA de CV SOFOM ENR* (Solucash) that had proposed installing several models of Philips luminaires. Whereas Solucash provides the financing, Electrotec is responsible for the technical work, including initial lamp installation, and the warranty covering the newly installed systems for the contract period of 10 years (counting from the day the LEDs are installed).

---

<sup>11</sup> [http://www.lighting.philips.com/pwc\\_li/se\\_sv/application\\_areas/assets/pdf/White-Light-brochure.pdf](http://www.lighting.philips.com/pwc_li/se_sv/application_areas/assets/pdf/White-Light-brochure.pdf)

## Installation

The project is led by Guadalajara’s Secretariat of Municipal Public Services (*Secretaría de Servicios Públicos Municipales*) through the Directorate of Public Lighting (*La Dirección de Alumbrado Público*). After awarding the contract, the project went through an approval process with various local and state entities including the Commission of Acquisitions, the National Ministry of Finance (*Secretaría de Finanzas*), and the State Ministry of Finance and Public Credit (*Secretaría de Hacienda y Crédito Público*).

Following these approvals, installation of luminaires began on 28 April 2015. Pilot testing of the new luminaires was completed in four districts.<sup>12</sup> Local residents report that the transition has increased safety and improved the lighting conditions and overall quality of life.

Installation of new LED luminaires is the responsibility of Electrotec, but a third-party comptroller will be on-site during installation to provide external supervision. The installation of all luminaires is expected to be completed by March 2016. After the initial installation period, maintenance of the new luminaires will be the responsibility of the Guadalajara Directorate of Public Lighting. This includes the installation of any replacements for faulty luminaires; however, it will be Electrotec’s responsibility to provide these replacement luminaires during the contracting and warranty period of 10 years.

At the end of the contract, the luminaires will become the property of the City of Guadalajara. Maintenance of the remaining sodium-vapor luminaires will remain the city’s responsibility throughout. The city will have some stock left over from the project for maintenance of the sodium-vapor luminaires. Figure 4 summarizes the responsibilities of the different stakeholders for the installation and maintenance of street lights in Guadalajara.

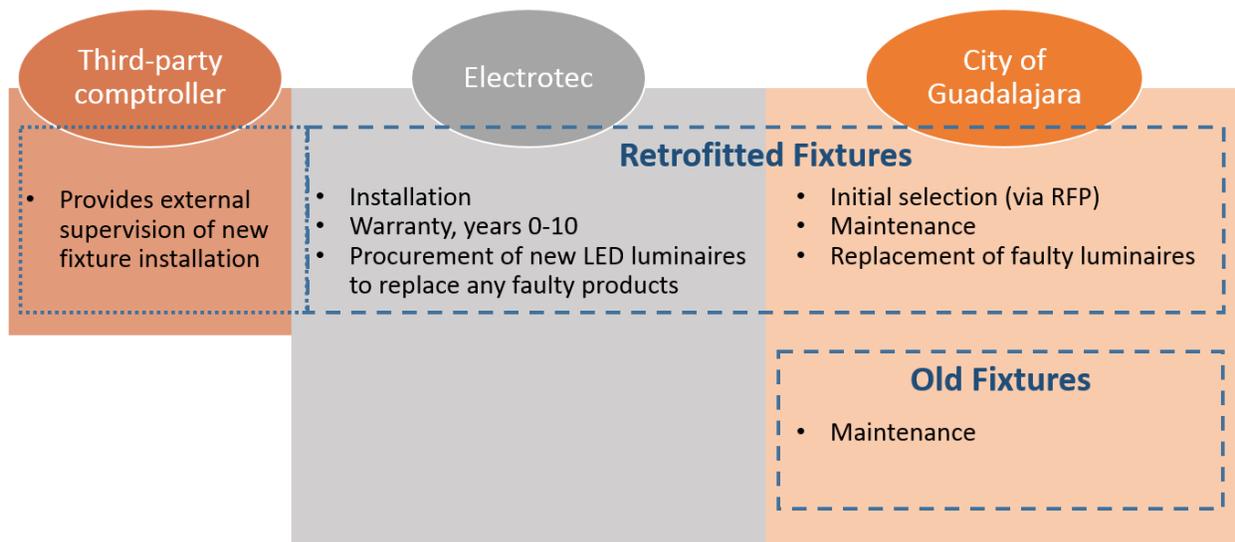


Figure 4: Responsibilities for installation and maintenance of street lights in Guadalajara

<sup>12</sup> Colonia Morelos, Colonia Aarón Joaquín, Benito Juárez, and Lago Oriente. <http://tinyurl.com/qhx9fk2>

## Lessons Learned

Cities planning to undertake similar projects should consider several elements in luminaire selection, including (a) potential energy savings, lower energy bills, and lower maintenance costs; (b) compliance with national and local regulations; (c) the quality and length of product warranties; and (d) the overall life span of the products. Programs should also be framed in the local context.

### *Consider municipal needs in project design*

A project should be designed to meet the city's needs, rather than accommodate suppliers' claims. Local conditions such as district coverage, types of roads, pole height, pole spacing, and lane width should be assessed early on. This enables the city to clearly establish supplier requirements from the beginning. Municipalities should invite stakeholders to become involved in the project planning process early to ensure all voices are heard.

### *The procurement process should be transparent and flexible*

Guadalajara released two tenders. After evaluating the bids for the first tender and finding none that complied, the criteria were altered slightly and then a revised tender was published. In the end, the city was able to meet or exceed its requirements, including purchasing 100 percent LEDs, and still come in under budget.

### *Take advantage of available tools and resources*

Many cities lack in-house technical capacity to undertake a large LED retrofit project. The use of tools and resources developed at the national level or by international organizations can help bridge this knowledge gap. The National Lighting Program was integral to the success of the street lighting retrofit in Guadalajara. In addition, use of the SEAD Street Lighting Tool in Guadalajara was key to assessing whether proposed LED luminaires would pass or fail performance specifications. CONUEE had established use of the tool before the project began, so the tool was used effectively to validate whether performance claims would meet the project requirements.

### *Reduce risk by collaborating with other stakeholders*

Mexico's National Lighting Program verified the feasibility of Guadalajara's program requirements and compliance of luminaires, thus reducing risk to the municipality, financial institutions, and energy service providers.

### *Guarantees improve the likelihood of attracting private funding*

The state guarantee was important in attracting private investment to the project. Given that measurement and verification are often difficult and cities have limited budgets, it was important for Solucash to have the guarantee from the state government.