PREFEASIBILITY STUDY

MUNICIPAL ENERGY-EFFICIENT PUBLIC STREET LIGHTING PROJECT

IN THE CITY OF RIO DE JANEIRO
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I. Introduction

The present prefeasibility study identifies potential implementation and financial structuring options for investments in energy-efficient public street lighting in the City of Rio de Janeiro, Brazil.¹

The objective of this study, which is the result of a joint effort by the World Bank and the International Finance Corporation (WB-IFC), is to provide city officials in Rio de Janeiro with (a) a brief overview of the global trends in EE public street lighting; (b) a review of the relevant regulatory, institutional and legal frameworks that would have an impact on an investment in energy-efficient public street lighting; and (c) recommendations for financing structures that achieve scale by bundling/aggregation. Ultimately, the goal of this study is to help decision makers in the City of Rio de Janeiro make an informed decision regarding the implementation model and sources of finance that are best suited.

The report evaluates applicable national and local regulations that affect municipal public street lighting systems. Although the study focused on Rio de Janeiro, many of the findings contained in the report can help other cities in Brazil and around the world evaluate the feasibility of implementing an energy-efficient public street lighting system in their own city.

This report was prepared by Megan Meyer (WB) and Luiz Maurer (IFC), with contributions from Cristina Ferreira (Public-Private Infrastructure Advisory Facility, PPIAF) and Pedzi Makumbe (Energy Sector Management Assistance Program, ESMAP). The study upon which this report was based was prepared by a joint WB-IFC team comprised of Megan Meyer (project coordinator), Cristina Ferreira, Pedzi Makumbe, Luiz Maurer, and Javier Freire, supported by a team of experts: Patricia Bentes, Patricia Sampaio, Livia Amorim, Joisa Dutra Saraiva, Luiz Diniz, and Benjamin Darche. The work was developed under the vision and guidance of Sebastian Scholtz and Valerie–Joy Santos, the Task Team leaders. The study builds upon the work done under the World Bank’s Low Carbon City Development Program (LCCDP) for Rio de Janeiro and was funded by ESMAP and PPIAF, two World Bank Trust Funds. The study is based on research and interviews conducted with key stakeholders. The authors would like to thank the many people who took the time to speak with us as we developed this report, and in particular officials from City Hall, RioLuz, SECONSERVA, the Public-Private Partnership Office in Rio and the city’s Secretary of Municipal Finance (Fazenda).

¹ The denomination “public street lighting” also includes parks, bridges, monuments, tunnels, public buildings and other facades under the jurisdiction of the municipality or authority in charge of providing those services to the community. In this report, “public street lighting” and “public lighting” are used interchangeably.
II. Executive Summary

The World Bank and the International Finance Corporation, sponsored by the Public Private Investment Advisory Facility (PPIAF) and the Energy Sector Management Assistance Program (ESMAP), prepared the present report for the Municipality of Rio de Janeiro as part of ongoing discussions with the city to support the City of Rio de Janeiro to achieve its objectives on climate change mitigation and sustainable development. The purpose of the report is to identify and assess implementation and financing option models for investments in energy-efficient street lighting.

The report reviews options and provides recommendations for implementing an EE street lighting project in Rio de Janeiro. The key considerations addressed in the report are:

- Optimal project design
- Applicable legal and institutional frameworks
- Financial and economic feasibility
- Financing options for the municipality

General Overview

Street lighting represents about 3 percent of world electricity consumption, an amount equivalent to the total electricity consumption of Germany, the world’s fourth-largest economy. According to Eletrobrás, Brazil has more than 15 million public lighting points, which represent 3.96 percent of the country’s electricity consumption. Within Brazil’s cities, public lighting electricity consumption ranges from 10 to 40 percent of municipal energy expenditures, depending on the number of lighting points and their efficiency. Thus, EE in public lighting represents significant opportunities for financial and energy savings for cities.

There are many advantages of implementing an energy-efficient public street lighting program using LEDs (light-emitting diodes). The Climate Group, an international nonprofit organization, conducted a study of 12 cities with LED lighting that showed an average savings of 53 percent after the installation of LEDs and smart system controls.\(^2\) This was due to the increase in lumens per watt produced by LEDs compared with common alternative technologies (such as high pressure sodium (HPS) or mercury vapor lamps). LEDs also offer significantly longer lifetimes, nearly double that of current technologies. Beyond savings, LEDs provide better lighting, which improves security as well as economic activity. The inclusion of smart control systems can further reduce energy and operating costs.

The key decision makers in Rio de Janeiro in favor of a large-scale LED street lighting project include the Mayor, City Hall, the Municipal Secretary for Public Services and Conservation (SECONSERVA), the Municipal Company for Energy and Lighting (Companhia Municipal de Energia e Iluminação, “RioLuz”), and, potentially, others. RioLuz, which is 100 percent owned by the municipality and is currently responsible for street lighting and energy supply in public schools and hospitals, has a key role to play. The City of Rio de Janeiro is a pioneer in the public street lighting sector in Brazil. It has already demonstrated best practice in many areas. For example, in the last four years, about 27 percent of the

existing street lights, or about 120,000 points, were retrofitted. The number of lighting points off during the night was reduced from 4 percent to less than 1 percent today (from a historical high of 19 percent in 2008). Significant investments were made in EE over the last years, reducing consumption per point from 448 watts in 1993 to 223 watts in 2013. In spite of the significant efforts and results achieved, there is still a potential for improving the provision of services (fewer outages, improved light) and reducing electricity and operation and maintenance (O&M) expenditures.

Many cities are now taking action around the world to benefit from this savings potential, including Buenos Aires, New York City, Bogota and Los Angeles. Cities in Brazil are also already acting. The largest such example includes the project currently under development by São Paulo to upgrade its 550,000 lighting points, probably using LEDs. RioLuz and SECONSERVA are also aware that a continuous improvement process requires a technological leap toward LED street lighting. The present study serves to support the efforts already underway to implement an LED project.

**Technical Fundamentals and Project Design**

The World Bank conducted a technical study to understand the profile of the current public street lighting system and to recommend a design for the LED project. The study found that there were approximately 425,000 lighting points in Rio de Janeiro as of the end of 2013, 67 percent of which are HPS lamps and 23 percent are mercury vapor lamps. The study showed that the luminance - the amount of lighting in the streets - in the city is fairly high, particularly in tourist areas; however, there are some poorly lit areas owing to the amount of mercury vapor still present in some parts of the city. An LED project would help establish a more consistent quality of light for all the citizens of Rio de Janeiro.

The study evaluated three options for the design of an LED project: (a) replacing the lighting fixtures only; (b) replacing the lighting fixtures and the control system; and (c) replacing the lighting fixtures, the control system and the distribution cables.

After careful study, option 2 – installation of LEDs plus smart system technology – was selected as the optimal design for the project. Although the financial analysis showed option 1 to have a slightly more attractive rate of return than option 2, the study concluded that the financial analysis alone was insufficient as a basis for making a decision about the project design (see section VI.B.2 for more information). For example, the financial analysis did not take into account other economic or social benefits that smart system technology would bring, including enabling the city to adjust street lighting in the event of a power crisis and to respond quickly to lamp underperformance or vandalism. It is therefore the conclusion of the study that the slightly higher cost of a smart system would be more than offset by the potential economic and social benefits that the technology could provide. Option 3 was determined to be a suboptimal project design on the basis that the cost of bundling the installation of LEDs with the installation of underground distribution cables for public street lighting would be prohibitively costly and would not likely offer benefits sufficient to justify the additional cost.

It is assumed that the investment and installation would take place progressively over a five-year period, covering 75 percent of Rio de Janeiro’s street lighting system, that is, 320,000 points of light. For the sake of simplicity, the study did not presume any expansion of the current public street lighting system. The details of how the project could be implemented and financed are discussed below.
Regulatory Framework and COSIP

Arguably, the most important federal regulation as far as public street lighting is concerned is the tax for funding public lighting services. Called “COSIP” (Contribuição para o Custeio do Serviço de Iluminação Pública), the tax is collected for the exclusive purpose of funding public street lighting services, thereby ensuring a reliable source of revenue to fund the operation of this sector without the need to rely on the municipal budget approval process. In Rio de Janeiro, COSIP is collected as a line item on end users’ electricity bills by Light, the local electricity distribution utility (“DISCO”). COSIP revenues make up part of the annual budget of SECONSERVA.

The purpose of COSIP is to fund the provision of electricity as well as the maintenance, installation, and improvement of public lighting equipment. According to municipal legislation, surplus COSIP revenues may also be allocated to public-private partnership (PPP) projects involving energy efficiency, renewable energy sources and public lighting technology improvement, among other purposes. While there have been some challenges to the legality of the collection and use of COSIP, to date all challenges relating to Rio de Janeiro have been unsuccessful.4

Regardless of the model followed, it is very likely that COSIP will be used as earmarked revenue to repay the up-front cost of the project. However, owing to the volatility associated with COSIP revenues, the city may need to backstop COSIP funds with municipal budget resources (or a guarantee).

Procurement

After reviewing various public procurement options applicable to a proposed installation of citywide LED lighting, the study identified two viable options: (a) Law 8.666/93; and (b) the PPP model.

Under Law 8.666/93, the city could pursue one of two possible approaches: (a) procure LED and smart system technology only; and (b) procure “energy-efficient street lighting services” (that is, bundling procurement of equipment with installation and O&M services).

One of the main benefits of Law 8.666/93 for procurement of LED and smart system technology is that this law is commonly used within the municipal government; therefore, its use would be relatively straightforward and would not require significant internal consultations or approvals. However, contracting under Law 8.666/93 would require the city to provide all of the up-front financing via municipal budget allocation or municipal debt. Therefore, the feasibility of this option depends on the availability of a significant budgetary surplus and the political will to use any existing surplus for this project. In addition, Law 8.666/93 does not expressly allow performance contracting; therefore, there would be little room to link payments under contract with overall electricity savings. There is also a

3 COSIP was established through an amendment to the Federal Constitution. There is no uniform national terminology for the contribution; it is sometimes referred to as COSIP and other times as CIP.
4 For example, in the case of AMPLA – the concessionaire that serves many other cities within the state of Rio de Janeiro – the state Attorney General has succeeded in obtaining a preliminary injunction that prevents AMPLA from charging COSIP directly in consumers’ bills. However, Light is currently protected by a decision of the Twentieth Civil Chamber of the state Court of Justice, which expressly affirmed Light’s right to bundle electricity services and taxes in consumers’ bills (Apelação Civil 0073361-96.2010.8.19.0001, issued on January 23, 2013).
mismatch between the contract duration (five years) and the average LED lifetime (10 years), which would make it difficult for the city to secure a warranty that would extend over the entire lifetime of the equipment. This means that the city would bear a significant amount of technical and performance risk under this approach.

Under the PPP approach, in contrast, a Special Purpose Entity (SPE) would be established by the winning concessionaire to procure the LED and smart system equipment and to install and maintain that equipment. The major benefit of this approach is that the city would not have to provide any up-front financing for the project; that would be provided by the concessionaire. In addition, PPPs explicitly allow for the payments under the contract to be linked to project performance in terms of electricity and O&M savings, which can bring economic and financial efficiencies. Moreover, the contract duration for a PPP can extend up to 35 years, meaning that the city could receive a full lifetime warranty for the LEDs. These factors combined would work to greatly reduce the performance risk faced by the public sector.

The drawbacks of the PPP approach include the longer timeline required to bid and execute the contract (estimated to be between 15 and 20 months\(^5\)) and the fact that RioLuz would need to adjust its current business model given that it would no longer be (solely) responsible for operation and maintenance of the entire public street lighting system.

In Brazil, PPPs for street lighting do not exist, although the PPP structure is legally allowable. Since precedent does not yet exist for this type of PPP, municipalities that seek to utilize this structure will have to develop regulatory capacity to prepare and monitor concession agreements. Perhaps the first large-scale street lighting concession to be granted in Brazil will be for the city of São Paulo, which is making great strides to complete the bidding for one or more concession areas to efficiently manage its 580,000 lighting points. Many municipalities are monitoring the São Paulo process with great expectation; if executed well, the process will likely create a precedent to be followed by other large cities in Brazil.

Role of RioLuz

RioLuz currently has the role of overseeing the administration of the entire public street lighting system, including, but not limited to, new equipment installation and oversight of contracts for system maintenance. If a PPP model is selected, this role would change, as the concessionaire would become responsible for a number of functions, probably including installation and maintenance of the system.

However, under an institutional scenario of a PPP, certain new functions and responsibilities would need to be filled, and RioLuz would likely be the most appropriate entity to fill them. New functions would include strategic planning, monitoring, as well as regulation, quality control, and granting and monitoring the concession contracts. These activities are critical to ensuring proper functioning of a service granted under the concession regime. Another possibility could be for RioLuz to participate as a minority partner of an SPV to which a concession for street lighting would be granted. In that case, special attention should be paid to avoid conflicts of interest between RioLuz as a “regulator” and RioLuz as an “operator,” possibly creating firewalls, or transferring some of the functions to SECONSERVA.

\(^5\) Based on interviews with local stakeholders, including RioLuz.
Financial Analysis

Table 6.7 - Base Case Assumptions and Results

<table>
<thead>
<tr>
<th>Summary of assumptions</th>
<th>Financial analysis</th>
<th>Base case</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total luminaires in Rio</td>
<td>424,977</td>
<td>75%</td>
</tr>
<tr>
<td>% luminaires replaced in project</td>
<td></td>
<td>318,733</td>
</tr>
<tr>
<td>Years to fully implement</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Cost per luminaire (R$)</td>
<td>1,500</td>
<td></td>
</tr>
<tr>
<td>Use of smart system technology (Y/N)</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>Cost of electricity in year 1 (R$/MWh)</td>
<td>238</td>
<td></td>
</tr>
<tr>
<td>Real annual increase in electricity rate</td>
<td>4%</td>
<td></td>
</tr>
<tr>
<td>% savings on electricity bill</td>
<td>57%</td>
<td></td>
</tr>
<tr>
<td>% savings on O&amp;M</td>
<td>33%</td>
<td></td>
</tr>
<tr>
<td>WACC (net of Inflation)</td>
<td>6%</td>
<td></td>
</tr>
</tbody>
</table>

Estimated project results

| Total project investment over 15 years (R$, millions)         | 420                |
| Total financial savings (electricity + O&M) over 15 years (R$, millions) | 830                |
| Total greenhouse gas reductions up to 2020 (tCO₂e)           | 300,000            |
| Total electricity savings over 15 years (GWh)                | 2,200              |
| Payback period (years, nondiscounted)                        | 8.5                |
| ROI                                                          | 98%                |
| NPV over 15 years (R$, millions)                             | 149                |
| IRR                                                          | 14%                |

This study also assessed the financial and economic viability of an LED (plus smart system) project in Rio de Janeiro. The financial analysis estimated the project's NPV to be approximately R$150 million over a 15-year period. The return on investment (ROI) is nearly 100 percent. The estimated payback period is 8.5 years (nondiscounted). See table 6.7 in section VI, reproduced at left.

These figures are based on an expected investment for this project of approximately R$ 420 million over a five-year period (2015–2019), including the cost of LED equipment, smart system equipment, as well as installation labor costs. This study estimates a potential electricity savings of 57 percent; over a 15-year period, the project is expected to save approximately 2,200 GWh of electricity for the city. In terms of O&M savings, the study forecasts total savings of R$ 105 million (33 percent) over 15 years. This includes the impact of increased project costs from the additional capital expenditures, with a decrease in administrative and maintenance costs that can materialize when using smart system technology.

A sensitivity analysis was also conducted around seven different scenarios, ranging from exclusion of smart systems, changes in LED price and changes in electricity prices, to variance in the electricity and O&M savings of the project. Of all the scenarios analyzed, the lower LED price scenario (R$ 1,300, including smart system technology) offered the most attractive financial return, with a payback period of 7.7 years. The least financially profitable scenario is one with lower electricity and O&M savings (45 percent, down from the base case assumption of 55 percent), with a payback period of 10 years. The study also analyzed the break-even point for three variables: LED price, expected average electricity rate change per year, and savings for electricity and O&M. This analysis can be useful if the City of Rio de Janeiro wishes to estimate the thresholds that the project needs to meet if it is to be financially viable. See table 6.9 in section VI, reproduced below.

Table 6.9 Break-Even Analysis

<table>
<thead>
<tr>
<th>Variable</th>
<th>Break-even point</th>
</tr>
</thead>
<tbody>
<tr>
<td>LED price</td>
<td>R$ 2,150</td>
</tr>
<tr>
<td>Average electricity price change per year</td>
<td>-2%</td>
</tr>
<tr>
<td>Savings (electricity, O&amp;M)</td>
<td>40%, 15%</td>
</tr>
</tbody>
</table>
ENERGY-EFFICIENT PUBLIC STREET LIGHTING PROJECT IN RIO DE JANEIRO

August 2014

The break-even analysis indicates that the threshold for price is reasonable for the city to achieve, particularly given the anticipated competition among manufacturers for a contract of the size proposed for the project. Furthermore, the threshold for electricity prices is unlikely to be reached given the expected increase in electricity prices in Brazil in the coming years (see section VI.A.4 for more details). The risk regarding a decrease in savings is of more concern for the city. The analysis shows that if the savings on electricity decreased to 40 percent and the O&M savings decreased to 15 percent, the project would no longer be financially viable. Whereas failure to achieve electricity savings may be covered by manufacturer guarantees, unless the PPP model is used, the city will directly bear the risk that O&M savings do not materialize. As previously described, achieving substantial O&M savings will require a decrease in the labor force performing O&M on public street lighting. Given that a reduction in the labor force can be challenging and slow, the risk of a lower O&M savings is significant.

Lastly, the study conducted an economic analysis of the project and estimated an economic payback period of 5.2 years. This means that when taking into account the real economic cost of the project to the city (that is, after elimination of taxes and subsidies on electricity and equipment), the returns to the city will be even higher than the financial analysis suggests. The City of Rio de Janeiro should evaluate the project not solely on the basis of its potential financial return, but also on the basis of the economic value it can add to the city.

Financing Options

The last section of the report identifies and reviews the main options for funding the cost of a public street lighting program: (a) on the city’s balance sheet through municipal budget allocation (potentially including COSIP) and/or municipal finance (loans or bonds); or (b) off the city’s balance sheet through private sector finance.

If the city wished to finance the project by means of a budget allocation, it would need to allocate approximately R$ 84 million each year in order to complete the project within five years. COSIP could be used to at least partially fund the project; however, it is difficult to forecast the future COSIP surplus, as COSIP is currently indexed only to inflation, not to electricity prices (see box 7.1 in section VII.A for more information). Municipal budget allocation could be used to backstop COSIP, but this would take up fiscal space that the city may prefer to use for other priorities.

The transaction could also be funded through international or domestic lending facilities. Some possible examples include loans from local commercial banks (Caixa Econômica, Itaú, Banco do Brasil, Banco de Santander, and many others) and international development banks (World Bank Group, Inter-American Development Bank, and others). This issue needs to be explored carefully, however, because of the strict limitations that Rio de Janeiro and many other Brazilian municipalities face on their indebtedness. A decision on whether to use fiscal space to fund an energy-efficient public street lighting program would presumably be based on the city’s priorities for investment in that year. Municipal bonds were also explored, but deemed less attractive than loans owing to the fact that recent municipal and state bond issuances have not been well received by the Federal Government.

If the city were to move the investment for this project off its balance sheet through private sector financing, the establishment of a PPP is the most appropriate option. Under this structure, an SPE would
need to be created to raise capital to fund the up-front investment cost. Debentures (bonds) or FIDCs (Receivables Investment Funds) were determined to be the most attractive options for raising private sector capital for the SPE to fund the project.

Debentures are debt instruments issued by an SPE that grant investors credit rights and are the most accepted securitization instrument in Brazilian capital markets today. Infrastructure debentures may be even more attractive because of their substantial tax benefits. This report suggests that several players in the financial market, such as the Brazilian Development Bank (BNDES) and Eletrobrás, could acquire debentures issued by an SPV, thereby contributing to the development of the financial market in Brazil. FIDCs, mutual investment funds that invest at least 50 percent of their net assets in receivables, are becoming an increasingly common tool used to securitize future flows from infrastructure projects. FIDCs have proved to be attractive for both borrowers and lenders, since they provide for substantial diversification of funding sources while, eventually, reducing intermediation costs and offering additional protection against bankruptcy risk. FIDCs also offer significant tax advantages for investors.

The idea of bundling infrastructure debentures into large FIDCs is being pursued by many banks, which are reportedly buying outstanding infrastructure debentures in the market in order to build portfolios for further securitization under this type of FIDC. The creation of this type of fund would add some additional transaction costs for Rio, but would enable neighboring cities to join the modernization program, thereby strengthening Rio's leadership role for the entire metropolitan area.

Attracting the private capital for modernizing street lighting infrastructure seems feasible, given the strong credit rating of the city and the beneficial regulatory framework (including COSIP). Given the strong interest in the PPP project in São Paulo, there will likely be strong interest by market players to participate in the SPE. Informal discussions with local investors indicated that a successful placement in the current market will require yields of between 11 and 12 percent per annum in local currency (inflation plus 5-6 percent). Financing for the project may need to include some concessional financing to support a term longer than the market average of seven years. Guarantees for political risk and credit risk for Rio de Janeiro will not likely be required given that the city has a strong credit rating (BBB) and that local investors are accustomed to taking on this kind of risk unsecured.

Conclusions and Next Steps

Investment in LED street lighting is a great opportunity for Rio de Janeiro to reduce energy use, generate savings on electricity and O&M expenditures, and improve the provision of public street lighting to citizens. The fiscal space created by the savings from an LED project can allow Rio de Janeiro to invest capital in other priority sectors over time, such as education, health, and transport. Beyond financial savings, an investment in energy-efficient public street lighting has the potential to improve security and increase economic activity in well-lit areas.

The returns are estimated to be very favorable, thus making it feasible to attract the private sector to finance the project if so desired. The ability of the city to receive a competitive price as well as to ensure that it can capture the potential O&M savings from an LED street lighting program will be key determining factors for the overall financial and economic success of an LED street lighting project.
In selecting the procurement approach, it is important that the city take a long-term view. The city should consider three main variables as part of this review: (a) whether the city has sufficient fiscal space to finance the project on its own balance sheet and, if so, whether it wants to prioritize the use of that budget for public street lighting projects; (b) the potential savings that can be achieved under each model and the risks the city will face under each approach; and (c) the future role of RioLuz. It could very well be the case that short-term savings (in terms of time, or avoidance of changes to the institutional setup) could result in a significant opportunity cost for the city in the long term.

Under the procurement model of Law 8.666/93, the city will need to use its own balance sheet to pay for the up-front cost of LEDs, and it will face higher financial and project performance risk because of the limitations on performance contracting and product warranties associated with the Law. The business model of RioLuz would remain largely unchanged, although a reduction in staff would still be required in order to reap the necessary O&M savings needed to make the project financially viable. Under the option of a PPP, the city would not need to provide any capital up front and it would minimize its exposure to financial and project performance risk. The business model of RioLuz would need to be adjusted to focus more on strategic planning, administration and oversight of the PPP concessionaire.

The most important next step is for the key stakeholders in Rio de Janeiro to agree on their preferred implementation model and seek political support to move forward. This report suggests that the City of Rio de Janeiro, represented by the Office of the Mayor, SECONSERVA, RioLuz, Casa Civil, the PPP Office, the Secretary for Municipal Finance, and other key parties, should assess the findings and recommendations contained in this draft report. The result of this deliberation can form the basis for the preparation of a concept note to be sent to Eduardo Paes, Prefeito (Mayor) of Rio de Janeiro, for his approval. If the concept is approved, the city should deepen the analysis of possible business models and prepare a detailed implementation plan.

The World Bank and the IFC make themselves available to the City of Rio de Janeiro to provide continued technical support to the ongoing efforts, either at the concept level or in subsequent phases of detail and implementation of a PPP/concession model. Our interest may also include financing through lending facilities or equity participation in structures or funds to be created with the specific purpose of supporting the PPP/concession model.

The City of Rio de Janeiro has been a pioneer in the public street lighting sector in Brazil and now has the opportunity to continue to lead by example by implementing an ambitious LED street lighting program.
III. Overview of Energy-Efficient Public Street Lighting Trends

A. Opportunities for Investing in Energy-Efficient Public Street Lighting in Cities

Street lighting represents about 3 percent of world electricity consumption, which is equivalent to the total electricity consumption of Germany, the world’s fourth largest economy. While a significant amount of the consumption is in developed countries, consumption in developing countries is increasing. The UN estimates that more than 50 percent of the global population will live in cities by 2030, and this increased urbanization is expected to result in higher electricity consumption in terms of public lighting.

Brazil has about 17 million public lighting points, which represents roughly 4 percent of the country’s electricity consumption. Within cities themselves, consumption of electricity for public lighting accounts for 10-40 percent of the municipal energy used, depending on the number of lighting points and their efficiency. Thus, EE in public lighting presents significant opportunities for cities.

Cities are interested in EE in public lighting for a variety of reasons. One of the main reasons is the realization that the energy savings correlate directly with financial savings, and the savings can be used to fund other municipal services. For example, the Climate Group conducted a study on LED pilots in 12 cities around the world, including New York City, Toronto, Hong Kong, London, Sydney, Adelaide and Kolkata, and found that there was an average saving of 53 percent after the installation of LEDs and smart system controls. Street lighting is often an attractive starting point for cities to invest in energy efficiency, as implementation is often less complex than in other sectors and the technology is proven.

Beyond savings, energy efficiency often results in better lighting, which improves security as well as economic activity. In Rio de Janeiro, tourism plays an important role in the economy, and good public lighting improves tourism. For example, the Municipality of Rio de Janeiro installed tall and bright metal halide lamps on the beaches in Copacabana and Ipanema. This allows residents and tourists to enjoy the beach into the evening, and stimulates additional economic activity for local businesses.

B. Benefits of LED Technology

Investment in LED public lighting is one of the most promising EE investments that cities can make. LED lighting is solid-state lighting, implying that it has neither glass tubes nor internal gas, as is typical in other lighting technologies. This translates into several advantages, as summarized in Table .1 below.
Table 3.1 Summary of LED Characteristics Compared with Related Technologies

<table>
<thead>
<tr>
<th>Lamp Type</th>
<th>Luminous Efficacy (lumens/Watt)</th>
<th>Color Rendering Index (CRI)</th>
<th>Lamp Life (hours)</th>
<th>Price (BRL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HI Pressure Sodium</td>
<td>50 - 150</td>
<td>24</td>
<td>15,000 - 24,000</td>
<td>$316</td>
</tr>
<tr>
<td>Low Pressure Sodium</td>
<td>100 - 190</td>
<td>5</td>
<td>18,000 - 24,000</td>
<td>N/A</td>
</tr>
<tr>
<td>Metal Halide</td>
<td>70 - 130</td>
<td>96</td>
<td>8,000 - 12,000</td>
<td>$320</td>
</tr>
<tr>
<td>Mercury Vapor</td>
<td>35 - 65</td>
<td>17</td>
<td>10,000 - 15,000</td>
<td>$285</td>
</tr>
<tr>
<td>Light Emitting Diode</td>
<td>70 - 160</td>
<td>70 - 90+</td>
<td>40,000 - 90,000</td>
<td>$1,550</td>
</tr>
<tr>
<td>Induction</td>
<td>61 - 76</td>
<td>82</td>
<td>100,000 - 120,000</td>
<td>N/A</td>
</tr>
</tbody>
</table>


LED lighting produces 70-160 lumens per watt, which is higher than most peer technologies. In addition to the efficiency of the lamp itself, LED luminaires, which contain sophisticated optics, produce a better-targeted flow, resulting in better luminance at street level. This combination generally results in LED lighting being 40-60 percent more efficient than current public lighting technologies, which consist largely of HPS and mercury vapor lighting. The higher efficiency offers municipalities the opportunity to provide lighting at lower costs. The costs are further lowered owing to the fact that LEDs have longer lifetimes compared with peer technology. For instance, LED lifetime is at least twice that of HPS and mercury lighting, implying lower replacement costs. This leads to reduced expenditures on O&M. Overall, savings from LED lighting can be substantial.

LEDs produce better light. The Color Rendering Index (CRI) of LED is 70-90+, meaning that the human eye sees 70-90+ percent of the colors that it would typically see in daylight. This compares favorably with mercury, which has a CRI of 17 percent, and HPS, with a CRI of 24 percent. Metal halides have a high CRI of 96, but their lifespan is significantly lower than that of LED. LED also has better light uniformity compared to peer technologies. Each LED lighting fixture has hundreds of light-producing diodes, and these can be manufactured to point in the right direction so that the light is distributed uniformly. This is not possible with bulb- or inert gas-based technologies.

Lastly, LEDs have instant ignition, which enhances their efficiency when lamps are turned on and when there are voltage fluctuations or brownouts on the grid. LEDs can be installed in tandem with smart control systems. The smart control systems enable individual control of lighting points, which easily enables dimming, immediate detection of problems, real-time monitoring of the entire lighting system, and remote metering. These have all been proven to reduce energy and operating costs.

C. Global Examples

Investment in LED street lighting programs is beginning to accelerate, and many cities have already committed to such programs. Table 3.2 below provides a brief overview of a few select programs from around the world.
In Rio de Janeiro, LED lighting is being installed in Porto Maravilha. The plan is to replace 5,000 street lights with LEDs; 1,500 lights have already been installed, and energy savings are expected to exceed 50 percent.

São Paulo is in the midst of preparing a Request for Proposals (RFP) for a PPP for efficient public street lighting. Although the exact project design is still being finalized, it is understood that a significant portion of the city will eventually be converted to LEDs as a part of the PPP agreement. Box 3.1 below provides more detail on the São Paulo street lighting project.

Table 3.2 Examples of LED Public Lighting Programs around the World

<table>
<thead>
<tr>
<th>City/company</th>
<th>Number of LED lighting points</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Los Angeles (USA)</td>
<td>140,000 points and remote monitoring system installed as of June 2013</td>
<td>63 percent energy and maintenance savings reported</td>
</tr>
<tr>
<td>Buenos Aires (Argentina)</td>
<td>91,000 points to be installed by 2015; 10,000 already installed</td>
<td>50 percent energy savings realized around the Obelisk area</td>
</tr>
<tr>
<td>Enlighted (China)</td>
<td>LED installed on 100,000 sq. ft.</td>
<td>65 percent savings realized</td>
</tr>
<tr>
<td>Vienna (Austria)</td>
<td>5,000 street lighting points</td>
<td>1,200 installed in first tranche and savings of €77,000 per year</td>
</tr>
<tr>
<td>Poznan (Poland)</td>
<td>1,800 lighting points and intelligent remote control installed</td>
<td>50 percent efficiency gains realized</td>
</tr>
<tr>
<td>New York City (USA)</td>
<td>250,000 points to be installed by 2017</td>
<td>Planning started</td>
</tr>
<tr>
<td>Bogota (Colombia)</td>
<td>20,000 points installed by 2010</td>
<td>Results currently under study</td>
</tr>
</tbody>
</table>
Box 3.1 São Paulo LED Street Lighting Program

Driven by the need to improve public safety and expand access to public street lighting and quality of service delivered to citizens, São Paulo is in the process of implementing the world’s largest LED public lighting program. The program would replace its 550,000 lighting points with LEDs. The city opted to go through a two-phase competitive process to implement the project: (a) issue Expression of Interest for a technical study to inform project design; and (b) issue tender to award the project. The process is led by the Secretary of Municipal Services, and SP Negócios (PPP Office) is managing the tenders and contract structuring. The total street lighting infrastructure will be transferred to the winning bidder, and will be supervised by the municipality as an administrative concession.

The project design tender was published in mid-2014. The city received 14 proposals, and among the companies that have signed up for the right to present proposals are GE, Philips, CPFL, AES, Odebrecht, Queiroz Galvão, Andrade Gutierrez, BTG Pactual, and KPMG. The winner will be the one that offers the higher expected savings index combined with the lowest compensation from the energy savings. The project is funded by the São Paulo city COSIP, which collects about R$ 300 million annually. The municipality may bring additional funds to guarantee its own performance.

Many of the companies participating in the design phase have expressed their intent to manufacture the LED lighting fixtures locally if awarded the contract. This would potentially halve the LED costs as local manufacturing is cheaper. Many other Brazilian cities, such as Rio de Janeiro (425,000 lighting points) and Belo Horizonte (178,000 lighting points), are exploring LED opportunities.

IV. Technical Fundamentals

A detailed technical study of public lighting in Rio de Janeiro was conducted as part of the prefeasibility study. The technical study included site audits of different lighting points which were conducted to give a sense of the quality of the light currently existing in the city. For details on the site auditing methodology, see appendixes A and B.

A. Current Street Lighting Inventory

There were 424,977 lighting points in Rio de Janeiro at the end of 2013, categorized as shown in table 4.1 below. Although a full GPS mapping survey would be needed to precisely confirm the existing inventory, this inventory is deemed to be sufficient for the purposes of this prefeasibility study.
As of late 2013, 67 percent of the street lighting in Rio de Janeiro was HPS lamps. The next largest share was mercury vapor lamps, representing 23 percent of the total inventory. As discussed later in the report, the city currently has a program to replace all the mercury vapor lamps with HPS. Metal halide lamps represent 6 percent of the existing inventory and are most commonly found in tourist areas such as the beaches. The “other” category (4 percent) includes incandescent, halogen and LED lamps. Incandescent and halogen lamps require the highest power per lumen and have the shortest life. There are a few LED lighting points in Rio de Janeiro, located mostly in areas such as Porto Maravilha, Maracanã stadium, Lagoa Rodrigo de Freitas, and Lapa. The majority of the lighting points are sodium and their power distribution is shown in Figure 4.1 below.

![Image](image-url)

Table 4.1 Proportions of Each Technology in the Rio de Janeiro Public Lighting System

<table>
<thead>
<tr>
<th>Technology</th>
<th>Lamp/rated power (W)</th>
<th>No. of lamps</th>
<th>Percent share</th>
</tr>
</thead>
<tbody>
<tr>
<td>HPS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>70</td>
<td>39,427</td>
<td>9%</td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>41,624</td>
<td>10%</td>
<td></td>
</tr>
<tr>
<td>150</td>
<td>83,840</td>
<td>20%</td>
<td></td>
</tr>
<tr>
<td>250</td>
<td>84,759</td>
<td>20%</td>
<td></td>
</tr>
<tr>
<td>350</td>
<td>0</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>400</td>
<td>34,895</td>
<td>8%</td>
<td></td>
</tr>
<tr>
<td>Tubular HPS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>150</td>
<td>0</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>250</td>
<td>0</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>400</td>
<td>0</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>Mercury vapor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>80</td>
<td>199</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>125</td>
<td>33,909</td>
<td>8%</td>
<td></td>
</tr>
<tr>
<td>250</td>
<td>33,023</td>
<td>8%</td>
<td></td>
</tr>
<tr>
<td>400</td>
<td>28,656</td>
<td>7%</td>
<td></td>
</tr>
<tr>
<td>Metal halide</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>23</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>70</td>
<td>5,543</td>
<td>1%</td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>3,999</td>
<td>1%</td>
<td></td>
</tr>
<tr>
<td>150</td>
<td>1,695</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>175</td>
<td>186</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>200</td>
<td>329</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>250</td>
<td>1,581</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>400</td>
<td>13,963</td>
<td>3%</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>160</td>
<td>17,296</td>
<td>4%</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>424,977</strong></td>
<td><strong>100%</strong></td>
<td></td>
</tr>
</tbody>
</table>
A site audit was carried out to quickly assess the minimum luminance (Emin) and Uniformity (Uo) indicators. A sample of 315 lamps was selected and those parameters evaluated based on ABNT standard 5101:2012. The study showed that the luminance in the city is fairly high, particularly in tourist areas. However, there are large discrepancies owing to the amount of mercury vapor still present in some parts of the city. The program to replace the mercury vapor is ongoing, and LED lighting would help in reducing the variation in the luminance in the city. Measurements in Porto Maravilha showed that LED luminance was consistently higher than for HPS lighting.

In this respect, LEDs may contribute to improving the uniformity of street lighting in Rio. LEDs allow directional lighting and can be placed under the canopy of the trees. Measurements in Porto Maravilha showed that LED uniformity was consistently superior to that of HPS lamps.

B. Options for Installing LEDs in Rio

As noted above, three main options could be considered when implementing an LED project in Rio de Janeiro: (a) replacement of LEDs only; (b) replacement of LEDs and installation of a smart control system; (c) replacement of LEDs, installation of a smart control system, and interment of all street lighting distribution cables. The following section provides a brief description of these three options.

Option 1 - Replacing the lighting fixtures only

Under this project concept, Rio de Janeiro would replace the lighting fixtures only as well as any lighting poles that are badly damaged. If an LED project is going to be implemented, at minimum, the city would need to replace the fixtures currently housing the sodium, mercury or metal halide lamps. This is because using LED lamps in HPS fixtures would result in overheating, which would damage the lamps and reduce their efficiency. In addition, LED fixtures can be designed to meet the aesthetic requirements of the city. Because of the directionality of LEDs, the fixtures make it easier to comply with international lighting ordinances that restrict lighting pollution such as “uplighting” and lighting trespass.
Option 2 - Replacing the lighting fixtures and the control system

Under this project concept, the city would replace the lighting fixtures and would also replace the current public lighting control mechanisms with a smart control system that would allow the city to centrally monitor and operate the street lighting system. The addition of the smart system would also enable the public lighting system managers to eliminate time spent on patrols to identify malfunctioning lights, enabling them to focus on maintenance and repair of defective lighting points. The control system also allows the city to measure its actual electricity consumption. The system allows the city to dim public lighting when streets are mostly vacant (few people and little traffic) in a way that is not visible to the naked eye, leading to reduced electricity consumption. Additionally, the city could turn up the lighting in bad weather conditions such as rain or flash lights in emergency situations. This smart system can also be used to support other public services such as flood monitoring, safety, alarms, and others. In sum, the addition of the smart system offers potential savings on electricity and O&M, while also allowing improved flexibility and provision of services to citizens. These benefits need to be weighed against the additional cost of the smart system technology. Undoubtedly, there are multiple benefits, but there are no clear mechanisms for quantifying and charging for those social benefits. The financial costs and benefits of smart system technology are discussed in more detail in section VI.

Option 3 - Replace lighting fixtures, the control system and distribution cables

In addition to replacing the lighting fixtures and installing the new control system, Rio de Janeiro could bury the cables used for electricity distribution as well. Approximately 80 percent of the current distribution system is aerial and burying the cables underground could improve the aesthetics in Rio de Janeiro. Currently, distribution poles are also used as telephone poles; hence, they are not designed for public lighting. If the effort is carried out in conjunction with the burying of the electric distribution network, the overall system would be less prone to failures due to lighting strikes. However, the interment of distribution cables is a costly endeavor and the costs need to be compared with the potential economic benefits for the city. It is unlikely that the distribution company will develop a citywide underground program. Therefore, the installation of LEDs should not establish as a precondition a full-fledged interment of the distribution and street lighting cables. Appendix C provides more detail on the expected cost and benefits of this project concept.

C. Selected Project Design

From a technical standpoint, the study suggests that the optimal approach is option 2 - replacing the lighting fixtures and the control system. Option 3 was not selected on the determination that the cost of bundling the installation of LEDs with the installation of underground distribution cables for public street lighting would be prohibitively costly and would not likely offer benefits sufficient to justify the additional costs. It should be noted, however, that a more thorough analysis is warranted in order to fully understand the costs and benefits of underground cable installation. Moreover, if the installation of underground cables is a priority for the city, the city could consider implementing this as a project that is separate and independent from the installation of LEDs and smart lighting systems. When a detailed financial analysis was carried out, it was determined that the incremental costs of smart systems did not seem to justify the benefits. However, the analysis took into account only the projected energy and maintenance savings; if other social benefits had been included, it is possible that the installation of
smart systems would make sense from an economic standpoint. Nevertheless, doubts remain about how the incremental cost would be financed and the mechanisms to recover those costs.

Although the financial analysis showed option 1 to have a slightly more attractive rate of return, the conclusion of the study is that this analysis alone is insufficient to make a decision about the project design (see section VI.B.2 for more information). For example, the financial analysis did not take into account other economic or social benefits that smart system technology would bring, including enabling the city to adjust street lighting in the event of a power crisis and quickly respond to lamp underperformance or vandalism. It also did not take into account the fact that the LED smart system technology can be used as infrastructure to support other smart systems in the city, including systems that can be used by police to monitor events and improve safety. Thus, it is the conclusion of the study that the slightly lower value in the financial return under Option 2 is more than offset by the potential economic and social benefits that the smart system technology can provide. Thus, option 2 – installation of LEDs plus smart system technology – is the selected project design for this study. In this regard, the study recommends a concerted effort between Light and RioLuz to determine the vulnerabilities of the existing aerial network and estimate the cost, effort and time needed to equip the network with the necessary protective devices to make it more resilient to lightning strikes, which can damage LEDs.

Under some scenarios, (for example, higher electricity cost or lower capital costs), the deployment of smart systems may prove to be economically viable. On this basis, the remainder of this report assumes that the project design involves the installation of LEDs and smart systems, consisting of GPS transponders on each point of light and a central control system to monitor and adjust the performance of the street lighting system in real time. Cost comparisons between this option and the other options are offered when possible. Furthermore, the analysis assumes the implementation of an LED program in the City of Rio de Janeiro for the installation of LEDs for 75 percent of Rio de Janeiro’s 425,000-point street lighting system, that is, 320,000 points of light. The investment and installation are expected to take place progressively over a five-year period; in other words, 65,000 points of light will be procured and installed every year for five years. RioLuz is in the process of identifying the optimal roll-out plan for the project.

The study does not include any expansion of the current public street lighting system, as the financial investment needed for adding new points of light in the city should be considered as a separate investment from that of the retrofit analyzed in the study. The rationale for analyzing the retrofit separately is to clearly understand whether the savings associated with the replacement of existing technology with LEDs is high enough to fully repay the costs associated with the investment. Investment in new points of light will not have an explicit financial return but will certainly have an economic/social return that is important for the city, and it should be explored in a separate study.
V. Institutional and Regulatory Framework

Before delving into the financial analysis of the proposed project, it is important to have a solid understanding of the institutional and regulatory frameworks within which this project would take place. The following section provides this overview.

A. Key Players

1. City Hall

City Hall (Casa Civil) has provided the vision and strategic guidance for the process. It had been leading the LCCDP/TRACE (Tool for Rapid Assessment of City Energy), with World Bank support. The efficiency of key municipal services has been assessed and compared to those of other large cities in the world. Based on this analysis, City Hall has prioritized two areas for action, namely efficiency in public buildings and street lighting, with an initial focus on the latter.

City Hall has provided leadership throughout the process by engaging different stakeholders and acting as a liaison between the multiple Secretariats and the Office of the Mayor.

2. SECONSERVA

The Municipal Secretary of Conservation and Public Services (Secretaria Municipal de Conservação e Serviços Públicos, SECONSERVA) was established on February 23, 2010 to centralize and coordinate the work of agencies and municipal companies responsible for the conservation and provision of public services provided to the citizens of Rio de Janeiro.6

SECONSERVA is responsible for the conservation and maintenance of urban infrastructure of the city, the provision of street cleaning and street lighting services. SECONSERVA oversees a number of subordinate municipal departments and companies, including RioLuz.

3. RioLuz

In Rio de Janeiro, the Municipal Company for Energy and Lighting (Companhia Municipal de Energia e Iluminação) is responsible for street lighting and energy supply in public schools and hospitals. RioLuz is 100 percent owned by the municipality.

According to municipal Law 1561/1990, the corporate purposes of RioLuz include:

6 http://www.rio.rj.gov.br/web/SECONSERVA.
• Planning, implementation, performance, recovery, maintenance and improvement of the municipal public lighting system
• Installation and maintenance of traffic lights
• Analysis, approval and inspection of electricity projects, including public and private expansion plans, as well as their performance
• Preventive and corrective maintenance of electric installations in municipal buildings
• Preparation of studies, research and projects related to the electricity sector, including those in the form of technical consultancies for third parties
• Enforcement, by delegation, of municipal police power related to public services in which the company acts as a concessionaire, including inspection of building installations
• Support to all events directly or indirectly promoted by the municipality or municipal-owned companies, independent agencies and public foundations

In view of the broad responsibilities outlined above, it can also be inferred that RioLuz has a legal mandate to plan and implement energy efficiency studies and projects for public lighting, municipal hospitals, and public health.

4. Light

The Light Group has several companies operating in electricity generation, transmission, distribution and energy services. They are ultimately controlled by Light Holding S.A. Following the electricity regulatory reform of 2004, distribution services were required to be divested through the creation of a special purpose company. In the case of Light, this led to the establishment of the distribution concessionaire (DISCO) Light Serviços de Eletricidade S.A., which owns the concession to provide distribution services in many cities in the State of Rio de Janeiro, including the City of Rio de Janeiro. The Light DISCO's concession agreement was executed on June 4, 1996 for a 30-year term, renewable by the granting authority. It generates the funds used in the mandatory investments in energy efficiency projects known as PEE-ANEEL funds (described further in the section on Financing Options).

The Light Group also has an energy service company (ESCO), Light ESCO Prestação de Serviços Ltda., whose corporate purpose is to deliver energy solutions, including EE projects, nationwide. Light ESCO has focused its activities on providing services to the private sector.

5. PPP Council

If the LED street lighting project is developed as a PPP, the project will need to seek approval from the Municipal PPP Managing Council, PROPAR-RIO. The Managing Council of PROPAR-RIO has the following membership:

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8 The renewal term for Light’s concession contract is not provided in the concession agreement. Some DISCOs may be eligible to have their contractual term extended under Law 12.783/2013 (conversion of Provisional Measure 579/2012). This is not the case of Light.
The Sub-Secretariat of Strategic Projects, Concessions and PPP (CVL/SUBPPP's) is responsible for following up PPP projects and shall act as the Executive Secretariat of the PROPAR Managing Council (Decree 33.733/2011). According to article 11 of Municipal Decree 32.420/2010, the Managing Council decides by majority vote. The President has qualified powers in the case of a tie.

6. Federal Players

There are also key actors for EE projects at the federal level, such as Agência Nacional de Energia Elétrica (ANEEL), the federal electricity regulatory commission, and Centrais Elétricas Brasileiras S.A. (Eletrobrás), the federal state-owned holding company that manages PROCEL, as described further in this report.

Currently, ANEEL plays two major roles in supporting street lighting activities. The first is to set street lighting rates (and annual price adjustments) for each concession area. The second – applicable only for distribution companies still in charge of street lighting – is to monitor the soundness of the investment decisions in this area and to allow those investments to be part of the asset base for the purpose of setting rates.

B. National Regulation of the Public Street Lighting Sector

In Brazil, the electricity sector is regulated by federal statutes enacted by the National Congress, as well as by regulations set by ANEEL. Electricity services are governed by ANEEL Regulation 414/2010 in which consumer units are classified according to the type of use of electricity, that is, residential, industrial, commercial, rural, government, public lighting, public services, and own consumption.

Consumer units are also divided into two groups according to the amount of electricity consumed. Group A is consumer units supplied with voltages equal to or greater than 2.3 kV that are connected to the distribution system in secondary voltage, characterized by a binomial rate that includes payment for consumption and capacity. Group B is consumer units supplied with voltages below 2.3 kV, characterized by a single rate that does not distinguish energy consumption or demand; they are divided

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9 The residential consumer type includes a low-income resident subcategory entitled to pay subsidized rates. The electricity social rate is governed by Law 12.212/2010.
into subgroups B1 – residential, B2 – rural, B3 - other classes, and B4 - public lighting. Thus, the rate for the street lighting energy supply is the B4a rate.\(^{10}\)

ANEEL annually sets and publishes the rates applicable to each type of consumer, adjusted according to the concession agreement in place between the Federal government and the concessionaire. The concession agreement also provides for a multiyear rate review under a price cap regime.\(^{11}\) Consumer units may be charged either a conventional rate, which is a fixed amount on a per kWh basis, or an hourly rate, which varies according to the time of the day when the electricity is consumed.\(^{12}\) In the case of public street lighting, a fixed, conventional rate applies (article 56-A, Ruling 414/2010).

1. Regulation of Ownership and Maintenance of Assets

Public lighting includes project design, implementation, expansion, operation and maintenance of street lighting, parks, tunnels, and traffic light installations. These activities may be developed by a municipal entity or another party that is delegated to provide such services. ANEEL regulates the rates charged by the utility to the municipalities for the provision of street lighting services. Municipalities are responsible for regulating the standards and quality of service, and for establishing the street lighting contribution to be charged to ratepayers via the electricity bill.

Currently, Brazil has 63 different DISCOs. Each one has exclusivity in its conceded territory, except for serving “major consumers” classified as such by federal rules (in general those using > 3 MW), which are entitled to freely contract electricity with generators or marketers.

For historical reasons, some of the DISCOs still own public street lighting assets and, as such, list assets associated with public lighting services on their balance sheets. This is the case in eight states in Brazil, including São Paulo and Minas Gerais. As a consequence, such DISCOs had to operate and maintain those assets. These costs resulted in additional line items under the DISCOs’ Regulatory Asset Base (RAB), which in turn is the basis for ANEEL’s evaluation of appropriate electricity rates charged by the respective utility.

In order to reduce RAB and, thereby, reduce electricity rates for consumers, ANEEL enacted article 218 of Ruling 414/2010, which states that by December 31, 2014,\(^{13}\) all street lighting assets held by DISCOs

\(^{10}\) The current regulatory framework sets differentiated rates for situations in which (a) the municipality owns and manages the public street lighting assets (B4a); and (b) the DISCOs own and manage the public street lighting assets (B4b). Given that new regulation will require ownership of all public street lighting assets to transfer to the municipalities (discussed further in the report), the B4b rate will shortly become obsolete.

\(^{11}\) A regulatory mechanism whereby rates remain constant (capped) between two review periods. This provides the operator with incentives to invest in efficiency gains and capture the benefits, in contrast to the typical cost-plus regulation, whereby costs, once allowed by the regulatory agency, are immediately passed on as rates. In price cap regimes, the regulator also allows the immediate passing on to rates rate of costs that are not under the control of the operator, such as fuel price increases.

\(^{12}\) The current regulation in Brazil does not contemplate either time of use rates or any other type of dynamic pricing mechanism for residential consumers. However, beginning in 2015, residential consumers will face a time-of-use (ToU)-like rate structure. Under the proposed scheme, rates will be increased by a fixed and previously set surcharge to reflect higher energy prices in the spot market.

\(^{13}\) This date has been postponed several times.
shall be transferred to the entitled municipal authority. With this transfer of assets, public street lighting assets can no longer appear on DISCOs’ balance sheets. Hence, after December 31, 2014, all Brazilian municipalities will be responsible for operating and maintaining the assets. New assets shall also be built and owned by the municipalities.

2. Billing

Unlike other classes of consumption, in which billing is performed according to actual consumption metered and valued at the corresponding rate, DISCOs are not required to install metering devices for street lighting.\(^{14}\) Thus, the consumption of electricity from the street lighting grid is estimated on the basis of the inventory of installed equipment and the power consumed (that is, wattage) at the associated rate, which is agreed between the municipality and the DISCO.\(^{15}\) The total calculated wattage of the installed equipment is multiplied by a fixed number of hours of daily use to derive the estimated kWh consumed per day for public street lighting services.

ANEEL has ruled that the standard daily use of public street lighting is 11 hours and 52 minutes per day (11h52m/day), except for public parks and/or tunnels that require continuous lighting, for which the time of use is considered to be 24 hours per day (24h/day). If a city wishes to propose adjustments to the estimate of daily consumption, it shall submit a study for approval by ANEEL and the DISCO demonstrating a deviation from ANEEL’s standard assumption of 11h52m. In fact, Rio de Janeiro conducted such a study, which demonstrated that its average daily consumption is equivalent to 11h32m. The study was reviewed and approved, and the change is now reflected in the calculation of Rio de Janeiro’s public street lighting electricity bill. Installation of any new equipment or automatic controls aimed at reducing consumption must also be reviewed and approved before the reduction provided by such equipment is factored in the bill.

3. Collection of COSIP and Use of the Special Fund for Public Lighting (FEIP)

According to article 149-A of the Federal Constitution,\(^{16}\) amended in 2002, municipalities are entitled to create by local statute a tax called the Contribuição para o Custeio do Serviço de Iluminação Pública,
COSIP (Contribution to Public Lighting Services) with the exclusive purpose of funding public lighting services.¹⁷ Municipalities have the right to adopt a local law to allow for the collection of COSIP and to define its level, among other characteristics.

In the City of Rio de Janeiro, COSIP was created by Municipal Law 5132/2009 and is charged to all consumers receiving electricity from the local DISCO, Light. According to the law, COSIP resources shall be used to finance public lighting as well as the installation, maintenance and improvement of public lighting infrastructure. The amount due as COSIP depends on the monthly consumption of each unit, in accordance with Table 5.1 below, which reflects the provisions of Municipal Law 5132/2009. Table 5.1 reports the COSIP rates for 2010–13, which are based on the level established in 2009 and are adjusted annually according to the inflation rate index, used for the adjustment of all municipal taxes.

<table>
<thead>
<tr>
<th>Monthly consumption range (kWh)</th>
<th>Original amount (R$)</th>
<th>Updated amount (R$, adjusted by inflation rates)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;80</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>80-100</td>
<td>2</td>
<td>2.11</td>
</tr>
<tr>
<td>100-140</td>
<td>3</td>
<td>3.17</td>
</tr>
<tr>
<td>140-200</td>
<td>4.5</td>
<td>4.76</td>
</tr>
<tr>
<td>200-300</td>
<td>6.5</td>
<td>6.87</td>
</tr>
<tr>
<td>300-400</td>
<td>9.8</td>
<td>10.36</td>
</tr>
<tr>
<td>400-500</td>
<td>12.8</td>
<td>13.54</td>
</tr>
<tr>
<td>500-1,000</td>
<td>16</td>
<td>16.92</td>
</tr>
<tr>
<td>1,000-5,000</td>
<td>30</td>
<td>31.73</td>
</tr>
<tr>
<td>5,000-10,000</td>
<td>60</td>
<td>63.47</td>
</tr>
<tr>
<td>&gt;10,000</td>
<td>90</td>
<td>95.21</td>
</tr>
</tbody>
</table>

In Rio de Janeiro, Light is responsible for collecting COSIP as a line item on end users’ electricity bills based on an agreement executed between Light and the municipality. Light acts as a mere collector on behalf of the municipality; Light sends COSIP funds to an account owned by the municipality called the Special Fund for Public Lighting (Fundo Especial de Iluminação Pública, FEIP), which was also created by Municipal Law 5132/2009.

¹⁷ Article 149-A was introduced into the Federal Constitution by means of Constitutional Amendment 39 of 2002, after years of judicial disputes regarding what type of tax could be imposed to collect revenues that could be used to pay for public lighting expenditures. Since at present municipalities can impose COSIP on constitutional grounds, challenging it has become more difficult. The present study found only two precedents at the Supreme Court discussing the constitutionality of local rules that created COSIP, and in both cases the Court affirmed that consumers could be charged, provided that the relevant municipal rule has instituted the tax in accordance with article 149-A of the Federal Constitution (precedents AC 3087 MC-QO/MG and RE 573675/SC).
FEIP is merely a bank account; it is not an investment fund subject to the Brazilian Securities and Exchange Commission (Comissão de Valores Mobiliários, CVM) regulations. According to Article 10, §1º, of Municipal Decree 32.238/2010, FEIP's annual budget is part of the annual budget of SECONSERVA. FEIP is managed by an Executive Secretary, appointed by SECONSERVA, who shall observe the instructions to be given by FEIP's Managing Council.  

According to Municipal Decree 32.238/2010, FEIP resources may come from:

- COSIP, including added fines for late payments
- Donations, subventions, contributions, transfers and participation that may be earmarked for FEIP under agreements or other consensual terms
- Donations made to the Municipality of Rio de Janeiro under some kind of special agreement
- Financial profits, revenues of any nature, interest, monetary adjustments, investments in general
- Any resources arising from contractual penalties earmarked for FEIP
- Balance sheet surpluses
- Any other resource earmarked for FEIP

The purpose of FEIP is the funding of public lighting as well as the maintenance, installation, and improvement of public lighting equipment; these are the same as for COSIP (Municipal Decree 32.238/2010). FEIP resources additional to requirements may also be allocated to PPP projects involving energy efficiency, renewable energy sources and public lighting technology improvement, among other purposes. Ultimately, the use of FEIP funds shall be approved by FEIP’s Managing Council.

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18 Currently, FEIP’s Managing Council is comprised of the Secretary of SECONSERVA, who shall act as President of the Council; the President of RioLuz, who shall act as Vice-President; a representative and her alternate from the Municipal Secretariat of the Treasury; a representative and her substitute from City Hall; and a representative from the Municipal Secretariat of Public Services and Conservancy.

19 Municipal Decree 32.238/2010 stipulates the purposes for which FEIP funds can be used as follows:
   i. Maintenance of the park street lighting in the City of Rio de Janeiro, including the purchase of permanent equipment and consumables necessary for the development, expansion and maintenance of the park;
   ii. Full or partial funding of public lighting projects;
   iii. Total or partial financing of projects in the area of public lighting and energy, being those developed and/or implemented by third parties, whether public, private and/or under a public-private partnership established in legislation;
   iv. Development of, providing incentives for, participation in and implementation of energy efficiency projects and the use of energy originating from renewable sources;
   v. Development and application of new technologies for public lighting;
   vi. Development and qualification of human resources focused on public lighting, as well as programs of demonstrated quality, productivity and other attributes that contribute to the technical improvement of those assets;
   vii. Securing better prices in the market, preferably, from renewable sources when economically viable;
   viii. Acquisition of movable or immovable assets, their maintenance, materials, furniture, and supplies and/or services for the maintenance, operation, and expansion of street lighting services of the City of Rio de Janeiro, properly incorporated into the heritage of the City;
   ix. Prevention of damage to the park lighting of the City of Rio de Janeiro; and
   x. Payment for services provided by energy utilities by means of collecting the contribution to fund the public lighting service, if the services are costly.

20 According to article 9, II, FEIP’s Managing Council decides by a simple majority of votes.
It is worth noting that, although expressly authorized in the Federal Constitution, charging COSIP directly on consumers’ bills has been the subject of legal disputes: the state Attorney-General (Ministério Público) of Rio de Janeiro claims that bundling payments of electricity services and taxes is a violation of consumers’ rights.

At least two suits have been brought in that respect. In one of them, brought against AMPLA – the concessionaire that serves many other cities within the State of Rio de Janeiro – the state Attorney General has succeeded in obtaining a preliminary injunction that prevents AMPLA from charging COSIP directly in consumers’ bills. The dispute is ongoing, and the injunction does not directly affect Light or the Municipality of Rio de Janeiro. In fact, Light is currently protected by a decision of the Twentieth Civil Chamber of the State Court of Justice that expressly affirmed Light’s right to bundle electricity services and taxes in the same bill. There is no known precedent of the Superior Court of Justice or the Supreme Court on this subject.

C. Procurement Rules

Depending on their structure, municipal procurement laws can either help or hinder the promotion of municipal energy efficiency projects. This section reviews the most relevant procurement laws that could be used to implement an energy-efficient public street lighting project in Rio de Janeiro.

The present study conducted a detailed analysis of the main procurement models that could be considered for an LED public street lighting project in Rio de Janeiro. This includes: (a) general procurement of goods and services (Law 8.666/93); (b) procurement by auction for standard goods and services (Law 10.520); (c) the Special Contracting Regime (Regime Diferenciado de Contratações, RDC) (Law 12.462/2011); and (d) the law on public concessions (Law 8.987/95), including the law on Public-Private Partnerships (Law 11.079/04, subsequently amended by Law 12.766/12).

The detailed analysis by procurement model is included in appendix E. This section of the report attempts to summarize the main findings from a model-by-model review. It narrows the possible models down to three and then provides an overview of the pros and cons of the three approaches.

Before delving into each of the procurement models, it is important to point out that for all contracts with a value greater than R$ 650,000 (for purchases, sales and services), or over R$ 1.5 million (in cases of engineering work and engineering services), a competitive selection process (concorrência) is required. Given that the estimated total value of the project (approximately R$ 440 million, discussed further in the report) is significantly higher than the threshold, even if the project is broken down into
multiple phases, this study assumes that competitive selection under *concorrência* will be used in all models, unless otherwise stated.

It is also important to point out that where a project (that is, engineering works, service or purchase of goods) is financed with resources from a foreign official cooperation agency or a multilateral financial body of which Brazil is a member, the procurement process may follow the conditions set forth in agreements, protocols, conventions or international agreements approved by the National Congress, as well as the rules and procedures of such entities.\(^\text{25}\) In other words, if the LED project is to be financed by a multilateral organization, the procurement rules discussed in this section would not apply. For example, competitive selection through *concorrência* is not required if the project is financed by a multilateral agency; in that case, the procurement rules of the multilateral agency can be used instead.

### 1. Summary of findings

The models are evaluated on the basis of key criteria that affect their applicability for an LED (plus smart system) project in Rio de Janeiro. These criteria are as follows, listed generally in order of importance (although this is not a rigid ranking of the criteria):

- **Eligibility for use today.** This evaluates whether there are any restrictions within the procurement law that will make it impossible to use that model for this project.
- **Ability to evaluate bids based on technical standards.** This is important because it indicates whether characteristics other than lowest price need be used to select the winning bidder. If only price can be used, then the city must ensure that the product being purchased is very standardized and, to the extent possible, any deviation from specifications should be covered by warranties provided by the supplier. In addition, if only price can be used as an evaluation criterion, the model can only be used to procure goods and services that can be clearly standardized.
- **Ability to include performance metrics in contract.** This evaluates whether the city can link payments to the contractor with the performance of the project in terms of energy and/or O&M savings. It also indicates whether the city can evaluate bids based on the "best energy saving proposal" rather than solely the best technical proposal or lowest price.
- **Duration of contract matches LED lifetime.** For any LED project, the city will want to maximize the manufacturer's warranty it can receive on the technology (measured by EE savings, performance, depreciation factor, usable life, etc.). In the event that the city seeks to bundle procurement of equipment and services, a performance guarantee becomes even more important. However, an extended warranty or performance guarantee may be restricted by the duration of the procurement contract. Many procurement models have short contract time frames whereas LEDs are expected to last, on average, 11-13 years. This criterion evaluates

\(^{25}\) This may include criteria for selecting the best proposal through means other than those expressly provided for in Brazilian legislation, provided that such criteria are required as a condition for the granting of the financing, do not conflict with the principle of objective judgment, and are expressly approved by the contracting party in a grounded decision approved by the superior authority. See article 42, §5\(^\circ\), of Law 8.666/93.
whether there is a mismatch between the maximum length a contract can last without being renewed and the expected lifetime of LEDs.

- **Ability of one company to design and execute the project.** For energy efficiency projects, one of the main barriers in Brazil is that the entity that completes the “Basic Project” (that is, the project design) cannot be the same entity that implements the project. The need to create a Basic Project before issuing a bid can be a hindrance for public procurement of energy efficiency projects, particularly in the case of procurement of goods and services. This is largely because the energy efficiency project has to be fully designed before the tender is issued. However, the company submitting the winning bid may have better, more innovative ideas on how to design a slightly different project in order to maximize efficiency. Therefore, it may be difficult to bid on a project involving energy efficiency retrofits and modernization, since the scope of work is not perfectly known ex ante, and often can only be defined after an energy efficiency audit by the entity that will execute the actual project is carried out.

- **Pre- or post-qualification required.** This evaluates whether bidders have to be qualified in order to have the contract awarded to them. This affects the timing and complexity of using the model, particularly for prequalification, which can be a time-consuming process.

Table 5.2 below provides a summary of the key features of each model according to the criteria described above.

**Table 5.2 Overview of Key Characteristics of Procurement Models for LED Plus Smart Systems**

<table>
<thead>
<tr>
<th>Procurement model for LED plus smart system</th>
<th>Eligible for use today on LED plus smart system project</th>
<th>Can evaluate bid on technical standards</th>
<th>Performance metrics can be included in contract</th>
<th>Contract duration matches LED lifetime</th>
<th>One company can design execute project</th>
<th>Prequalification not required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Law 8.666/93</td>
<td>X</td>
<td>X</td>
<td>1) X</td>
<td></td>
<td>X</td>
<td>Xb</td>
</tr>
<tr>
<td><strong>Pregão/Auction</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RDC</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>Xc</td>
</tr>
<tr>
<td>PPP</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>Xd</td>
</tr>
</tbody>
</table>

**Notes:**

a. Only in cases where energy efficiency projects can be contracted as Service Level Agreements, as previously discussed in this report.

b. Qualification documents shall be required from the bidder that presents the best proposal, which shall submit to the public contracting party documentation attesting its qualification after its proposal has been selected.

c. The law does not oblige, but allows for, a procurement process, according to which qualification documents shall be required only from the bidder that presents the best proposal.

d. The law does not oblige, but allows for, a procurement process, according to which qualification documents shall be required only from the bidder that presents the best proposal.

After reviewing the four models described above, it became clear that not all of them would be a good fit for use in the short term for a citywide LED street lighting project in Rio de Janeiro.

Importantly, the Pregão regime and the RDC regime are currently disqualified from consideration. The Pregão regime is disqualified because LEDs in tandem with smart system technology are unlikely to be considered “standard” products, since they involve the provision of a product (which can be
standardized) and a special technical service (design and implementation of the smart system). Rio de Janeiro could consider using Pregão during later phases of the project if additional lamp procurement is necessary.

The RDC regime is disqualified in the near term because legislation does not allow it to be used for the procurement of goods or services related to energy-efficient lighting. However, new legislation is being considered that could eliminate this restriction. If new legislation is adopted, the RDC regime could become an attractive model to pursue given the flexibility it offers with regard to qualification of bidders, bidding on a turn-key project, and inclusion of performance metrics in the contract.

Since Pregão and RDC are not considered good options in the near term, the possible procurement options are narrowed down to Law 8.666/93 and the PPP model. Under Law 8.666/93, there are two possible approaches to consider: one would involve the procurement of LED and smart system technology only, and the other would involve the procurement of “energy-efficient street lighting services,” meaning the bundling of the procurement of equipment with the procurement of services for installation and O&M. The following section provides an overview of the pros and cost of these three approaches based on the other characteristics shown in table 5.2 above.

**Contracting of LED plus smart system equipment only using Law 8.666/93**

Using this model, RioLuz would tender the bid for procurement of LED plus smart system technology but would remain responsible for installation and maintenance (although both services could be subcontracted in a separate bid if desired). Figure 5.1 provides an overview of the pros and cons of this approach.

**Figure 5.1 Evaluation of Procurement of Goods Only Using Law 8.666/93**
One of the main benefits of this approach is that Law 8.666/93 is very commonly used within the municipal government; therefore, its use would be relatively straightforward and would not require significant internal consultations or approvals. Using Law 8.666/93 would necessarily require a two-step process to tender the project, that is, first selecting a contractor to design the Basic Project and then selecting the contractor to implement the project. Under Law 8.666/93, these tasks must be done by distinct entities. The bids can be evaluated based on technical standards (including a combination of price and technical evaluation) and bidders must be prequalified before they are able to bid on the project.

Should Law 8.666/93 be used to purchase LED equipment only, the city would be responsible for installation, operation and maintenance. Thus, in this scenario, there would be little room or need to link the contract with overall performance in terms of electricity savings. This is because the manufacturer would not be directly involved in the operation of the equipment and, thus, would have limited ability to guarantee overall electricity savings throughout the system. That being said, the equipment supplier should be willing to provide some form of equipment warranty for the performance of the LED equipment itself (for example, LED lifetime, and lumen output per watt).

The maximum duration of a contract for procurement under Law 8.666/93 is five years, after which time the contract can be renewed through a competitive selection process. However, the LED lifetime is over 10 years. The maximum five-year duration of the contract could make it difficult for the city to secure a warranty that extends over the entire lifetime of the equipment. As a result, the city would bear a significant amount of technical and performance risk under this approach. To mitigate this risk, the city could consider purchasing an extended warranty or purchasing additional insurance from a third party.

Another important consideration is that, under this approach, the city will need to provide all of the up-front financing via municipal budget allocation or municipal debt. The feasibility of this option therefore depends on the current budgetary situation for public street lighting, the remaining fiscal space in the city overall, and the prioritization of the use of any current budget surplus or fiscal space. Our understanding is that Rio’s borrowing capacity is very limited, in light of the debt negotiation agreement covenants with the Federal government.

Although this option offers the fewest number of barriers and transaction costs up front, the overall cost to the city may be higher over the long term compared with the other two approaches discussed below owing to the difficulty of receiving the strongest possible warranty and the risk the public sector will face in case any technical risk materializes in the project.

**Contracting of LED equipment and services using Law 8.666/93**

Under a scenario where Law 8.666/93 is used to procure LED and smart system equipment and services, RioLuz could issue a tender for “energy-efficient services” of public street lighting. The winner of the bid would be responsible for procurement, installation and/or efficient maintenance of LEDs and the smart system. Figure 5.2 provides an overview of the pros and cons of this approach.
Similar to the approach described above, the main benefit of this approach is that Law 8.666/93 is very commonly used within the municipal government. The prior design of a Basic Project and a two-step process would still be required.

In the case where Law 8.666/93 is used to purchase LED equipment as well as services, it will still likely be difficult for Rio de Janeiro to include metrics within the contract to link payments to energy efficiency performance. This is because Law 8.666/93 does not expressly address performance contracts and the selection criteria for proposals do not allow the city to adopt the “best energy saving proposal” as the criterion on the basis of which to award the winning bid. Thus, although the city could receive a warranty from the manufacturer, it will be challenging to link payments under a contract using Law 8.666/93 to the actual energy efficiency performance of the project.

In the scenario, the maximum contract duration for procurement under Law 8.666/93 is still five years. Thus, the city will still face a mismatch between the duration of the contract and the maximum lifetime of the equipment. The strength of the warranty would also be affected by the amount of services provided by the contractor, ranging from installation only to installation, operations, and maintenance. The more services procured the more control the contractor will have over the entire supply chain process and, therefore, a stronger warranty should be provided. In any case, the guarantee offered under this approach will likely be stronger over the five-year contract period than that which would be offered in the previous model. This has the potential to reduce the performance risk faced by the city.

This model would also still require up-front financing from the city.

In summary, this option could substantially reduce the performance risk faced by the city over a five-year period, but the city could still face significant risk from that point onward unless additional guarantees outside the main contract can be obtained.

\[26\] See appendix E for an explanation the criteria that may be used to select the winner of the bid.
PPP approach

Under the PPP approach, a Special Purpose Entity would be established by the winning concessionaire to procure the LED and smart system equipment and to install and maintain that equipment. This SPE could be comprised of several partners, including large equipment manufacturers, operators (utility companies or international street lighting operators), financial institutions, and some government entities such as RioLuz and Eletrobrás.

There are two types of PPP: Sponsored Concessions (*Concessões Patrocinadas*) and Administrative Concessions (*Concessões Administrativas*). Sponsored Concessions are those in which the citizens are the primary end users of the service and revenues arising from the provision of public services by the concessionaire (rates) are not enough to make the project attractive from a financial and economic perspective. In this case, the Public Administration makes the concessionaire whole by providing additional payment for the services, on top of the regular charges. For Administrative Concessions, the Public Administration is the end user of the services to be provided by the concessionaire and, as such, shall bear all the costs. Since the city would be the end user for the provision of public street lighting goods and services, the Administrative Concession is the most appropriate PPP model to employ for an energy-efficient public street lighting project in Rio.

Figure 5.3 provides an overview of the pros and cons of this approach.

![Figure 5.3 Evaluation of Contracting Goods and Services Using a PPP](image)

The contract duration for an Administrative PPP is from five to 35 years. Thus, it would be possible for the city to receive a full lifetime warranty for the LEDs since the PPP concessionaire will be responsible for the procurement, installation, operation, and maintenance of LEDs over their entire lifetime. In addition, PPPs explicitly allow for the payments under the contract to be linked to project performance.

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27 This contractual structure does not prohibit the concessionaire from seeking alternative sources of revenues from third parties, when feasible, for example by using publicity.
This will bring economic and financial efficiencies as a consortium, created to supply equipment and services, will have a vested interest in an SPE created for the project and will benefit from the project efficiency, that is, energy savings. These two factors combined would work to greatly reduce the performance risk faced by the public sector.

The concessionaire would be responsible for raising the financing to cover the up-front cost of the equipment and the city would pay the concessionaire in installments. The payments can include performance gains, to be reviewed over time as specified in the concession contract.

Despite these attractive benefits, there are some drawbacks to this approach. First, the time and transaction costs involved in the preparation of a PPP are higher than for the other two options (see Appendix D for more detail on concession models that could be explored). In addition, RioLuz would need to adapt its roles and structure to this new business model. Given the importance of the role of RioLuz in any LED project, this issue is discussed in more detail in the following section.

D. Potential role of RioLuz

1. RioLuz under Law 8.666/93

According to its legal mandate, RioLuz is empowered to undertake EE projects involving public lighting. As such, RioLuz could actually be regarded as an ESCO company for municipal public lighting projects.

This is relevant because state-owned companies can be hired directly by public entities without undergoing a bidding process. According to article 24, VIII, of Law 8.666/93, among cases in which the legal obligation to undertake a public procurement process is waived are those involving “acquisition, by a public legal entity, of goods produced or services provided by an office or entity that belongs to the Public Administration and that was incorporated for this specific purpose before the approval of this law [8.666/93], provided that the price is comparable to the one practiced in the market”.

In Brazil, the incorporation of state-owned companies shall be preceded by legal authorization. The incorporation of RioLuz was approved by Municipal Statute No. 1561/1990, prior to the enactment of Law 8.666/93.

Therefore, the Municipality of Rio de Janeiro and its legal entities (such as autarquias other local authorities and state-owned companies) are not required to launch a public procurement process to contract RioLuz to implement and manage EE projects.

2. RioLuz under a PPP

RioLuz is legally entitled to perform certain ESCO-type activities and can be hired by municipal entities to execute EE projects.
Apart from its current legal attributes, should the final decision be to structure a PPP project to attract private investors to public lighting, RioLuz could perform at least three different roles: (a) as the contracting party, as well as the regulatory authority; (b) as the entity responsible for strategic planning, monitoring and supervision of the concession contracts; (c) as a partner of the SPE formed for the PPP/concession. Some of those responsibilities may be mutually exclusive. For example, if RioLuz is the granting or regulatory authority, it cannot play the role of an operator or equity holder in the SPE. Firewalls will have to be put in place if potential conflicts of interest exist.

Although this is the subject of some controversy, in principle state-owned companies would not be expected to perform typical governmental duties, and Law 11.079/04 expressly allows State-owned companies to be contracting parties in PPP projects.

In order to act as the concession grantor, there will likely be a need for the Municipal Assembly to pass a law to amend RioLuz’s bylaws. According to article 37, XIX, of the Federal Constitution, the incorporation of any state-owned company must be preceded by legal authorization. The law shall define the basic characteristics of the company to be incorporated, including its corporate purposes. Hence, to enlarge a state-owned company’s legal attributes, the law authorizing its incorporation will have to be amended.

With regard to the financing of the project, the municipality could consider using FEIP funds to increase the capital of RioLuz up to the amount needed to pay for the EE project. This could be challenged on the basis that, because COSIP’s legal status is that of a contribution, rather than a tax, it cannot be charged to private entities within the Public Administration (which is the case of RioLuz). However, arguments could be built to support the case since the use of COSIP would not deviate from its intended purpose; rather, it would be used precisely to improve public lighting. In addition, RioLuz does not have private shareholders, being 100 percent owned by the municipality of Rio de Janeiro.

Finally, RioLuz could become a partner of the SPE formed by the consortium winning the public procurement process launched by the municipal government. 28 The stake to be retained by RioLuz, as well as whether it would be entitled to participate in management boards would be decided by the municipal government ex ante. It is also likely that an amendment to the local law that authorized the incorporation of RioLuz would be required.

In terms of the implementation plan of the project, RioLuz has proposed to divide the city into two parts and, potentially, to grant two separate concessions. The first concession, comprising about 90,000 street lights, 29 could be granted soon. RioLuz understands that the remaining concession would require a thorough retrofit to bury the cabling infrastructure and install new dedicated poles. This should be further explored as the process moves forward.

28 There is a precedent in airport concessions. The concession to operate public airports in Brazil has required INFRAERO, the federal state-owned company, to retain 49 percent of the SPE formed by the winning bidders. These are not PPPs, however; they are typical concession agreements (that is, no payments to the concessionaire are due by the conceding power and revenues are collected from users).

29 Based on recent discussions, the authors understand that this would encompass an area stretching from the Santos Dumont Airport to Barra da Tijuca.
E. Regulating the Street Lighting Business

In the event that Rio de Janeiro – or other cities in Brazil – opts to implement a PPP for its public street lighting assets, it is important to recall that there is no existing regulatory body in charge of supervising and monitoring the issuance of public street lighting concessions in Brazil. Considering that the responsibility for ownership and management of public street lighting will be transferred from utilities to all municipalities by December 2014 (see section V.B.1), ANEEL will no longer have jurisdiction over the provision and regulation of the street lighting business.

Establishing a concession includes a number of complex steps, including preparing the legal agreements, setting adequate rate levels based on revenue requirements (potentially linked to COSIP), establishing rules to share efficiency gains, monitoring performance, and renegotiating concession terms, among other things. This work will require a lot of regulatory capacity, which is currently lacking for many cities in Brazil. In light of this vacuum, it will be important for regulatory norms and capacity to be developed to ensure that sustainable contracts are put in place.

There are a number of key issues that will need to be taken into account. For example, the terms of the concession agreement should provide aligned incentives for the operator to invest aggressively in street lighting modernization and capture the benefits of energy and operational efficiency. Cities will also need to investigate whether they can effectively ring fence COSIP revenues to make payments to the concessionaire. Cities will also need to determine the best approach to determine the level of payments received by the concessionaire (that is, cost plus or revenue cap), particularly in the event that exogenous factors, including electricity prices, affects the total expenditures for public street lighting. These details should be dealt with at the outset, before a concession is granted. A renegotiation process, or even an extraordinary rate review, can be time-consuming and potentially disruptive.

To overcome these challenges, many lessons can be learned from years of experience in the power sector, particularly from the experience of privatization of the electricity distribution business. This issue is worthy of study as a follow-up to this report.
VI. Financial and Economic Analysis

This section of the report provides a financial and economic analysis of the LED street lighting project as defined in section IV, Technical Fundaments. The report first reviews all of the key assumptions used in the model to estimate the economic and financial returns from this project. Next, the results of the financial and economic analysis are presented, including a sensitivity analysis under various pricing and savings scenarios. Finally, the report analyzes whether it makes sense for the city to implement the project now or wait another few years for LED prices to drop further.

A. Assumptions

The following provides a summary of all the key assumptions used in the financial and economic analysis presented in the subsequent sections. Please note that this study forecasts all costs in real terms, that is, net of inflation.

1. Baseline and project inventory

One of the most important drivers of the financial and economic analysis is the baseline. A technical study was conducted to identify the current public street lighting inventory of the city as well as any imminent plans to make changes to this inventory. Section IV.A (table 4.1) shows Rio de Janeiro’s public street lighting inventory. However, as also mentioned previously, discussions with RioLuz indicate that it is currently replacing all remaining mercury vapor lamps with HPS lamps using previously allocated funding from PROCEL/RELUZ. This replacement is expected to be completed by the end of 2014. Thus, RioLuz assumes that by the time an LED street lighting project would begin, there would be no remaining mercury vapor lamps. Table 6.1 below shows the expected future inventory of street lighting in Rio de Janeiro. This expected inventory forms the basis of the baseline for the purpose of the financial and economic analysis.
Before total electricity usage can be calculated, it is necessary to define the average number of hours that public street lighting is used per day. As discussed in section V.B.2, the standard assumption for hours of street lighting usage per day in Rio de Janeiro is 11.5 hours/day.

The project scenario is developed by establishing the equivalent wattage needed for LEDs in order to produce the same lumen output of the baseline scenario in 6.1 above. This evaluation was done for each of the lamps. To simplify the presentation, 6.2 below shows the existing weighted average wattage and the equivalent weighted average LED wattage. Based on these figures, the estimated overall electricity savings potential is 50 percent. The full detail of the equivalent wattage for all existing technologies and rated wattages can be found in appendix F.

Table 6.2 Equivalent Weighted Average LED Wattage

<table>
<thead>
<tr>
<th>Fixture type</th>
<th>Weighted average wattage of existing technology (W)</th>
<th>Weighted average wattage of LEDs (W)</th>
<th>Estimated replacement efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>HPS</td>
<td>221</td>
<td>114</td>
<td>48%</td>
</tr>
<tr>
<td>Metal halide</td>
<td>284</td>
<td>110</td>
<td>61%</td>
</tr>
<tr>
<td>Other</td>
<td>160</td>
<td>40</td>
<td>75%</td>
</tr>
<tr>
<td><strong>All</strong></td>
<td><strong>222</strong></td>
<td><strong>111</strong></td>
<td><strong>50%</strong></td>
</tr>
</tbody>
</table>
2. Price

Price is the single most important assumption used in this analysis. The weighted average price of existing technology was derived based on the technology distribution shown in table 4.1 above and a survey of existing lamps available in the Brazilian market. For the purposes of this study, the weighted average price is determined to be R$ 322/lamp – see table 6.3 below (appendix G contains full pricing details).

Table 6.3 Weighted Average Price of Existing Technology

<table>
<thead>
<tr>
<th>Fixture type</th>
<th>Weighted average retail price</th>
</tr>
</thead>
<tbody>
<tr>
<td>HPS</td>
<td>R$1,893</td>
</tr>
<tr>
<td>Metal halide</td>
<td>R$2,230</td>
</tr>
<tr>
<td>Other</td>
<td>R$1,080</td>
</tr>
</tbody>
</table>

To determine a reasonable price range under the project scenario, research was conducted on prices recently paid for LED programs around the world and interviews were conducted with Brazilian branches of international manufacturers.

a. International Precedents

Research was conducted on international prices of LEDs in order to give a perspective on the potential prices that could be obtained in Brazil over time. Although international pricing of LEDs is not directly indicative of the pricing of LEDs in Brazil, owing to import taxes and lack of local manufacturing, these international examples still provide a useful benchmark against which the domestic pricing estimates in the following section can be compared. Prices paid for LEDs in recent projects developed in the United States, China, and Mexico range from US$ 250-500 per point (equivalent to R$ 575-1,150, according to April 2014 exchange rates). See appendix H for more detail.

b. Domestic Due Diligence

Interviews were conducted with four manufacturers in late 2013 to estimate the weighted average LED price for the expected inventory described in table 3.1. As table 6.4 below shows, the estimated weighted average retail cost of an LED for public street lighting in Rio de Janeiro is approximately R$ 1,900. Smart systems are expected to add an additional cost of approximately R$ 450/lamp. Thus, inclusive of smart system technology, the total cost per point is estimated to be R$ 2,350/lamp. Aside from the additional cost per point, smart systems also entail a fixed cost, up-front investment of R$ 100,000 for the software and control center (this fixed cost is accounted as a separate line item under capital expenditure, not as part of the cost per point).

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30 Interviews were conducted with GE, InsightLight, Philips, and Aalok (DZM Industria e Comercio).
There are a number of presumed reasons for the difference between the international prices and the Brazilian retail prices listed above. First, the domestic content for LEDs is very small, resulting in total taxes of about 75 percent, or twice as much as the taxes charged on high pressure sodium manufactured locally. In addition, the prices given above do not take into account potential economies of scale from bulk procurement that were priced into the international prices quoted.

c. Estimated Price Decline

Prices of LEDs are falling quickly for an equivalent lumen per watt. Interviews with experts indicate that prices are falling at a rate of 8–10 percent per annum; studies forecast price declines of up to 16 percent per annum.\footnote{Foote, J, & Woods, E. (4Q 2014). “Smart Street Lighting: LEDs, Communications Equipment, and Network Management Software for Public Outdoor Lighting: Market Analysis and Forecasts.”: Pike Research. Retrieved March 2014 from \url{http://www.navigantresearch.com/research/smart-street-lighting}.} To be conservative, this analysis assumes a price decline of 10 percent per year for the next 10 years, after which prices will plateau.

d. Pricing Scenarios

Given the importance of price to the analysis of this project, the present study analyzes four different pricing scenarios. The first three scenarios are conducted for the financial analysis – base case, low price, and high price. Finally, the study uses the economic price of LEDs (that is, net of taxes) when calculating the economic return of the project. All adjustments to price are based on the prices quoted in the Domestic Due Diligence section above (that is, R$ 1,900 for LED only and R$ 2,350 for LED plus smart system).

Before delving into the analysis, it is important to point out that the City of Rio de Janeiro will only be able to truly ascertain the likely price it will pay for LEDs after it launches a competitive bidding process. This is particularly true because there is still significant uncertainty regarding the annual price decline of LEDs, the potential discount that can be captured owing to bulk procurement and competition, and the potential for local manufacturing. Thus, the figures presented in this study are based on a significant amount of due diligence but should be considered as indicative owing to the large number of unknown variables in a market in a state of flux.

e. Financial assumptions

To determine the price used in the financial analysis, three key variables were assessed: (a) potential discount from retail prices resulting from bulk procurement; (b) expected percentage of equipment that will need to be imported; and (c) expected annual decline in LED prices over the life of the project.

\begin{table}[h]
\centering
\begin{tabular}{|l|c|}
\hline
Fixture type & LED weighted average retail price \\
\hline
Total LED & R$ 1,882 \\
Total LED plus smart system & R$ 2,232 \\
\hline
\end{tabular}
\caption{LED Weighted Average Price}
\end{table}
In the base case, this study assumes that the price at time of purchase will be approximately R$ 1,200.\(^{32}\) Incorporating the cost of smart system technology, the final price is estimated to be R$ 1,550. This assumes Rio de Janeiro can negotiate a 20 percent price decrease in the price of LEDs shown in table 6.4 above.\(^{33}\) The base case also assumes that 100 percent of the LED equipment will be imported and thus subject to imported goods tax rates of 75 percent. The base case also assumes that prices will fall by 10 percent per year, and that the first LEDs will not be purchased until 2015 (two years later than 2013, for which the prices are quoted above).

In the low price scenario, the assumed prices are R$ 1,000 for LEDs only and R$ 1,300 for LEDs plus smart systems. This assumes the city can negotiate a 20 percent discount and that prices will decline by 10 percent per year. In addition, the low price scenario assumes that domestic manufacturing sites open in Brazil and competition among domestic manufacturers takes place.\(^{34}\) In this case, 50 percent of the LED equipment is domestically manufactured and, as a result, the effective tax rate decreases to 60 percent.\(^{35}\)

In the high price scenario, the study assumes that the reduction for bulk purchase is only 10 percent of the retail price. All other assumptions remain the same as in the base case scenario. As a result, the high price scenario assumes a price of R$ 1,400 with LEDs only and R$ 1,700 for LEDs plus smart systems.

The study assumes that smart system technology will be used in all scenarios, except when explicitly indicated otherwise.

f. Economic Assumptions

For the economic analysis, the study uses the same assumptions as for the base case scenario, excluding all taxes (import and domestic) from the price of LEDs. In this case, the estimated prices are R$ 700 for LEDs only and R$ 900 for LEDs plus smart systems.

3. Administration, Operation and Maintenance costs

The current administration, operation and maintenance costs have been derived based on interviews with RioLuz and expert opinions from the technical consultants hired for this study. Interviews with RioLuz indicate that current annual expenditures on O&M services is approximately R$ 60 million per year.\(^{36}\)

\(^{32}\) \$1200 = $1900 * (1 - 0.2) * (1 - 0.1)^2. \\
\(^{33}\) This is based on economies of scale from bulk procurement and the expectation that there will be significant competition among LED manufacturers to win a citywide LED contract in the City of Rio de Janeiro. \\
\(^{34}\) This scenario is based on interviews with leading international manufacturers who have indicated they would be willing to build a domestic manufacturing plant in Brazil if they were to win a contract on a scale of 100,000 points of light or above. \\
\(^{35}\) The tax on domestically manufactured goods is 45.75 percent. \\
\(^{36}\) To be confirmed.
The study assumes that approximately 75 percent of these costs involve O&M work and 25 percent involve operational costs (including administrative costs). Based on the existing total inventory of approximately 425,000 points of light, this is equivalent to maintenance costs of R$ 105 per point and operational/administrative costs of R$ 35 per point, totaling about R$ 140 per point per year.

4. Cost of Electricity

Cost of electricity is an important parameter that has an impact on the feasibility of the project. As with LED prices, there are several degrees of uncertainty concerning the future of retail electricity prices, in particular electricity prices for street lighting.

As of April 2014, the electricity rate for public street lighting in Rio de Janeiro is R$ 0.23832 per kWh. This includes a base electricity rate of R$ 0.1578 and taxes of R$ 0.08052. For the purposes of this analysis, the main driver of the estimated future price of electricity is the annual increase (or decrease) of electricity prices over the life of the project.

Before delving into the assumptions on price, it is important to describe a phenomenon now taking place in the electricity sector. Starting in 2013, and continuing into 2014, generation costs (fuel) for the electricity sector have increased substantially. The Federal government has opted not to immediately increase retail electricity prices to take account of the higher generation costs. To soften the impact on consumers, the Federal government is expected to absorb some of the costs (presumably to be recovered from taxpayers) and to defer the increase in rates until 2015.

After accounting for estimated subsidies from the Federal government of R$ 18 billion, the revenue shortfall in the electricity sector in 2013 and 2014 is estimated to range from R$ 22 to R$ 34 billion. Additionally, the regular rate review mechanism is expected to result in an annual revenue increase of R$ 11-17 billion. As a result, revenues in the Brazilian electricity sector are expected to increase over the coming years to recover a total sector revenue shortfall of R$ 33-51 billion, which corresponds roughly to an equivalent rate increase of 33-51 percent in one year (see appendix I for more information).

Even in light of the significant revenue shortfall in the Brazilian electricity market today, a one-time increase of that magnitude is unlikely to take place for political and economic reasons. Thus, for the purpose of this study, the model assumes that the increase in rates will be spread over a five-year period.

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37 The primary driver of increased generation costs was the decline in production from hydroelectric plants, whose production was negatively affected by lower than average rainfall and high temperatures in 2013-14.
39 Ibid.
a. Financial Assumptions

For the purposes of the financial analysis, the study assumes that the price at the start of the project is equivalent to 2014 prices (R$ 0.23832 per kWh).

The base case assumption is that electricity rates will increase at an annualized rate of 4 percent over the 15-year period of this project. This assumes that the total increase in revenues for the power sector will be R$ 58 billion and, after deducting the R$ 18 billion subsidies from the Federal government, the revenue increase passed on through higher rates for electricity consumers will be R$ 40 billion.

The low price scenario assumes an annualized increase in electricity rates of 3 percent over a 15-year period. This assumes that the total increase in revenues for the power sector will be R$ 51 billion and, after deducting the R$ 18 billion subsidies from the Federal government, the revenue increase passed on through rates to electricity consumers will be R$ 33 billion.

Finally, the financial analysis considers a high price scenario, assuming an annualized increase of 5.5 percent over a 15-year period. This assumes that the total increase in revenues for the power sector will be R$ 69 billion and, after deducting the R$ 18 billion subsidies from the Federal government, the revenue increase passed on through higher rates for electricity consumers will be R$ 51 billion.

It is also assumed that the COSIP proceeds will be able to fund the project. If there is a shortfall (owing, for example, to a rationing program in Brazil and a sudden decrease in COSIP revenues), public funds will be allocated to offset it.

b. Economic Assumptions

Rates for public street lighting are significantly lower than those for equivalent voltage levels for nonresidential customers (R$ 0.46670 per kWh, or about 50 percent of the “full rate.”) However, and in contrast to subsidies for low-income customers, there are no legal or regulatory mechanisms that support such a price differential. For the purpose of the economic analysis, this study assumes no taxes

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40 This assumes electricity rates will increase by 7 percent per year over the next five years to reflect the pricing of deferred costs from 2013-14. After five years, the real price increase will be 2 percent per year, with the exception of years 10 and 11, in which real prices will increase by 5 percent each year. This second increase is included on the assumption that electricity prices are likely to increase at least one more time over a 15-year period.

41 This assumes electricity rates will increase by 5.9 percent per year over the next five years. After five years, the real price increase will decrease to 2 percent per year, with the exception of years 10 and 11, in which the analysis assumes no real change (zero percent) in electricity prices.

42 This assumes electricity rates will increase by 8.6 percent per year over the next five years. After five years, the real price will increase by 2 percent per year, with the exception of years 10 and 11, in which the analysis assumes a real price increase of 12 percent each year.

43 It is understood that this comparison is indicative, as commercial costs for street lighting are significantly lower. At any rate, the difference demonstrates an order of magnitude of the embedded subsidies for street lighting.

44 Interview with ANEEL, December 2013.
are levied on electricity and all subsidies are eliminated.\textsuperscript{45} This corresponds to the nonresidential low-voltage customer category as of April 2014, equal to R$ 0.30902 per kWh.\textsuperscript{46}

5. LED Lifetime

LEDs have a significantly longer life expectancy than that of the lamps currently installed in Rio de Janeiro. Table 6.5 below compares the expected lifetime of the existing inventory and LEDs. Even without smart systems, LEDs are expected to last more than four years (50 percent) longer than the best currently installed technology.\textsuperscript{47}

Smart systems can affect the expected lifetime of the equipment because they are typically used to dim the power of the lamps during dawn and dusk hours of operation. The technical study indicated that dimming of 30 percent for five hours per day would be nearly imperceptible to citizens and would allow the city to optimize its electricity usage by using the lamps at full power only during the darkest hours of the night. Based on these assumptions, the inclusion of smart system technology would extend the expected life of an LED from 50,000 hours (11.9 years) to 55,000 hours (13.1 years).

<table>
<thead>
<tr>
<th>Fixture type</th>
<th>Average life (hours)</th>
<th>Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>HPS</td>
<td>32,000</td>
<td>7.6</td>
</tr>
<tr>
<td>Tubular HPS</td>
<td>32,000</td>
<td>7.6</td>
</tr>
<tr>
<td>Metal halide</td>
<td>20,000</td>
<td>4.8</td>
</tr>
<tr>
<td>Mercury vapor</td>
<td>24,000</td>
<td>5.7</td>
</tr>
<tr>
<td>Other</td>
<td>4,000</td>
<td>1.0</td>
</tr>
<tr>
<td>LED</td>
<td>50,000</td>
<td>11.9</td>
</tr>
<tr>
<td>LED lifetime with control system</td>
<td>55,000</td>
<td>13.1</td>
</tr>
</tbody>
</table>

6. Discount rate

The nominal weighted average cost of capital used for this study is 12.1 percent. This assumes a nominal cost of debt of 10 percent, a nominal cost of equity of 17 percent, and a debt-to-equity ratio of 70:30. These figures were determined on the assumption that the project would be financed using capital markets and are based on interviews with Brazilian capital market experts. Of course, the actual WACC

\textsuperscript{45} Taxes on electricity currently include ICMS, PIS, and COFINS.
\textsuperscript{46} Light Rio de Janeiro. Rate Schedule, April 2014.
\textsuperscript{47} It is important to note that many manufacturers now sell LEDs with an advertised average life of 100,000 hours (nearly 24 years), double the assumption used below. The assumption of 50,000 hours was selected for this study on the basis that there is little evidence of the ability of LEDs to last 100,000 hours, and that one of the mechanisms that manufacturers use to extend the life of LEDs is to reduce the current supplied to the lamp during dimming periods and/or to increase the current toward the end of the lamp’s life to compensate for the depreciation factor. Thus, the assumption of 50,000 hours is deemed to be conservative, and is in line with the estimated prices described in the preceding section.
for the City of Rio de Janeiro will depend on the financing model ultimately selected. For example, if the city chooses to use municipal finance to fund the project, the cost of capital would decrease, as equity would no longer be required. The same is true if the city opted to finance the project using only loans from local or international development organizations. Thus, the WACC used for this model can serve as an indicative figure, assuming that the project is financed in capital markets.

In order to simplify the model, all future prices are shown in real terms and, therefore, the real WACC (net of inflation) is used as the discount rate. The analysis assumes a current inflation rate of 6 percent in Brazil. The real WACC is therefore assumed to be 6.1 percent.

B. Financial Analysis

The following section of the report provides the bases for all the key assumptions used in the financial and economic analyses presented in the subsequent sections. Please note that this study forecasts all costs in real terms, that is, net of inflation.

1. Base Case

   a. Investment

Based on the base case assumptions outlined in the pricing section above, the total expected investment for this project is approximately R$ 420 million over a five-year period, from 2015 to 2019 (see table 6.6 below). Although the number of LEDs procured in every year is forecast to be constant (around 65,000 per year), the price of LEDs is expected to decline every year; thus, the capital expenditure also declines every year. Note that these figures include the cost of LED equipment, smart system equipment, as well as installation labor costs.

Table 6.6 Capital Expenditures

<table>
<thead>
<tr>
<th>Period</th>
<th>Units</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>End date of period</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual No. of LEDs bulbs procured</td>
<td>n</td>
<td>818,758</td>
</tr>
<tr>
<td>Cumulative % bulbs replaced by LEDs</td>
<td>%</td>
<td>10%</td>
</tr>
<tr>
<td>LED equipment costs</td>
<td>R$/fixture</td>
<td>1,500</td>
</tr>
<tr>
<td>Installation costs</td>
<td>R$/fixture</td>
<td>100</td>
</tr>
<tr>
<td>Smart system overhead costs</td>
<td>R$</td>
<td>100,000</td>
</tr>
<tr>
<td>Capital expenditure</td>
<td>R$</td>
<td>(423,346,020)</td>
</tr>
</tbody>
</table>

b. Electricity Savings

In the base case scenario, this study estimates a potential savings of 57 percent with the installation of LEDs in tandem with smart systems. This translates into savings of approximately 170 GWh per year
once the project is fully implemented (that is, after five years).\textsuperscript{48} Over a 15-year period, the project is expected to save approximately 2,200 GWh of electricity for the city.

Using the base case assumption for electricity pricing of R$ 0.23832/kWh (R$ 238/MWh), a real price increase of 4 percent per year (net of inflation) and a price of R$ 1,500 for LEDs plus smart systems, this results in net financial savings (non-discounted) of approximately R$ 400 million for the city over a 15-year period. Without smart system technology, the savings would be 50 percent, equivalent to approximately 2,000 GWh and R$ 350 million over 15 years. Smart systems increase the savings potential owing to the ability of the city to dim LEDs during dawn and dusk hours.

Figure 6.1 below demonstrates the electricity savings potential of the project with LEDs only and with LEDs plus smart system technology in the base case scenario.

\textsuperscript{48}Assuming the baseline electricity usage for public street lighting in Rio de Janeiro is approximately 400 GWh per year (assumes complete replacement of existing mercury vapor lamps with HPS lamps) and 75 percent of the existing public street lighting inventory is replaced with LEDs, the baseline for this project is approximately 300 GWh.
c. O&M savings

The implementation of an LED street lighting project not only offers savings on electricity, but also offers reduced expenditures for operations and maintenance of the public street lighting system. There are two key drivers of the potential savings on O&M: the longer lifetime of an LED and the use of smart system technology to centralize the monitoring and control of the street lighting system. Figure 6.2 below shows the potential O&M savings after installing LEDs and LEDs with smart systems.

Without including smart system technology, the study forecasts an average annual savings of R$ 10 million and total savings of R$ 64 million (20 percent) over 15 years with LEDs only. This accounts for the impact of increased equipment costs with a decrease in administrative and maintenance costs. Including smart system technology, the study forecasts an average annual savings of R$ 11 million and total savings of R$ 105 million (33 percent) over 15 years with LEDs and smart systems. This includes the impact of increased project costs from the additional capital expenditures with the decrease in administrative and maintenance costs that can materialize when using the smart system technology. See appendix J for more details on the assumptions used to calculate O&M savings with and without smart system technology.

Owing to the higher replacement cost of the lamps, the savings narrow as the end of the average lifecycle of the LEDs approaches. Despite this narrowing, the installation of LEDs and smart system technology clearly offers significant potential for O&M savings. It is important to highlight that this analysis assumes flexibility of the labor force. If the City of Rio de Janeiro is not able to capture the potential labor efficiencies that result from installation of LEDs, the actual O&M savings will be smaller, or, potentially, even negative.

Figure 6.2 Estimated Cumulative O&M Expenses
d. Financial Metrics (Net Present Value, Financial Internal Rate of Return and Payback Period)

The following financial metrics relate to the base case scenario for LED and electricity prices described above, assuming the inclusion of smart system technology. The subsequent section (Scenario Analysis) provides a range of potential results by conducting sensitivity analysis on the key assumptions of the model.

Table 6.7 below summarizes the key assumptions and financial results of the base case analysis. The NPV over a 15 year period is approximately R$ 150 million. The FIRR is 14 percent, compared with a WACC of 6 percent (both figures quoted net of inflation). The ROI is nearly 100 percent.

Table 6.7 Base Case Assumptions and Results

<table>
<thead>
<tr>
<th>Summary of assumptions</th>
<th>Financial analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total luminaires in Rio</td>
<td>424,977</td>
</tr>
<tr>
<td>% luminaires replaced in project</td>
<td>75%</td>
</tr>
<tr>
<td>Total luminaires replaced in project</td>
<td>318,733</td>
</tr>
<tr>
<td>Years to fully implement</td>
<td>5</td>
</tr>
<tr>
<td>Cost per luminaire (R$)</td>
<td>1,500</td>
</tr>
<tr>
<td>Use of smart system technology (Y/N)</td>
<td>Y</td>
</tr>
<tr>
<td>Cost of electricity in year 1 (R$/MWh)</td>
<td>238</td>
</tr>
<tr>
<td>Real annual increase in electricity rate</td>
<td>4%</td>
</tr>
<tr>
<td>% savings on electricity bill</td>
<td>57%</td>
</tr>
<tr>
<td>% savings on O&amp;M</td>
<td>35%</td>
</tr>
<tr>
<td>WACC (net of inflation)</td>
<td>6%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Estimated project results</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total project investment over 15 years (R$, millions)</td>
<td>420</td>
</tr>
<tr>
<td>Total financial savings (electricity + O&amp;M) over 15 years (R$, millions)</td>
<td>830</td>
</tr>
<tr>
<td>Total greenhouse gas reductions up to 2020 (tCO2e)</td>
<td>300,000</td>
</tr>
<tr>
<td>Total electricity savings over 15 years (GWh)</td>
<td>2,200</td>
</tr>
<tr>
<td>Payback period (years, non-discounted)</td>
<td>8.5</td>
</tr>
<tr>
<td>ROI</td>
<td>98%</td>
</tr>
<tr>
<td>NPV over 15 years (R$, millions)</td>
<td>149</td>
</tr>
<tr>
<td>IRR</td>
<td>14%</td>
</tr>
</tbody>
</table>

Figure 6.3 shows the estimated cumulative net income over the life of the project and shows the estimated payback period of 8.5 years (non-discounted).
2. Scenario Analysis

To provide a more thorough analysis of the potential financial profile of a citywide LED street lighting project in Brazil, this section conducts a sensitivity analysis around seven different scenarios. Table 6.8 below provides an overview of the key assumptions used in these scenarios and the differing financial results on that basis.

Table 6.8. Scenario Analysis

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Total luminaires in Rio</td>
<td>424,977</td>
<td>424,977</td>
<td>424,977</td>
<td>424,977</td>
<td>424,977</td>
<td>424,977</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% luminaires replaced in project</td>
<td>75%</td>
<td>75%</td>
<td>75%</td>
<td>75%</td>
<td>75%</td>
<td>75%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total luminaires replaced in project</td>
<td>318,733</td>
<td>318,733</td>
<td>318,733</td>
<td>318,733</td>
<td>318,733</td>
<td>318,733</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Years to fully implement</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost per luminaire (R$)</td>
<td>1,500</td>
<td>1,200</td>
<td>1,350</td>
<td>1,700</td>
<td>1,500</td>
<td>1,500</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost of electricity in year 1 (R$/kWh)</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Real annual increase in electricity rate</td>
<td>4%</td>
<td>4%</td>
<td>4%</td>
<td>4%</td>
<td>3%</td>
<td>3%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% savings on electricity bill</td>
<td>57%</td>
<td>57%</td>
<td>57%</td>
<td>57%</td>
<td>57%</td>
<td>45%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% savings on O&amp;M</td>
<td>33%</td>
<td>35%</td>
<td>31%</td>
<td>33%</td>
<td>33%</td>
<td>22%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WACC (net of inflation)</td>
<td>8%</td>
<td>6%</td>
<td>6%</td>
<td>6%</td>
<td>6%</td>
<td>6%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The details of the seven scenarios are given below.
• **Scenario 1: No smart system.** This scenario maintains the base case assumptions with the exception of excluding the cost and savings potential of smart systems. As is shown in the table above, this means a cost of R$ 1,200 per point of light, electricity savings of 50 percent and savings on O&M of 20 percent. Notably, the financial profile of the project improves without smart systems. The payback period decreases to 8.1 years, the NPV increases to approximately R$ 215 million and the FIRR increases to 21 percent. This is because, based on the current pricing assumptions, the additional price of smart systems is greater than the additional financial savings they bring to the project. However, this does not take into account other economic or social benefits that smart system technology will bring, including enabling the city to adjust street lighting in the event of a power crisis and to respond quickly to lamp underperformance or vandalism. It also does not take into account the fact that the LED smart system technology can be used as infrastructure to support other smart systems in the city, including systems that can be used by police to monitor events and improve safety. Thus, evaluation by financial analysis alone may not be a sufficient basis for the City of Rio de Janeiro to evaluate the cost and benefit of smart system inclusion in the project.

• **Scenario 2: Lower LED cost.** This scenario assumes that domestic manufacturing and competition take place in Brazil. As explained in the pricing assumptions section, this would imply that 50 percent of the materials are domestically manufactured, thereby decreasing the effective tax rate to 60 percent and the price of LEDs plus smart system technology to R$ 1,300 (compared with R$ 1,500 with no domestic manufacturing). All other assumptions remain equal to those of the base case. In the lower cost LED scenario, the payback period decreases to 7.7 years, the NPV increases to nearly R$ 200 million and the FIRR is 18 percent. This is the most financially profitable scenario of all seven scenarios analyzed.

• **Scenario 3: Higher LED cost.** As explained in the pricing assumptions section, this scenario assumes that the city is not able to achieve significant discounts from bulk procurement and competition and that the LED price decline is slower than envisioned in the base case scenario. The resulting price is R$ 1,700 per LED including smart system technology. In the higher LED cost scenario, the payback period extends to 9.2 years, the NPV decreases to approximately R$ 100 million and the FIRR decreases to 11 percent. Despite this, it is worth pointing out that this scenario will likely be attractive as it allows the city to improve its provision of public street lighting services and still obtain significant savings for the city, and the nondiscounted payback period is shorter than the lifecycle of the equipment (13.1 years with smart system technology).

• **Scenario 4: Lower electricity prices.** This scenario assumes a real electricity price increase of 3 percent per year, rather than the base case assumption of 4 percent (see cost of electricity assumptions in section VI.A.4 for more details). In this scenario, the financial returns of the project decrease compared with the base case, as the monetary value of the electricity saved by the project is lower. In this case, the payback period increases slightly to 8.7 years, the NPV decreases to approximately R$ 120 million, and the FIRR decreases to 13 percent. Although the financial profile is less attractive in this scenario, the sensitivity analysis demonstrates that the returns are not highly sensitive to moderate fluctuations in the electricity price.

• **Scenario 5: Higher electricity prices.** This scenario assumes a real electricity price increase of 5.5 percent per year (see cost of electricity assumptions in section VI.A.4 for more details).
Compared to the base case, in this scenario the payback period decreases slightly to 8.2 years, the NPV increases to approximately R$ 200 million and the FIRR increases to 16 percent.

- **Scenario 6: Lower savings.** This scenario assumes that the savings on electricity is 45 percent rather than 57 percent, as assumed in the base case analysis. The scenario also assumes that the O&M savings decrease from 33 percent to 22 percent. As a result, the payback period increases to 10 years, the NPV decreases to R$ 40 million and the FIRR decreases to 8 percent. This is the least financially profitable scenario of the seven scenarios. However, similar to the high LED price scenario (scenario 3), this scenario could still be attractive for the city since it allows for improved provision of services with a positive (albeit smaller) financial benefit.

- **Scenario 7: Higher savings.** This scenario assumes that the savings on electricity is 70 percent rather than 57 percent, as assumed in the base case analysis. The scenario also assumes that the O&M savings increase from 33 percent to 38 percent. As a result, the payback period decreases to 7.5 years, the NPV increases to approximately R$ 250 million and the FIRR increases to 19 percent. This is the most financially profitable scenario of the seven scenarios. Given that the inventory assumptions are conservative inasmuch as they assume all mercury vapor lamps will be replaced by HPS lamps before the start of the project, it is not unreasonable that the savings could be higher than assumed in the base case.

### 3. Break-even analysis

While these scenario analyses are useful, the City of Rio de Janeiro may also wish to know the thresholds that the project needs to meet if it is to be financially viable. In other words, it is worthwhile to identify the break-even point for the key variables analyzed above: LED price, expected average electricity rate change per year, and savings for electricity and O&M. Assuming all other assumptions are held equivalent to the base case, the break-even analysis in table 6.9 below shows the point for the specified variable at which the project will no longer have a positive financial return.

**Table 6.9 Break-Even Analysis**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Break-even point</th>
</tr>
</thead>
<tbody>
<tr>
<td>LED price</td>
<td>R$ 2,150</td>
</tr>
<tr>
<td>Average electricity price change per year</td>
<td>-2%</td>
</tr>
<tr>
<td>Savings (electricity, O&amp;M)</td>
<td>40%, 15%</td>
</tr>
</tbody>
</table>

This analysis shows that, assuming all variables except price remain unchanged compared with the base case, the City of Rio de Janeiro needs to secure a contract for LEDs plus smart systems with a price of R$ 2,150 per lamp in the first year of procurement in order for the project to be financially viable. Although there is little transparency at this time regarding the potential price that Rio de Janeiro can obtain for LEDs, all evidence – both international and domestic – indicates that the city can readily sign a contract for below this break-even price.
The break-even point for the change in electricity prices is (-2)2 percent, meaning that there would need to be an annualized price decline of greater than 2 percent over the next 15 years for the project to no longer be financially viable. Again, it is beyond the scope of this exercise to undertake a detailed forecast of future energy prices in Brazil. Nonetheless, in light of the current situation in the electricity market in Brazil today and conspicuous anomalies in prices, a real decrease in electricity prices over the next 15 years seems to be unlikely.

Lastly, if the savings on electricity were to decrease to 40 percent and at the same time the O&M savings decrease to 15 percent, the project would no longer be financially viable. Given that the study already assumes a conservative baseline for electricity consumption, it is unlikely that the savings would be so much below expectations. If, however, this was to take place and the lower savings were due to LED performance, the city could seek reimbursement from the manufacturer, provided the city obtains a solid warranty for product performance. As previously described, achieving substantial O&M savings will require a decrease in the labor force performing O&M on public street lighting. Given that a reduction in the labor force can be challenging and slow, the risk of lower O&M savings is non-negligible. In order to avoid this risk, the city should ensure that it selects an implementation model that allows for maximum O&M efficiency.

Of course, the reality of a citywide LED street lighting project in Rio de Janeiro will not fit perfectly into any of the scenarios analyzed above. Nonetheless, this analysis can give decision makers an idea of how sensitive the financial viability of the project is to some key variables. It can also give decision makers a range of possible outcomes to consider. Based on the scenario analysis shown above, the financial profile of this project appears robust under a variety of potential scenarios.

4. Economic Analysis

The economic analysis for this project is limited to the removal of subsidies and taxes on LED equipment, labor for equipment installation, and the cost of electricity. As described in the assumptions discussed above in section VI.A, the economic analysis assumes that the economic cost of LEDs is equal to the base case cost of LEDs, less import and domestic taxes. However, since the base case assumes that 100 percent of the equipment will be imported, the import tax rate is used to calculate the cost of LEDs with no taxes. Thus, assuming a base cost of R$ 1,200 and the removal of import duties of 75 percent, the tax-free price of LEDs including smart systems is estimated to be R$ 900. To estimate the economic cost of electricity, existing subsidies and taxes for public street lighting are removed. The result is an increase in the economic cost of electricity from R$ 238/MWh to R$ 309/MWh.

These three factors are combined to estimate the economic return from this project in a base case economic scenario. The result is a significantly shorter payback period of 5.2 years, a much higher NPV of approximately R$ 430 million and an FIRR of 45 percent. Table 6.10 below summarizes the result of the economic analysis compared to the base case financial analysis. This analysis provides useful information for the City of Rio de Janeiro, as the project should be evaluated not solely on the basis of its potential financial return but also on the basis of the economic value it can add to the city.
Table 6.10 Economic Analysis

<table>
<thead>
<tr>
<th>Summary of assumptions</th>
<th>Economic analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total luminaires in Rio</td>
<td>424,977</td>
</tr>
<tr>
<td>% luminaires replaced in project</td>
<td>75%</td>
</tr>
<tr>
<td>Total luminaires replaced in project</td>
<td>318,733</td>
</tr>
<tr>
<td>Years to fully implement</td>
<td>5</td>
</tr>
<tr>
<td>Cost per luminaire (R$)</td>
<td>900</td>
</tr>
<tr>
<td>Use of smart system technology (Y/N)</td>
<td>Y</td>
</tr>
<tr>
<td>Cost of electricity in year 1 (R$/MWh)</td>
<td>305</td>
</tr>
<tr>
<td>Real annual increase in electricity rate</td>
<td>4%</td>
</tr>
<tr>
<td>% savings on electricity bill</td>
<td>57%</td>
</tr>
<tr>
<td>% savings on O&amp;M</td>
<td>38%</td>
</tr>
<tr>
<td>WACC (net of inflation)</td>
<td>6%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Estimated project results</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total project investment over 15 years (R$, millions)</td>
<td>250</td>
</tr>
<tr>
<td>Total financial savings (electricity + O&amp;M) over 15 years (R$, millions)</td>
<td>1,660</td>
</tr>
<tr>
<td>Total greenhouse gas reductions up to 2020 (tCO2e)</td>
<td>300,000</td>
</tr>
<tr>
<td>Total electricity savings over 15 years (GWh)</td>
<td>2,200</td>
</tr>
<tr>
<td>Payback period (years, nondiscounted)</td>
<td>5.2</td>
</tr>
<tr>
<td>ROI</td>
<td>324%</td>
</tr>
<tr>
<td>NPV over 15 years (R$, millions)</td>
<td>428</td>
</tr>
<tr>
<td>IRR</td>
<td>45%</td>
</tr>
</tbody>
</table>

It is important to note that these figures do not include other potential social benefits, such as a possible reduction in crime from improved street lighting. While there are as yet no sufficient studies to draw conclusions regarding the relationship between street lighting and crime, empirical evidence from a recent rapid and massive deployment of LED street lighting in Los Angeles suggests that there are several safety benefits over a two-year implementation period. For example, since the start of the Los Angeles LED street lighting project in 2009, the city has seen a 13 percent decrease in vehicle theft, an 8 percent decrease in robberies, and an 11 percent decrease in vandalism.49

If the City of Rio de Janeiro wants to assess the impact of better lighting on crime rates and the perception of safety, we recommend the municipality design, as early as possible, a rigorous assessment methodology to assess the impact of an LED street lighting project on the safety of the city in such a way that the influence of other variables that may affect crime and safety are properly factored into the analysis.

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5. Cost of Waiting

Given that the price of LEDs is expected to decline significantly going forward, it may be tempting to believe that the City of Rio de Janeiro would be better off if it waited a few more years to implement the program. However, analysis shows that there is a significant opportunity cost to waiting to implement the LED project. As Figure 6.4 below shows, the opportunity cost of the forgone savings in electricity and O&M by waiting one year (estimated at R$ 17 million) is much greater than the potential savings that could be gained on the capital expenditures of the project due to price decline (estimated at R$ 9 million). Thus, in spite of the declining price, the City of Rio de Janeiro is best served by implementing the large-scale modernization program as soon as possible.

Figure 6.4 Estimated Cost of Waiting One Year
VII. Financing Options

The City of Rio de Janeiro has three main options for funding a public street lighting program: municipal budget allocation (potentially including COSIP), municipal finance (loans or bonds), or private sector finance. This report presents the main characteristics of each of these options.

A. Municipal Budget Allocation/COSIP

Another option for the City of Rio de Janeiro to consider is using a municipal budget allocation or COSIP surplus to fund the up-front costs for the project. Municipal budget allocation and COSIP could also be used in tandem.

The use of municipal budget allocation would involve budgetary approval to earmark a fixed amount of revenues to cover the up-front capital expenditures of the LED equipment, smart system technology, and installation costs. Presumably, the O&M costs would not be funded through budget allocation, as they are currently being funded through COSIP revenues. The time it would take to roll out the project would depend on the amount that could be allocated in each year. According to the assumptions described in the base case of the financial analysis (see section VI.B above), if the city wanted to complete the project within five years, it would need to allocate approximately R$ 84 million each year over five years.

COSIP could also be used to fund the upfront investment, provided that sufficient COSIP surplus exists. As explained earlier in the report, COSIP collections are currently used to pay for electricity expenditures and O&M costs. If there is any cash remaining after these expenses are covered, the surplus can be used to fund investments to improve or expand the system. In 2013, RioLuz reported to have a COSIP surplus of approximately R$ 38 million. The current balance in the FEIP account as of April 2014 is understood by the authors to be R$ 120 million. Thus, there is already some capital available that could be used to fund the project. The main problem with using COSIP revenues is that it is very difficult to forecast the future COSIP surplus, as COSIP is currently indexed only to inflation, not to electricity prices (see box 7.1 below for more information). It is reasonable to expect that some volatility will always be present reflecting the decoupling between electricity prices and collection of COSIP.

To address this volatility, the city could adjust the formula for annual changes to COSIP by indexing the increase to inflation and electricity prices. If this is not possible, it will be risky to rely solely on COSIP to fund the project. Instead, COSIP surplus (on reserve in the FEIP account) could be designed to act as a “cushion” to absorb some of this volatility and assure a sustainable flow of funds to RioLuz (or to any concessionaire in charge of modernizing the street lighting system).
Box 7.1. Potential for COSIP Surplus Volatility

Unless the City of Rio de Janeiro decides to fully finance the modernization of the street lighting system through a municipal budget allocation, COSIP funds will play a major role in supporting the modernization program, whether it is carried out directly by RioLuz or via a PPP/concession.

One can reasonably expect certain volatility in COSIP proceeds, particularly owing to the fact that the cost of energy and COSIP revenues are to some extent “decoupled,” and may even be negatively correlated because of the price elasticity of demand.

For example, in times of rate freezes, the collection of COSIP may remain constant or even increase if the economy grows (increased electricity consumption would push customers up to the next COSIP rate bracket). This is the very situation being experienced today by Rio de Janeiro, and possibly other municipalities in Brazil. Electricity rates across the board decreased in real terms in November 2013 by virtue of a negotiation pact led by the Federal government, whereby several generation and transmission concessions were extended for those companies that accepted lower rates. At the same time, Rio de Janeiro has experienced particularly hot summers, leading to increased electricity consumption and, therefore, increased COSIP collections. Because the street lighting bill of the city has decreased (because of the lower rate) and the COSIP collections have increased, the City of Rio de Janeiro currently finds itself with surplus COSIP revenues. RioLuz estimates that there is R$ 120 million in the FEIP account, which compares very favorably with the original R$ 80 million forecast.

However, as described previously in the report, the Federal government has recently decided to defer the pass-through of fuel costs incurred in 2013 and 2014 to 2015 and beyond. Thus, it is possible, and even likely, that the factors that drove the COSIP surplus to unprecedented levels could revert in the short run, after two (or more) expected years of rate increases, without a corresponding increase in COSIP revenues (unless a new COSIP schedule is approved). In that case, a large part of the existing COSIP surplus may need to be used to pay for the higher cost of electricity. This is likely to be a bigger risk in the early years of the project because the electricity savings from the energy-efficient equipment would not have fully materialized. In the later years of the project, the reduction in electricity expenditures due to decreased electricity usage could at least offset to some degree any potential electricity price increase.

B. Municipal Investment

1. National Programs for Public Street Lighting

   a. PROCEL

One of the most relevant energy efficiency programs in Brazil is the National Program for Electricity Conservation (Programa Nacional de Conservação de Energia Elétrica, PROCEL), a program administered by Eletrobrás. The major goal of the PROCEL program is to promote energy efficiency, contributing to improving the quality of life and the efficiency of goods and services, and mitigating adverse environmental impacts. PROCEL consists of a credit line for channeling resources to fund
energy efficiency initiatives. In 1993, Law 8.631 allowed allocation from a levy charged as a proportion of concessionaires’ assets (Reserva Global Reversão, RGR)\(^ {50}\) to finance energy efficiency projects by transferring the available resources to compensate electricity concessionaires for assets that had not fully depreciated when the proposed terms were accepted.\(^ {51}\)

Importantly, RGR funds can only be lent to the power sector. Therefore, in the case of street lighting, the DISCO acts as an intermediary between Eletrobrás and the municipality. The majority of the resources allocated through PROCEL come from RGR (75 percent). The remaining funds (25 percent) are to be provided by the DISCO that is responsible for the project implementation. This funding may be used for the provision of services, such as transportation and technical support from the implementing entity.

The most relevant PROCEL program for the purposes of this study is RELUZ, which supports energy efficiency projects directed at public lighting and traffic lights.\(^ {52}\) The submitted projects may involve improved performance of existing systems of public lighting, expansion of service provision to an area that was not previously attended, a special lighting system for monuments that are deemed to be of great artistic, cultural and environmental merit, as well as sports venues. Additionally, technological innovation in energy efficiency is eligible for resources from RELUZ.

RELUZ has been the only program dedicated to financing energy-efficient street lighting programs in Brazil. Since its establishment, RELUZ has modernized more than 2 million points of public lighting in over 1,300 municipalities, making investments totaling more than R$ 500 million resulting in 2.76 million efficient street lighting points replaced, corresponding to an energy savings of 938 GWh per year and a peak load reduction of 216 MW. Most of the investments in efficient lighting entailed replacing mercury with sodium lamps. Average IRR for the investments is 19.5 percent, assuming a rate of R$ 180/MWh.

In order to be eligible for concessional financing from RELUZ, a project must meet the following conditions:

- 75 percent financing by Eletrobrás (the remaining 25 percent from DISCOs, the city or others)
- Interest rate of 5 percent per annum
- Management fees of 1.5 percent per annum
- Commitment fee (unfunded) of 1 percent per annum
- Grace period of 24 months
- Tenor of 84 months, with 24-month grace

\(^ {50}\) RGR is used to finance the National Program for Universal Access to and Use of Electric Power (Light for All), which has brought electricity to millions of Brazilians, and energy efficiency projects under PROCEL. The contributions of RGR, a sector fund created in 1957 by Decree 41019, are also directed to works to improve and expand the electricity system in the areas of generation, transmission and distribution of energy.

\(^ {51}\) Beginning in January 2013, RGR funds were to be allocated for payments arising from renewals of concessions that will expire in 2015 and 2017. See [http://www.Eletrobrás.com/elb/data/Pages/LUMISA14E9AB4PTBRIE.htm](http://www.Eletrobrás.com/elb/data/Pages/LUMISA14E9AB4PTBRIE.htm).

\(^ {52}\) PROCEL has three major lines of credit: PROCEL GEM, PROCEL EPP and PROCEL RELUZ. PROCEL GEM (Municipal Energy Management) finances actions aimed at improving energy management at the municipal level. The program involves collaboration with the municipal administration on the management and efficient use of electricity through training, development of a plan and the Network for Energy-Efficient Cities. PROCEL EPP was created in 1997 to promote energy efficiency in public buildings at the federal, state and municipal levels.
As described previously, the City of Rio de Janeiro used PROCEL/RELUZ funding to replace mercury vapor lamps with high pressure sodium lamps. Interviews with Light indicated that electricity charges were kept at historic rates during a certain period, so that the charge in excess (that is, savings generated by the new system) could support payment obligations in connection with the finance from the Energy Efficiency Program (PEE). Funds received by Light under the financing agreement were transferred to the City of Rio de Janeiro via Banco do Brasil, which acted as intervenient party in a cooperation agreement between the city and Light. The city was responsible for carrying out the services, including procurement bids.

For projects to be accepted by Eletrobrás, savings arising from the project must be at least 25 percent higher than the cost of the project. Projects submitted to Eletrobrás must comply with the protocols and criteria established in the Manual of the PROCEL program. Appendix K provides more details on the criteria used to evaluate PROCEL/RELUZ projects.

Unfortunately, PROCEL funds have essentially dried up as a result of new legislation - Law 12.783/12 - which extinguished RGR for renewed concessions, reducing funding for PROCEL and all its EE lending programs. The new law ended the collection of the RGR levy used to fund PROCEL. This legislation was put in place with the goal of increased competitiveness of the economy as a whole and the industry in particular.

When Law 12.783/12 was enacted, PROCEL had a portfolio of projects encompassing replacement of about 1.56 million inefficient lamps. Agreements have been signed for about 500,000 lamps, but they have not yet been delivered. PROCEL expects that the Treasury will provide funds to honor those contracts. The City of Rio de Janeiro has a few signed contracts that depend on funds from the Treasury in order to be executed.

Even though the lending from PROCEL has dried up, the considerable experience and expertise developed under PROCEL make it a very relevant player for implementing energy efficiency in Brazil. PROCEL could become a center of excellence, leveraging its experiences and human resources. Nevertheless, there is a pressing need to look for other sources of financing to keep the energy-efficient street lighting program moving.

b. PEE

The fulfillment of national objectives to promote energy efficiency is also supported by resources channeled from PEE regulated by ANEEL according to the guidelines set by Law 9.991/00. According to the concession contracts signed by the DISCOs, 0.5 percent of the net annual revenue of each DISCO must be directed to energy efficiency actions. There is also a legal mandate to allocate at least 60 percent of the resources for energy efficiency to low-income users, as a result of Law 12.212/10.

According to the PEE regulations, the DISCOs are responsible for selecting energy efficiency projects and presenting them to ANEEL. In some cases DISCOs work together with the respective institutions to develop the project. The DISCO is responsible for monitoring all expenses incurred in executing the projects, including proper documentation and monitoring, and for implementation of the budget transferred to the company/government entity, as well as for filing the analytical financial reports for
each project. Evaluation and auditing of the investments are to be carried out after review and approval of the final project by ANEEL. ANEEL monitors project execution until the work is concluded.

From 1999 to 2012, Light invested more than R$ 340 million in EE projects generating savings of 615.73 GWh/year. In partnership with government, society and other social players, Light has developed 171 projects aimed at increasing consumer awareness and fighting energy waste. In 2012, Light invested R$ 38.4 million in efficiency projects, 67.3 percent of which was concentrated in the low-income segment, 18.6 percent in the public sector and 5 percent in education. In Rio de Janeiro, Light currently invests on average R$ 30 million each year in energy efficiency. In 2012 the investment was R$ 38 million.

PEE can fund all the resources required under the project, which is subject to an ex ante evaluation as well as an ex post audit. The ex-ante evaluation of the feasibility of the project must take into account the estimated lifetime of the equipment, according to the approved technical standards. Additionally, the PEE projects must be considered viable from an economic perspective. This requirement is evaluated through the criterion of a minimum cost-benefit ratio that depends on the project typology. This is verified against the International Metering and Verification Performance Protocol.

PEE funds are mandatory grants, rather than loans, when they are allocated to the public sector. If funds are invested in the private sector, the principal when repaid forms a revolving fund for the utility to invest in new energy efficiency projects. The PEE Manual stipulates that all energy efficiency projects whose client is a for-profit organization must include a partial guarantee of a performance contract (that is, a pledge that future energy savings will arise from the project).

In 2005, ANEEL amended the PEE regulations by prohibiting the allocation of PEE funds to public lighting projects, making PROCEL/RELUZ one of the only sources of public funding for investments in energy efficiency in public lighting. However, shortly after the legal reform that set the termination of RGR in 2012, a new set of rules again allows the use of PEE to finance public lighting projects (Ruling 556/2013).

Despite this change in law, it is not expected that PEE will play a major role in supporting energy efficiency in street lighting. This is primarily because ANEEL has also ruled that the DISCO should invest at least 50 percent of its requirements (net of its obligation to invest in EE for low-income customers) in projects for the two largest consumer groups, thereby eliminating street lighting projects. In addition, recent changes in the law reduced the compulsory investment from DISCOs from 0.5 percent to 0.25 percent of net operating revenue for 2015. Thus, the total pool of funding has decreased and street

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53 Light Sustainability Report 2012.
54 http://www.light.com.br/grupo-light/Quem_percent20Somos/eficiencia-energetica_projetos.aspx  [[Author: This link was not found.]]
55 The LED lifespan in PEE projects is 20 years.
[[For the Portuguese version: Protocolo Internacional de Medição e Verificação de Performance – Conceitos e Opções para a Determinação de Economias de Energia e Água – vo. 1 – EVO 10000-1:2012.]]
lighting projects are unlikely to be prioritized. Instead, it is likely that PEE will end up using its limited funds to promote investments in industrial energy efficiency.

c. BNDES

BNDES offers credit facilities for the improvement, renovation or replacement of equipment associated with energy efficiency projects through a program known as PROESCO. PROESCO is a possible funding option for the objectives of this study; however, the pace at which disbursements are made under PROESCO does not meet the expectations of BNDES. One of the reasons is that BNDES has been reluctant to accept future cash flows from energy savings as the first option for the repayment of loans. Instead, BNDES criteria for credit approval under PROESCO include strong balance sheets and/or corporate guarantees that it is not feasible for middle-sized companies and projects to provide. LightESCO, for example, which has corporate guarantees from its holding company, Light DISCO, has been the largest borrower so far.

Beyond PROESCO, there are many other credit facilities provided by BNDES that could be considered for funding EE projects. Appendix L provides a snapshot of selected credit facilities provided by BNDES that could fit the purpose of funding EE projects.

One important variable that will affect the ability of BNDES to fund this project is the amount of imported equipment involved. Currently, BNDES cannot finance projects whose total capital expenditure from imported goods is more than 60 percent. Given the current lack of local LED manufacturing facilities in Brazil, this could be a prohibitive restriction.

Nonetheless, further investigation and dialogue with BNDES are needed to confirm the adequacy of these financing lines for the specifics of the projects covered by this study.

2. Municipal Loans

Another mechanism to finance this project would be for the municipality to raise capital by taking on municipal loans from domestic or international capital markets. Given the wide array of possible funding sources, this study does not delve into these sources specifically. Some possible examples include loans from local commercial banks (Caixa Economica, Itaú, Banco do Brasil, Banco de Santander, and many others) and international development banks (World Bank Group, Inter-American Development Bank, and others).

This issue needs to be explored carefully, however, owing to the strict limitations that many Brazilian municipalities face with regard to their indebtedness. Most importantly, after the restructuring of state and municipality debt with the Federal government between 1997 and 2001 and the Law on Fiscal Responsibility in 2000, local governments have been subject to various restrictions in relation to the issuance of domestic or external debt.

Amid the economic crisis, however, in order to enable governors to invest in infrastructure and stimulate the country’s economy, in 2012 the Treasury allowed 21 states to increase their indebtedness
by R$ 58.311,000,000 through the Program for Restructuring and Fiscal Adjustment (PAF). In August 2013, this limit was once again increased by R$ 42.2 billion and in September of 2013, still under the PAF, the Ministry of Finance announced an increase of the debt limit of the State of Rio de Janeiro by R$ 7,055,000,000.

In the case of the City of Rio de Janeiro, interviews with the Municipal Secretary of Finance (Fazenda) confirmed that there is currently little room for the municipality to increase its debt obligations. Even though some of the debt limitations have been eased (as described above), the city still has a very small envelope every year for new investments, and the envelope for 2014 has been fully allocated. A decision to use fiscal space that will be available in 2015 to fund an energy efficiency public street lighting program would presumably be based on the city’s priorities for investment in that year.

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**Box 7.2 Exceptions to the Debt Limitations**

There are a few notable exceptions to the restrictions on indebtedness that the City of Rio de Janeiro faces, for example:

- Loans already in place at the time of the restructuring were grandfathered in
- Tax rationalization (investments that are intended to improve tax collection)
- RGR funds via PROCEL
- Certain projects, including Projeto Favela-Bairro with the Inter-American Development Bank
- Loans intended to restructure existing debt under more favorable terms
- Investments related to the World Cup and the Olympics, which have taken the fiscal space that the city had in 2014; some room for new borrowing will appear only in 2016

Of relevance for this report is the exception related to PROCEL funds as well as the exception related to tax rationalization. The exception related to PROCEL is relevant because it demonstrates interest on the part of the Federal Government in promoting municipal energy efficiency measures, which are designed to ultimately bring fiscal savings to municipalities in the medium to long term. This approach is very similar to the exception for tax rationalization, which is presumably included for the same reason; although it requires an up-front investment, the ultimate goal is to increase revenues in the medium to long term.

However, as explained in section V.B.1 above, recent regulatory changes in the electricity sector have led to a defunding of PROCEL. Despite this defunding, one would assume that the principle of promoting investments that lead to improved fiscal sustainability, implied by the inclusion of PROCEL in the list of exceptions, still stands. If this is the case, there may be an opportunity for cities to seek an adjustment to the list of exceptions to broaden the definition of funding that can be used to promote municipal investments in energy efficiency so that funding from sources other than PROCEL can be used. Although further research would be needed to understand how this could be accomplished, interviews with stakeholders indicate that the most logical route would be to seek an exception via a Provisional Law (Medida Provisória), to be subsequently converted into a law. This could take six months to one year to accomplish and would require a political champion.
3. **Municipal Bonds**

Another mechanism to finance this project would be for the municipality to raise capital by issuing municipal bonds. However, the indebtedness restrictions on municipal loans discussed in the previous section apply to municipal bond issuance as well.

There is a precedent for using receivables to repay debt from bonds. For example, in a transaction entered into by the State of Minas Gerais in 2012, R$ 300 million in senior bonds were guaranteed, via fiduciary assignment, by the right to receive 60 percent of collections resulting from payments of renegotiated taxes in the form of monthly installments (credit rights). The credit rights consisted of renegotiated Imposto sobre Circulação de Mercadorias e Serviços (ICMS) taxes (taxes on delivery/transportation of goods and services) owed by obligors to the State of Minas Gerais and that have been renegotiated, with recognition of the ensuing debt by obligors. Under the transaction documents entered into between the State of Minas Gerais and the issuer, the State of Minas Gerais is required to make the issuer whole via indemnification payments for damages resulting from any future renegotiation of credit rights sold to MGI - Minas Gerais Participações S.A.57

In addition to the debt limitations faced by cities, recent issuances of state and municipal bonds have not been well received by the Federal government. Two sizeable transactions that reached the market in 2013 (States of Maranhão and Minas Gerais) negatively affected the prices of nearly sovereign-quality bonds such as those of BNDES and Caixa, as investors divested their positions in the latter to buy the states’ bonds, which offered better returns and guarantees from the Federal government as well. With higher premiums, the bonds from Minas Gerais and Maranhão distorted the Brazilian bond curve. Minas Gerais offered a premium of 120 bps above sovereign, while Maranhão bonds were expected to pay 175 bps above sovereign for the 2019 maturity.

The political opposition to this kind of issuance deepened last August when the new Brazilian Municipal Bond Market was brought to a standstill by the Federal government as news emerged that Crédit Suisse and Bank of America had collected colossal profits from trading those bonds at markups ranging from 360 bps to 920 bps. For the sake of comparison, Brazil’s sovereign bonds were trading in the 25 bps range at the time.

Thus, any new bond issuance will need to be carefully structured to avoid the pitfalls faced by previous issuances, and is likely to face significant scrutiny by the Federal government. As such, if the city sought to fund a citywide LED street lighting program through municipal debt, a municipal loan would likely be the more straightforward option to pursue.

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C. Private Sector Investment

Attracting financing from the private sector for energy efficiency has historically been difficult. The main hurdles for this project in attracting such financing are the following:

- EE project risks are new to financial investors and need to be addressed via an organized and well-orchestrated sales effort.
- The cost of capital in Brazil is still high; subsidized funding or enhancement will thus play a relevant role in any economically feasible transaction.
- Structuring costs require scalable instruments; that means that a transaction size of at least R$ 100 million is desirable.
- To commit with substantial savings generated by the project in the long run, an interest stake in the project by contractors and the ESCO is desirable, for example, balloon payments, equity stake, receivables, and others.

In light of these challenges, the targeted investors for this project should be those with a long-term view determined by the very nature of their portfolio, such as pension funds and insurance companies, as well as certain local and foreign long-term funds. They may be particularly interested in a project with this profile given that the returns are indexed to inflation (as they are tied to electricity prices and COSIP revenues, both linked to inflation). On the other hand, increased rates of inflation tend to increase investors’ risk aversion, thus making the choice for long-term investments more selective.\(^{58}\) The fact that the Government has controlled the prices of key components of the inflation index such as electricity, urban transport and fuels is one of the top concerns of investors with regard to expected energy savings in EE projects. Hence, for EE projects to be able to attract private players’ interest, documentation and regulatory safeguards must be proven enforceable and/or credit enhancements should be in place in order to protect investors’ returns.

The following section provides a review of the main private sector financing instruments that could be used to fund an energy-efficient public street lighting project. The instruments reviewed include Receivables Investment Funds (FIDCs), debentures, and Private Equity Investment Funds (FIPs). This section also discusses possible credit enhancements that could be used to improve the attractiveness of this project. The use of any of these three instruments should be preceded by the formation of an SPE.

4. FIDCs

Fundos de Investimentos em Direitos Creditórios (FIDCs) are mutual investment funds that invest at least 50 percent of their net assets in receivables of almost any kind or nature (the definition of

\(^{58}\) The Central Bank has revised its projections for the Consumer Price Index, the main index measuring inflation, upwards in this and future years, as indicated in its quarterly report released in September 2013. Projections in the report and the recent market report, Global Central Bank Focus, indicate real chances of continuing monetary tightening beyond the current high of 10 percent per annum. If interest rates rise even more to fight inflation, as widely expected, investors’ risk aversion will likely increase as the investment horizon shortens, thus negatively affecting the cost of funds and tenors for new issuances.
“receivables” in the regulation is extremely broad). They were created by resolution 2907 of the Central Bank of Brazil on November 29, 2001 and the rules of operation were set forth by CVM instruction 356 on December 17, 2001.

For many specialists, the sale of rights to future revenues in a securitization structure shall not be construed as a credit transaction. As an off-balance-sheet transaction (that is, not booked as debt by municipalities), future flow securitization could be the answer to the quest of Brazilian cities and states with high debt seeking funds for infrastructure projects.\(^{59}\)

FIDCs are the vehicles of preference in Brazil for securitization transactions in which funding is raised through the sale of senior and subordinate shares and, sometimes, mezzanine shares, under a sales structure, more often than not described as follows:

- Senior shares have predetermined redemption schedules and target returns set forth in the transaction documents (the most important being, the Fund’s Act of Incorporation (Regulamento) and the Receivables Purchase Agreement (Contrato de Cessão). In general, senior shares are distributed to qualified investors (in accordance with CVM rules, with a few exceptions).
- Mezzanine shares differ from senior shares in the target return level and the risk level, which are higher since they are second in the redemption schedule to senior shares in case of a liquidation event.
- Subordinate shares have no redemption schedule and no predetermined target return and are redeemed only after senior shares and mezzanine shares are redeemed in full, or in some very specific situations stated in the transaction documents.

In addition to being viable for use for a single investment, an FIDC would also establish the infrastructure that could eventually be used to bundle EE investments in other sectors within Rio de Janeiro or with investments in energy-efficient public lighting in other Brazilian cities. Over time, the bundling of investments has the potential to reduce borrowing costs owing to scale and diversification. The benefits of this option should be explored in more detail as a follow-up to this report.

The figure below shows a typical balance sheet structure of an FIDC.

\(^{59}\) For example, Rio Capital Energy, a program of the state of Rio de Janeiro in collaboration with private companies, government and universities created in 2011, uses the same rationale, that is, to finance an EE initiative on the campus of the Federal University of Rio de Janeiro. The state has committed the ICMS tax on the energy bills paid by the campus for the next 10 years to a fund established to invest in technological innovation and energy efficiency. This commitment will not affect the state’s indebtedness level. Collections flowing into the fund are expected to reach R$ 7 million per annum. The program comes under the Department of Economic Development, and aims to transform the state into a world reference for technological innovation, energy efficiency and environmental sustainability. In June [[2013?]], the program was running 53 projects with investments of R$ 2.2 billion. While most of the projects are in the area of technological innovation, energy efficiency accounts for 17 of them.
Figure 7.1. Balance Sheet of an FIDC

The value of assets and liabilities of an FIDC is always the same, that is, any decrease in the value of assets adversely affects the value of the subordinate shares (up to their total value), then the mezzanine shares; if the two layers of subordinate and mezzanine shares are not enough to absorb all the losses generated, then the value of the senior shares decreases. Likewise, any increase in the value of assets has a positive impact on the value of senior shares (up to their target return), then the mezzanine shares (up to their target return); if the two layers of senior and mezzanine shares achieve the targeted returns, the subordinate shares are left with all the remaining upside value of the assets. That is why FIDCs are bankrupt remote by nature, that is, there is no recourse available to the shareholders beyond what is available on the asset side of the FIDC's balance sheet. The rights granted to each class of shares (senior, mezzanine or subordinate), such as voting rights, amortization/redemption schedule, and rights upon liquidation of the FIDC, as well as maintenance costs incurred by the FIDC and paid with the assets, are defined in the FIDC's documents. Every FIDC is different and has its own rules, ring fenced by rules imposed by the regulator (CVM).

FIDCs raise capital to buy assets by issuing a number of senior shares (and sometimes mezzanine and/or subordinated shares), which are purchased by investors. The shares represent an interest in the asset portfolio of the FIDC that is actively managed by an administrator, a custodian, and a collection agent. Every FIDC must have an administrator who bears the civil and criminal responsibility for the management of the FIDC. A custodian must be appointed to perform certain obligations in accordance with the rules set forth in the FIDC's documents which, given the nature of the obligations, makes the role of the custodian comparable to the role of a trustee.

FIDCs can be open- or closed-end funds. In a closed-end FIDC, shares are issued in batches; each batch constitutes a a series. After a series is placed, it amortizes according to a predetermined schedule. The price of the shares of a closed-end fund fluctuates according to market forces (supply and demand for the shares) as well as the changing values of the assets in the FIDC. In an open-end FIDC, the amount of shares the fund will issue will depend on the demand. If demand is high enough, the fund will continue to issue shares. There are no series in open-end FIDCs, which also buy back shares when investors wish to divest, depending on grace, tenor and redemption rules, predetermined in the transaction documents.
FIDCs have proven to be attractive as securitization vehicles for both borrowers and lenders, since they provide for substantial diversification of funding sources while, eventually, reducing intermediation costs and offering additional protection against bankruptcy risk. FIDCs are subject to the same tax treatment as other financial investment funds, that is, they are not subject to the levy of any taxes, including the Imposto sobre Operações Financeiras (IOF) (tax on financial transactions). FIDC shareholders are subject to monthly withholding of income tax if the FIDC is open-end, or upon the redemption of shares if the FIDC is closed-end. Unlike a securitization structure that uses an FIDC, a securitization structure that uses an SPE is subject to a myriad of taxes, for example, income tax, social contribution, IOF, Programa de Integração Social (PIS) and Contribuição para o Financiamento da Seguridade Social (COFINS).

The year 2012 was not very favorable for FIDCs, which accumulated R$ 5.3 billion in redemptions in December, about 10 percent of the total value of FIDCs outstanding (R$ 52 billion). Problems at specific funds and regulatory changes such as new rules for financial reporting and financial statements (ICVM Instruction 489) are the probable causes for this performance.

With the release of CVM Instruction 531 in the beginning of 2013, asset managers are expecting FIDCs to regain importance in the coming years. In 2013, until October, nine new FIDCs were launched compared with 19 in the same period of 2012. The new instruction requires improved controls by the administrator and other service providers, with a clearer definition of responsibilities. These changes aim at mitigating the conflict of interests associated with undue concentration of functions by a party, while ensuring the good governance of this type of vehicle. Whether the FIDC market will perform better, however, is yet to be seen.

In the context of infrastructure projects, under Law 12.431/11, FIDCs can be more efficient vehicles for the acquisition of debentures compared to standard investment funds (regulated by CVM Instruction 409/04). FIDCs of this nature can invest 100 percent of their total capital in one single project/obligor, whereas investment funds regulated by CVM Instruction 409/04 can only do so if the minimum investment per shareholder is set at R$ 1 million. The new CVM rules bring some incentives for the use of the FIDCs as vehicles for infrastructure and research and development projects.

5. Debentures

Debentures are debt instruments issued by a corporation (sociedade anônima) that grants investors (the “debenture holders”) credit rights against the issuer, under the conditions specified in the respective

60 Prior to CVM Instruction 531, Provisional Measure 601, published on December 28, 2012 by the Federal Government, reduced to zero the rate of income tax on shares of FIDCs held by foreign investors and backed by investments focused on research, development and innovation. To be entitled to the benefit, the FIDC shall be a closed-end fund, the investor cannot be a financial institution, and the shares must be referenced in a fixed interest rate pegged to a price index or the Brazilian Reference Rate. It must also comply with the same requirements established for debentures under Law 12.431/11. If the FIDC invests in infrastructure, research & development and innovation. Local investors (individuals) benefit from a 0 percent income tax rate as well, and corporations and financial institutions from a 15 percent income tax rate (37.5 percent is the average standard).

indenture and certificates, if any. In Brazil, debentures are governed by Law 6.404 of December 15, 1976, as amended under Brazilian Corporation Law (BCL). In June 2011, local regulators introduced important changes to the BCL so as to provide more flexibility to the process of issuing debentures and facilitate the development of a secondary market for these securities.

As shown in the figures below, debentures are the instruments most accepted by the market so far. Figure 7.2 shows the total amount of new money raised each year with debentures in Brazil.

Figure 7.2 Debenture Statistics

![Figure 7.2 Debenture Statistics](image)


Abbreviations: CDA = Capital Dividend Account; FIP = Private Equity Investment Funds; FIDC = Receivables Investment Fund; CRI = Certificates of Real Estate Receivables; FII = Real Estate Investment Fund.

Infrastructure debentures, under Law 12.431/11, are subject to 0 percent income tax for domestic and international investors, and 0 percent financial transactions tax for foreign investors. To qualify for the 0 percent tax status, the bonds must be backed by infrastructure projects and have a tenor of at least four years.

As reported by the press, BNDES is willing to take a position in publicly distributed debentures of the same type and guarantees required in its typical credit facilities. Debentures of infrastructure linked to long-term projects are important targets for BNDES. BNDES plans to encourage borrowers to issue the instrument by providing advantages to those who accept placing the transaction publicly, with a partial firm commitment by BNDES.

BNDES reportedly aims to encourage smaller issuances (under R$ 100 million) as well. Since the process is too costly for companies seeking to fund smaller amounts, the bank is willing to purchase 100 percent
of the issuances of this type under special conditions, so as to bundle and further securitize (that is, divest) them via an FIDC.

Since 2011, foreigners and individuals in Brazil are exempt from income tax on profits generated by infrastructure projects and foreign capital is also exempt from the IOF upon the entry of financial resources in the country. However, two years after the enactment of the law that granted the tax benefit, funding for infrastructure debentures totaled only R$ 3.4 billion, considerably below the country’s needs in the area. Of the 51 projects that received formal government authorization, only nine had reached the market as of late 2013.

In April 2013, Decree 7595/2013 reduced to zero the IOF on loans made by financial institutions to finance:

- Acquisition/leasing and production of capital goods, including components and related technology services, and related working capital
- Production of consumer goods for the energy sector and for export
- Structures for the export of liquids in bulk
- Engineering, design, technological innovation and investment projects aimed at increasing productivity of technology- and engineering-intensive sectors
- Highway and railroad infrastructure projects

Before the enactment of this decree, the exemption was restricted to BNDES funds made available by accredited financial agents; the applicable IOF tax rate on private resources was 1.5 percent per year, plus 0.38 percent at inception.

The main objective of Decree 7595/2013 is to ensure that private financial institutions use compulsory deposits, released by the Government in 2012, to fund infrastructure projects. It is estimated that private banks have approximately R$ 15 billion in compulsory deposits available for this purpose.

Even with the tax exemption granted by the Government, the interest on this type of transaction remains low. Probable causes are the current volatility and the advantages offered by government bonds, which have been exempt from IOF as well since May 2013.

Debentures guaranteed, via fiduciary assignment, by the right to receive savings from EE projects and additional funds in FEIP should be well received by the market.

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62 Brazil jump-started investments in infrastructure in 2007 with the Government’s Growth Acceleration Program of Investment (PAC I) followed by a second program in 2010 (PAC II). According to PriceWaterhouseCoopers (“Crunch Time for Brazilian Infrastructure”, Spring 2013), more than 12,000 private and public infrastructure projects are currently in the works: Oil, gas, and biofuels account for about half of the nearly R$ 1 trillion (US$ 885.9 billion) of PAC II’s planned infrastructure investments by 2016 and beyond. The other half is divided between investments in housing (US$ 151.4 billion) and transportation (US$ 104.5 billion), and a massive build-out in basic sanitation, in the electricity grid, and in telecommunications systems.
A financial institution must be appointed as trustee of pledged accounts and the distributor and custodian of debentures.

- Estimated cost/tenor:
  - Structuring: R$ 300,000
  - Distribution fee: Up to 2.5 percent flat
  - Ongoing/funding: Consumer Price Index (IPCA) + 6 percent (12 percent per year) + guarantee fees
  - Tenor: 7 years

6. Infrastructure Debentures via FIDC

Local banks are articulating new ways to attract investors, especially foreigners. One of the initiatives is the creation of investment funds backed by publicly traded debentures. In August 2014, Banco do Brazil and Banco Votorantim filed with the CVM for the registration of a R$ 300 million FIDC backed by debentures of infrastructure (FIDC BB VOTORANTIM HIGHLAND INFRAESTRUTURA). The transaction is still under analysis by the CVM.

Similar to real estate funds (fundos imobiliários), infrastructure FIDCs would be closed-end, with funds raised through the placement of amortizing series. Investors willing to divest during the life of the series could do so by accessing the secondary market. With a diversified base of assets and the prospect of greater liquidity, infrastructure debentures issued by FIDCs could attract resources to finance priority infrastructure projects in the country.
The idea of bundling infrastructure debentures into large FIDCs is being pursued by many banks, which are reportedly buying outstanding infrastructure debentures in the market in order to build portfolios for further securitization under this type of FIDC. The main concern is standardization, so as to enable investors to compare and select FIDC shares in terms of risks and rewards. ANBIMA (the Brazilian Finance and Capital Markets Association) is working with the CVM to refine this kind of instrument despite the overall market perception that no major change in the regulation is required to make these FIDCs a reality.

Publicly traded shares of FIDCs backed by this asset class would solve two major obstacles to the growth of the debenture infrastructure market in Brazil: low liquidity, and little familiarity of local and international investors with the Brazilian infrastructure market. Appendix M lists FIDCs backed by utility assets as of September 2013 and their respective administrators.

Figure 7.4. Indicative Diagram – FIDC + Debentures

A financial institution should be appointed as trustee of an account that would receive funds directly from FEIP. A custodian and an administrator (which could be the same financial institution) must be appointed to the FIDC.

- Estimated cost/tenor:
  - Structuring: R$ 500,000
  - Distribution fee: Up to 3.5 percent flat
  - Ongoing/funding: IPCA + 6 percent (12 percent per year) + guarantee fees
  - Tenor: 7 years
7. FIPs

Fundos de Investimento em Participações (FIPs) are closed-end investment funds that invest in shares, debentures, subscription bonds and convertible securities of any Brazilian publicly or privately traded company, provided it is a corporation (sociedade anônima). They cannot invest overseas or in real estate assets or in shares issued by the administrator. FIPs are regulated by the CVM through Instruction 391. Investors need to be “qualified” to participate, that is, financial institutions, insurance companies, pension funds and investors holding more than R$ 300,000 in cash and marketable securities.

The investment is effected through the subscription of shares of the FIP. Unlike other equity funds, an FIP is required to participate in the decision-making process of the invested companies. Companies in which the FIP invests must have members of the Board of Directors appointed by the FIP.

Income and capital gains earned by the FIP are subject to zero withholding tax as long as: (a) the investor and its related parties own less than 40 percent of the FIP's shares; (b) the investor is not domiciled in a tax-haven jurisdiction; (c) the investment in the FIP using offshore vehicles complies with the requirements of Central Bank Resolution 2689; (d) the FIP does not hold, at any time, debt securities exceeding 5 percent of the FIP’s net equity, except for investments in public bonds or convertible notes. If these conditions are not met, earnings generated by the FIP are subject to a 15 percent withholding income tax. The IOF on FIPs is also zero.

On July 1, 2013, the CVM amended its Instruction 391 governing the organization, administration, and operation of FIPs in Brazil. The main change introduced by the amendment was the possibility for the FIP to provide guarantees to debt securities, which could be helpful in a structure considering FIPs to fund EE projects. For example, the Instituto Pereira Passos is planning to launch in the first half of 2014 a FIP for Unidades de Policia Pacificadora (UPPs), a public program targeting public safety, as a way to fund services to communities in the City of Rio de Janeiro. The goal is to build a portfolio of social investments made by Brazilian and foreign investors.63

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63 Renata Batista, Valor Economico, November 1, [[Author: No title of article or year given; editor could not find with this information.]]
RioLuz, Light ESCO and the City of Rio de Janeiro are partners in a FIP that invests in each SPE. The FIP is a party in SPE agreements and debenture contracts as guarantor.

A performance guarantee by FIP replaces the pledge of FEIP and utility bills collection accounts.

- **Estimated cost/tenor:**
  
<table>
<thead>
<tr>
<th>Description</th>
<th>Cost/Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structuring</td>
<td>R$ 300,000</td>
</tr>
<tr>
<td>Distribution fee</td>
<td>Up to 2.5 percent flat</td>
</tr>
<tr>
<td>Ongoing/funding</td>
<td>IPCA + 6 percent (12 percent per year) + guarantee fees</td>
</tr>
<tr>
<td>Tenor</td>
<td>7 years</td>
</tr>
</tbody>
</table>

8. **Credit Enhancements for Financing Options**

   a. **ABGF-Sponsored Guarantee**

   In April, 2013, the government of Brazil released Decree 7.696/13 creating a new State-owned company called Brazilian Fund and Guarantee Management Agency (Agência Brasileira Gestora de Fundos Garantidores e Garantias, ABGF), 100 percent controlled by the Union and linked to the Ministry of Finance.
With an initial equity of R$ 50 million and a mandate to provide guarantees to large infrastructure concession projects, ABGF aims at reducing borrowing costs. According to local newspapers, ABGF would manage funds worth R$ 25 billion (R$ 11 billion for infrastructure financing and R$ 14 billion for foreign trade) by incorporating existing funds for naval construction and public-private partnerships plus contributions from the Treasury. These funds will form the Infrastructure Guarantee Fund (FGIE), which will be managed by ABGF and will cover the so-called non-controllable risk, such as political events and others of a specific nature, such as the risks and losses associated with delays in the issuance of work permits. As is the case for standard loans, amounts drawn under ABGF guarantees due to bureaucratic delays, for example, will be returned to the Fund by the beneficiary once the project recovered its financial balance.

The FGIE is an additional step taken by the Government to make infrastructure projects more attractive; it has not been an easy task for government officials to convince private banks to finance these projects. In the case of highways, after much negotiation, financial institutions have agreed with Government to provide loans of up to 25 years, with five years of grace. The cost of financing is the BNDES long-term interest rate Tasa de Juros de Longo Prazo (TJLP), currently 5 percent per year plus up to 2 percent per year when carried out by consortia between public and private financial institutions, or TJLP plus 1.5 percent per year when funded by public financial institutions only. The minimum rate of return of the project should be 7.2 percent per year.

b. Performance Guarantee

To invest in an EE project collateralized by energy savings generated by the contract, investors would value a guarantee on the expected energy savings generated by the project as stipulated under the EE contract. Performance risk is one of main constraints faced by local ESCOs with respect to funding EE projects, since banks and investors do not have the expertise required to assess the performance risk associated with the underlying EE project. As a result, investors are not prone to fund projects of this nature, or require significant additional, non-project-related collateral (such as properties and cash) from the ESCO.

The guarantee would be callable in the event that the investor received less than the expected return supported by contracted energy savings.

c. Liquidity Backstop

Brazil has the largest mutual fund industry in Latin America and one of the largest in the world by international standards. Nevertheless, the mutual fund industry has been historically concentrated on short-duration and liquid assets. Brazilian investors favor asset allocation in safe and liquid assets such as government bonds and repo transactions. Typically, local pension funds target returns above inflation using a short-term interest rate view, which benefits inflation-linked bonds as well. As a result of this short-term/inflation-linked approach, the private bond market remains shy and investment levels are far from reaching their potential.
The value of issuances in Brazilian reais-denominated corporate bonds has risen 40 percent between 2009 and 2013, reaching R$ 64 billion in 2013, but the market is still very concentrated in short durations, with a limited investor base and low diversification of issuers. The low liquidity in the secondary market is one of the most significant factors affecting the interest of investors in long-term private bonds.

A liquidity backstop facility, in which a guarantee is given to investors that they can put their securities position to the guarantor if they are unable to sell them in the market, would be very appealing to investors. The facility would be in place as long as the transaction remained current, that is, the facility would not cover credit risks and could not be drawn upon in the event of default.

D. Summary of Funding Sources and Instruments

The major funds to potentially finance energy efficiency for street lighting are shown in table 7.1 below.

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Table 7.1 Summary of Possible Sources of Funding

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Information on applicability</th>
<th>Instruments to consider combine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Off municipal balance sheet</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Municipal on-budget financing/COSIP</td>
<td>Would budgetary approval to earmark a fixed amount of revenues to cover the upfront capital expenditures be required? The time it would take to roll out the project would depend on the amount that could be allocated in each year.</td>
<td>Budget availability is the key determinant of viability of this approach. The FEIP (COSIP) outstanding cash balance reached R$ 178.6 million in October 2012. However, it is difficult to forecast the future COSIP surplus, as COSIP is currently indexed only to inflation, not to electricity prices.</td>
<td>✔</td>
</tr>
<tr>
<td>PROCEL/RELUZ</td>
<td>PROCEL/RELUZ program consists of a credit line destined to channel resources to fund EE street lighting projects. Local DISCO acts as an intermediary between Eletronorte and the municipality. 75% of project costs covered by PROCEL/RELUZ remaining 25% is provided by the DISCO. Annual interest rate is 5 percent, tenor is 5 years.</td>
<td>PROCEL/RELUZ has essentially been defunded through recent regulatory changes to RG-122 collections.</td>
<td>✗</td>
</tr>
<tr>
<td>PEE</td>
<td>0.25 percent of the net annual revenue of each DISCO must be directed to EE actions. When funds are invested in the public sector, PEE is a mandatory grant, not a credit facility. For funds invested in the private sector, the principal amount needs to be repaid at very low to zero interest rates. Although PEE can theoretically be used for street lighting projects, such projects are unlikely to be prioritized under the new guidelines (65 percent to be invested in low-income communities; 20 percent of total investment must be in the two largest consumer groups, i.e., street lighting does not belong). Even if they receive funding, the contribution will be small compared to total project costs.</td>
<td></td>
<td>✗</td>
</tr>
<tr>
<td>BNDES</td>
<td>BNDES offers credit facilities for improvement, renovation or replacement of equipment associated with EE projects. PROCESCO is one option to consider if an ESCO model is chosen. Other BNDES credit facilities also warrant further exploration.</td>
<td>BNDES cannot finance projects for which capital expenditure for imported goods exceeds 60 percent. Given the lack of local LED manufacturing facilities in Brazil at this time, this could be a prohibitive restriction. It would be addressed if domestic manufacturing facilities were established.</td>
<td>✋</td>
</tr>
<tr>
<td>International lending facilities</td>
<td>The city could explore other lending facilities from the IFC Clean Technology Fund, the new International Lighting Efficiency Facility (ILEF), the GEF, the IDB, and others.</td>
<td>The strict debt limitations that many Brazilian municipalities face may affect Rio de Janeiro's ability to take on debt, particularly 100 percent of the project costs. Joint financing with municipal budget can be considered.</td>
<td>✔</td>
</tr>
<tr>
<td>National commercial banks</td>
<td>The city could explore funding from Banco do Brasil, Caixa Econômica, Banco do Santander, and others. This study did not identify any lending instruments specifically dedicated to funding municipal public street lighting projects, but these may eventually be established.</td>
<td>Strict indebtedness limitations that many Brazilian municipalities face may impact Rio de Janeiro's ability to take on debt, particularly 100 percent of the project costs. Joint financing with municipal budget can be considered.</td>
<td>✔</td>
</tr>
<tr>
<td>Off municipal balance sheet</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FIDC</td>
<td>FIDCs are mutual investment funds that invest at least 50 percent of their net assets in receivables. The FIDC could warehouse a sequence of infrastructure debentures for scale, risk, and investor-base assessment. Capital raised by the FIDC can be used to finance the upfront cost of EE projects and savings are used to repay FIDC investors.</td>
<td>As an off-balance-sheet transaction (not booked as municipal debt), this could be the answer for Brazilian cities with debt restrictions seeking funds for infrastructure projects. It would also establish the infrastructure that could eventually be used to bundle EE investments in other sectors or with other cities. However, the instrument may be perceived as more complex than other options.</td>
<td>✔</td>
</tr>
<tr>
<td>Debentures</td>
<td>Debentures are debt instruments issued by a corporation (sociedade anônima) that grants investors credit rights against the issuer. Capital raised from the issuance of debentures can be used to finance the upfront cost of EE projects and savings are used to repay investors.</td>
<td>This is a commonly used and simple instrument, highly acceptable to investors. There is demand and pricing that, if the transaction is well rated, is reasonable. Infrastructure debenture offers additional tax benefits for domestic and international investors.</td>
<td>✔</td>
</tr>
<tr>
<td>FIPs</td>
<td>Equity Investment Funds are closed-end investment funds that invest in shares, debentures, subscription bonds, and convertible securities of an SPE. FIPs can provide guarantees to debt securities.</td>
<td>Investment gains can be reinvested without taxation. Taxes are due upon redemption based on net gains. This instrument is less commonly used in Brazil and less likely to attract private sector investment.</td>
<td>✗</td>
</tr>
</tbody>
</table>
The overall interest for securities backed by EE projects is yet to be tested with local investors; however, a preliminary market read with local players indicated that:

- Debentures and FIDC shares are likely to be the instruments with the best acceptance rate.
- A successful placement in the current market will require yields between 11 and 12 percent per year in local currency (inflation + 5 percent and 6 percent). For example, a recent issuance of debentures backed by tax revenues from the State of Minas Gerais was priced at 300 bps over the local interbank rate (CDI), approximately 11 percent per year at the time. The tenor was 4-5 years. In a subsequent issuance, the cost dropped close to 200 bps (approximately 10 percent p.a). During the economic boom, CEMIG, the Minas Gerais state DISCO, placed clean 10-year bonds in the local market at 70 bps over CDI.
- Investor appetite beyond seven years is unlikely.
- As to the political risk associated with the project, that is, tax, regulatory and legal risks, additional guarantees may not be required. So far, local investors have taken on this kind of risk unsecured.
- Private local investors aside, BNDES may be able to purchase debentures issued by an SPE for EE projects as a way of fostering the local debentures market, one of the development Bank’s mid-term goals.

Table 7.2. Potential Credit Enhancements

<table>
<thead>
<tr>
<th>Type</th>
<th>Use</th>
<th>Instruments to consider/combine</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABGF-sponsored</td>
<td>Covers the so-called noncontrollable risks, such as political events</td>
<td>✔</td>
</tr>
<tr>
<td>guarantee</td>
<td>and others of a specific nature, such as the risks and losses</td>
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</tr>
<tr>
<td></td>
<td>associated with delays in the issuance of permits required prior to</td>
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<tr>
<td></td>
<td>the beginning of the construction work.</td>
<td></td>
</tr>
<tr>
<td>Liquidity backstop</td>
<td>A liquidity backstop facility, in which a guarantee is given to</td>
<td>✔</td>
</tr>
<tr>
<td></td>
<td>investors that can put the securities to the guarantor if they</td>
<td></td>
</tr>
<tr>
<td></td>
<td>are unable to sell their position in the market, would be very</td>
<td></td>
</tr>
<tr>
<td></td>
<td>appealing to investors. The facility would be in place as long as</td>
<td></td>
</tr>
<tr>
<td></td>
<td>the transaction remains current, that is, the facility does not</td>
<td></td>
</tr>
<tr>
<td></td>
<td>cover credit risks and could not be drawn upon in the event of</td>
<td></td>
</tr>
<tr>
<td></td>
<td>default.</td>
<td></td>
</tr>
<tr>
<td>Performance guarantee</td>
<td>The guarantee would be callable in the event that the investor</td>
<td>✔</td>
</tr>
<tr>
<td></td>
<td>receives less than the expected return supported by contracted</td>
<td></td>
</tr>
<tr>
<td></td>
<td>energy savings.</td>
<td></td>
</tr>
</tbody>
</table>

Given certain hurdles that need to be overcome by EE projects in order to tap local private funding, the preferred instruments are likely to be debentures, FIDCs or FIPs. In fact, the ideal private sector financing instrument could be a combination of these instruments.

The SPE is of utmost importance in the overall structure as a way to box risks and mitigants associated with the project itself, and to enable a clear and transparent arrangement of interests among all participants in the project supported by clear-cut documents, that is, SPE bylaws and Receivables Purchase Agreements, and others.

Conversely, the participants in the project will have their interests aligned, that is, an equity interest or mezzanine position, so as to foster the successful placement of the transaction among capital market
investors. Capital market investors shall be senior to the participants for the benefit of the cost of funds and tenor.

As to the efficiency of the overall funding cost, fees associated with structuring and private investors’ returns are significantly higher than the cost of subsidized funding. In addition, given the expected cash flow from EE savings and the funding profile from the private sector (shorter than the payback of the project and more expensive when compared to public financing), some form of concessional funding was considered in all the proposed structures designed to raise private funding. Credit enhancements to mitigate performance and liquidity risks are also good to have (despite not being absolutely necessary) as private investors tend to reward well-mitigated structures with lower expected returns, thus reducing the overall funding cost.

Finally, trust accounts to trap the cash generated by the project for the indirect benefit of the investors and participants would allow for better management and protection of participants and investor interest.

E. Repayment mechanisms

After reviewing the options for investment in this project, it is important to point out that the sources of funding used to repay any investment (by the city, the Federal government or other public entities, or the private sector) will likely be municipal budget allocation or COSIP surplus. Thus, it is worthwhile to discuss the potential risk perception of the private sector investors under each of these schemes.

9. Municipal budget allocation

In the case of a municipal budget allocation scheme (potentially using notionally earmarked COSIP surplus), the investors will face the municipal credit risk of the City of Rio de Janeiro. Currently, the city has investment-grade credit ratings (Baa2 by Moody's and BBB by S&P, both with a stable outlook since October 2013 and March 2014, respectively).

10. COSIP surplus allocation

In this case, private investors are exposed to performance and settlement risks. In terms of performance, a performance guarantee provided by the engineering, procurement and construction (EPC) consortium should be able to mitigate the risk satisfactorily. As to the settlement risk, cash control arrangements including a trustee, concentration and escrow accounts shall be set up for the benefit of ESCOS and private investors so as to ensure that COSIP funds will be collected and, consequently, made available to the contractual beneficiaries.

Finally, potential fluctuations in COSIP collections associated with political risk in the long term (for example, changes in tax law during the lifetime of the project) can be mitigated by representation from the Public Administration and make-whole provisions designed to protect the investor/concessionaire from such alterations whenever they occur. The mere existence of such mechanisms may help mitigate the investor’s perception of risk.
VIII. Replicability in Other Cities in Brazil

Although federal regulation creates many similarities among cities in terms of their public street lighting systems, municipalities still have a significant level of autonomy to set their own institutional structures, which may include state-owned companies, PPP Councils, and other councils with deliberative powers.

In addition, municipalities are very different in terms of size, population, consumption of electricity for public lighting, and situation of their fiscal accounts, among other characteristics. Importantly, municipalities may be in different situations with regard to implementation of ANEEL’s mandate to own and operate all assets related to public lighting.

Regarding ownership of assets, in the City of Rio de Janeiro, RioLuz already owns, operates and maintains the public lighting network. However, in some municipalities, taking on this new role could prove challenging, as providing public lighting services is not necessarily part of their core business activities. Municipalities that do not currently own and operate their public street lighting assets will either need to establish capacity internally to manage these new assets, or they may choose to issue a concession to the private sector (discussed further in this report). However, even if municipalities choose not to issue a concession, many will be too small to efficiently operate and maintain their public street lighting assets using in-house staff and will therefore need to subcontract this work. Some municipalities may face a learning curve with regards to the optimal approaches to subcontracting the operation and maintenance of these assets.

To mitigate such risk and counterbalance potential impacts arising from this change, municipalities could engage in efforts to increase their capacity to assess the best options available for the implementation of public street lighting services. It is important to highlight that such options should include the coordinated management of the assets among municipalities, which in some cases could be the optimum solution.

Ability to achieve scale will likely be one of the most significant barriers to replicating the models discussed for Rio de Janeiro in smaller cities across Brazil. This report identified two possible options to overcome this challenge.

A. Municipal Consortiums

For small and medium-size municipalities, it could be beneficial to enter into public consortia or other cooperative agreements to jointly contract EE projects, in order to share costs and profit from scale gains.

Regarding the joint management of public services by different state bodies, the Federal Constitution (article 241)65 provides for the establishment of consortia/program deeds66 in the public sector oriented toward the efficient provision of the services.

65 Article 241: The Union, the States, the Federal District, and the Municipalities shall issue legislation to regulate public syndicates and cooperation agreements between members of the Federation, authorizing the joint management of public services, as well as the
When appraising the potentially viable solutions to provide the service, municipalities could consider this form of cooperation in order to benefit from economies of scale when applicable. In this sense, municipalities can cooperate to put in place a joint concession to undertake the EE project in the whole area covered by the consortium. In this first hypothesis, municipalities would agree under the public consortium agreement to delegate the conceding power to the consortium, which would then open the public procurement process to contract a private concessionaire. Under this regime, by covering a wider area, municipalities can make the project more attractive for private sector investment and capture gains from economies of scale.

Another option would be to join forces in the consortium to directly execute the EE project. In this case, municipalities would come together to jointly implement the project themselves rather than engage in efforts to contract a third party(ies). However, this option is not likely to be feasible given that the provision of these services is not the core business of municipalities.

Other forms of cooperation are also possible under public conosortia. For example, municipalities can collaborate to transfer know-how, and share personnel and costs. Such arrangements are currently being used in Brazil for sanitation services.67

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66 Such legal forms are governed by the terms of Federal Law 11.107/05.
67 For more information about solid waste conosortia see Law 11.445/07.
B. PROEE Cooperative Model

In 2002, Law 9991 determined that utilities companies must invest at least 0.5 percent of their net operating revenue in energy efficiency projects approved by ANEEL under the PEE. Among the types of projects listed in the PEE, the “Cooperative Projects” type is of particular relevance in defense of project bundling across cities and across buildings/municipal agencies. According to the Procedures of the PEE (PROPEE), section 5.4 of module 5, Cooperative Projects, projects are designed to allow the joint action of distributors seeking economies of scale, complementary skills, application of best practices, and improved efficiency and quality of projects. To be considered a Cooperative Project, the project has to be carried out jointly by more than one DISCO in the areas of concession of the respective DISCO participants. The energy efficiency actions of Cooperative Projects are to be implemented in the DISCOs’ respective areas of concession with a financial contribution by each DISCO in proportion with its respective area.

Cooperative Projects should comply with modules 3, 4, 5 and 7 of the PROPEE, which establish the criteria for determining feasibility based on DISCOs and their contribution rates, cost of energy and demand.
IX. Conclusions and Next Steps

The City of Rio de Janeiro, through the concerted efforts of RioLuz and SECONSERVA, has significantly improved the quality and efficiency of its street lighting services. In spite of the significant efforts and results achieved, there is still potential to improve the provision of services (fewer outages, improved light) and cost reductions in terms of electricity and O&M expenditures. RioLuz and SECONSERVA are cognizant that in order to continue improving the public street lighting system, the next step is to make a technological leap toward LED street lighting. The World Bank agrees with this vision.

LED street lighting is a great opportunity for Rio de Janeiro to reduce energy use, create savings on electricity expenditures and improve the provision of public street lighting to citizens. Over time, these savings can create fiscal space to allow Rio de Janeiro to invest additional capital in other priority sectors, such as education, health, and transport. Beyond financial savings, an investment in energy-efficient public street lighting has the potential to improve security and increase economic activity in well-lit areas. Many cities in the world have tested this technology, and there are a few examples of full-scale deployment of LEDs in the developing world.

The technical study conducted for this paper concludes that the preferred implementation model would involve the installation of LEDs plus smart system technology, owing to the fact that this combination will provide the best overall benefits for the city at the lowest cost (when considering financial as well as economic/social benefits). Under this scenario, the study finds that Rio de Janeiro could save approximately 57 percent on electricity bills and 33 percent on O&M expenses. This significant savings potential would come with improvement of overall quality of light around the city.

Modernizing the system will require a significant up-front investment. The base case scenario assumes a total capital expenditure of R$ 420 million over a five-year period. Despite these high costs, the investment has an NPV of R$ 150 million over a 15-year period and is forecast to be repaid after 8.5 years, after which the city will enjoy the full benefit of reduced expenditures. Sensitivity analysis to the energy price cost of equipment and actual energy and O&M savings suggests a range of payback periods of 7.5-10 years, and an FIRR of 8-21 percent. For the economic analysis, which reflects the real cost to the economy of Rio de Janeiro by eliminating taxes and subsidies, the payback period decreases to 5.2 years with an FIRR of 45 percent and an NPV of R$ 430 million.

The sensitivity analysis shows that the project will still be attractive even at somewhat higher LED prices, lower electricity rates and lower savings rates. The conclusion of this study is that there is a strong likelihood the city will be able to obtain LEDs at a price that makes the project financially viable (that is, well below $R 2,150 per installed LED plus smart system). Furthermore, the project is not highly sensitive to changes in electricity prices. However, the study finds that it is very important for the city to maximize the potential O&M savings that can come from an LED street lighting program. Presumably, this will ultimately require a decrease in workforce staff operating and maintaining the public street lighting program, regardless of the procurement model selected. This issue will need to be carefully but comprehensively addressed.

Regarding LED pricing, the final price that Rio de Janeiro can receive will likely only be revealed as a result of a competitive bidding process. LED prices are falling rapidly, at approximately 10 percent per
year. Given that the price of LEDs is expected to decline significantly going forward, it may be tempting to believe that the City of Rio de Janeiro would be better off if it waited a few more years to implement the program. However, the study concludes that there is a significant opportunity cost in waiting to implement the LED project; the forgone savings in electricity and O&M are expected to be nearly double the possible savings that could be achieved due to price decline. Thus, in spite of the declining price, the City of Rio de Janeiro is best served by implementing the large-scale modernization program as soon as possible.

Given the high up-front costs, it may be attractive for the city to source private sector financing. Furthermore, the city has limited fiscal space, so off-balance-sheet financing through a PPP could be the optimal financial solution. The conclusion of this study is that the city should be able to attract private sector financing to this project, as the estimated financial returns cited above are attractive. The PPP approach also has the greatest potential to maximize savings and minimize the financial and performance risk faced by the city. These significant benefits will need to be evaluated against the potential costs of a PPP approach, namely the longer project preparation time and the need to make adjustments to RioLuz’s business model. The alternative solution is for the city to fund the project from its own balance sheet, using procurement under Law 8.666/63; however, this model could result in lower savings from the project over the long term.

If a PPP model is selected, RioLuz could play several possible roles. One possible role is to execute the functions of strategic planning, quality monitoring and supervision, and granting and regulating concession contracts. These are critical activities for ensuring proper and smooth functioning of a concession service granted to third parties. Some of the functions could require amendments to existing municipal legislation, as they are not spelled out in the RioLuz bylaws. The second possible role for RioLuz would be to participate as a minority partner should an SPV be established to serve as the concessionaire for public lighting services in Rio. The roles and responsibilities of each partner in the SPV would need to be clearly spelled out in a shareholders agreement. RioLuz may have to scale down some of its current operational activities depending on the agreed responsibilities among the partners, and to adjust its headcount accordingly.

Another issue that will need to be addressed if the PPP option is selected is the lack of clear regulations regarding concession agreements for public street lighting. There could be a number of complex variables included in the concession contract (for example, setting adequate rate levels based on revenue requirements, rules to share efficiency gains, dealing with exogenous factors such as changes in electricity prices). These details should be dealt with at the outset, before a concession is granted. A renegotiation process, or even an extraordinary rate review, can be time-consuming and potentially disruptive. To overcome these challenges, many lessons can be learned from years of experience in the power sector, particularly from the experience of privatization of the electricity distribution business.

Regardless of the implementation and financing model selected, the city needs to ensure that it completes a comprehensive study to realistically forecast future COSIP surpluses (or deficits) if it considers using the COSIP surplus to fund the project, because the expected increase in energy prices has the potential to significantly reduce or eliminate COSIP surpluses in the future. Thus, unless COSIP laws are changed so that COSIP revenues are indexed to future electricity prices, it is not advisable for the city to rely solely on the COSIP surplus to fund the project, but rather to earmark revenues out of the
general municipal budget to fund the project and to use COSIP revenues to offset the planned budget allocation when possible.

In summary, the City of Rio de Janeiro is a pioneer in the public street lighting sector in Brazil. It has recently met its primary operational targets for 2015 and is now interested in focusing its efforts on innovation, including installation of LEDs. This decision acknowledges the vast financial, economic and social benefits that LEDs (plus smart system technology) can offer the Municipality of Rio de Janeiro and its citizens. The City of Rio de Janeiro will need to assess its budgetary and fiscal space, in tandem with evaluating the impact that each procurement model would have on the operation of the street lighting system and the potential efficiency of the project. It is important that the city take a long-term view when making this assessment. It could very well be the case that short-term savings (in terms of time, or avoidance of changes to the institutional setup) could result in a significant opportunity cost for the city in the long term. The World Bank Group remains available to support the city in a variety of ways going forward, from technical assistance to deal structuring to investment.
X. APPENDIXES
Appendix A: Site Auditing Methodology

Sampled unity:
Public lighting points

Sampling purposes
Understand technologies in use, lighting quality and energy savings potential to replace existing public lighting in Rio de Janeiro.

Data collected and parameters evaluated:
- Bulb technology, rated power and Luminaire cover
- Pole configuration, kind of public way and luminaire height
- Kind of urban area: commercial, residential, touristic, others
- Luminance measurements

Sampling selection:
- By clusters, using sampling standard NBR 5426 table: normal sampling, level I.
- Groups of at least five poles were clustered for streets with poles on both sides and at least three poles for one-sided street poles

Object population/sampled population:
Areas experiencing social unrest or that were difficult to reach were excluded from sampling.

Sampling site:
- Rio de Janeiro: public lighting population: 425,000 thousand points
- Sampling standard: NBR 5426, sample code M, normal inspection, general inspection level M
- Sample size: 315 lighting points
- Data provided by utility: lamp type, power/luminaire/bracket/suburbs

Results were obtained with a calibrated Minipa MLM-1011 lux meter, all measurements were done after 8 p.m., each site comprised of at least three poles in sequence and their counterparts across the street, five measurements were performed on one sidewalk, five in the middle of the street and five on the sidewalk across the street.

68 To be elaborated in final version of report
Appendix B: Luminance and Uniformity Sampling Data

The analysis indicated that the minimum luminance is relatively low for the selected sample. Results are shown in figure B.1 below. Almost half of the cases present a luminance between 20 and 40 lux and almost 30 percent between 40 and 60 lux. Only as a reference point, a double-lane road would require a luminance of about 30 lux.

Uniformity was fairly low for the selected sample. In more than 60 percent of the cases, uniformity was below 60 percent, as shown in figure B.2. A double-lane road, with proper lighting, would require a uniformity index between 0.3 and 0.4. Poor uniformity reflects the fact that electric poles are not spaced equally. Rio is a very “green” city, with many trees, what also contributes to low uniformity indicators (as lamps are placed above the canopy of the trees).
Appendix C: Installation of Underground Distribution Cables and the Potential Impact on the Selection of the Business Model

RioLuz has been considering two business models for the modernization of the street lighting system in the City of Rio de Janeiro.

The first model, to be applied to areas mostly located along key avenues and in the South zone of the city, an area served by underground power distribution, encompassing a total of 80,000-90,000 lighting points. The street lighting cables are already buried in those areas and there are dedicated poles. RioLuz believes that with minimum retrofits this subset of the street lighting footprint would be ready to be tendered as a concession/PPP to have its lighting system modernized and replaced by efficient LEDs.

The second model under consideration by RioLuz involves modernizing the basic public street lighting infrastructure before or in tandem with LED installation, primarily by implementing an underground cabling system and dedicated poles. The understood goal of this project is to improve the aesthetics of the city and reduce vulnerability to lightning strikes, cable theft, traffic accidents, costly tree trimming, and other events.

Cost/Benefits of Underground Systems

The results of preliminary research conducted in Brazil and of researching international precedents indicate that the costs of this project would not justify the benefits. As a rule of thumb, it is estimated that an underground system costs five times more than a traditional, albeit aesthetically unpleasant, aerial one with the same carrying capacity. The incremental investment cost alone for street lighting, including underground cabling, would be close to R$ 1,600 per pole, equivalent to the total investment to modernize the system with LEDs. Thus, if the two projects (installation of LEDs and underground distribution cables) were bundled, the cost of the project would double.

The question then becomes whether there would be sufficient benefits to justify these additional costs. The primary benefits discussed thus far include savings due to reduced cable theft and to reduced lamp outages from to lightning strikes.

Recent studies carried out in the state of Virginia (United States), concluded that the relocation of existing overhead lines would result in tremendous costs and significant disruption. A major relocation initiative could take decades to complete. The costs estimated by utilities would exceed US$ 80 billion and the resultant annualized revenue requirement would be US$ 3,000 per customer. The additional cost to bury telecommunication and cable TV would be an additional US$ 11 billion. The study also concluded that the placement of new distribution lines underground, though not as costly, was probably not as cost effective. The study’s final conclusion was that reallocation of existing utility overhead lines and placement of all new utility distribution lines underground was probably not cost effective. The economic effects would be significant. Similar studies have been carried out for the states of North Carolina and Maryland, and by the Edison Electric Institute, confirming those conclusions.
While there is no doubt that an underground system is more reliable and less prone to outages overall, industry experts have different views on the benefits in terms of theft protection and ability to withstand lightning strikes. For example, interviews with experts in PROCEL indicate that underground cabling is not necessarily less prone to theft because the inspection boxes can be opened and access to cables is sometimes even easier\(^70\) (such was the case of Linha Vermelha in Rio and some in some tunnels where the cabling had to be moved to the upper part of the tunnel to avoid recurrent theft).

**Cooperation with Power Utility**

As far as lightning strikes are concerned, there are only benefits if both the power distribution network and the street lighting are retrofitted and buried underground. Having an aerial distribution network and underground street lighting would not offer extra protection, since most of the voltage surges responsible for damaging electronic equipment come from the aerial network and are due to poor grounding, deficient protection, or faulty surge arresters.

Installation of electric underground cables for the entire electricity distribution network will be very costly and would require cooperation with Light. This is likely to be a complicated, city-disruptive, and time-consuming process. Perhaps even more important, ANEEL is unlikely to allow this type of investment to be passed on to consumers through higher electricity rates,\(^71\) except under exceptional circumstances, when the benefits clearly exceed costs.

**Legal Mandates**

On the other hand, there are ongoing discussions to oblige cities/local utilities to retrofit their overhead infrastructure into underground systems. A municipal law in Rio mandates that all cables must be moved underground, but it has been repealed by a legal injunction. There are also bills being drafted in Congress, which are at several stages of development. For example, Bill 119/2011 stipulates that underground distribution networks should be put in place prior to the paving of new streets, and that federal funding should only be granted to municipalities abiding by this provision. However, none of the bills specify who is going to bear the additional costs for developing underground infrastructure. A clear regulatory framework for cost recovery should be put in place to make any underground project feasible for the utility.

**Alternative Approaches**

RioLuz is genuinely concerned that before a decision to deploy LEDs on a massive scale is made, the risk to the physical integrity of the equipment should be minimized, in other words, the electric network is able to

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\(^70\) To avoid this problem, RioLuz has started to place lighting poles on top of inspection boxes.

\(^71\) ANEEL’s approach to requests to implement underground systems and pass on costs to ratepayers has been a very conservative one, analyzing carefully on a case-by-case basis. For example, authorization has been provided for historic cities in Minas Gerais, such as Ouro Preto. Other cases have not been financed by ratepayers, such as in the tourist city of Gramado (Rio Grande do Sul) – largely financed by the Minister of Tourism - and Rua Bela Cintra in São Paulo, financed by local businesses and residents.
provide good quality power and the LED equipment is able to withstand the voltage fluctuations and voltage surges originating from the distribution line.

For the area of the city containing the 80,000-90,000 lighting points served by underground distribution, the work to retrofit the system would be relatively modest, consisting of replacing the original grounding cable where it has been stolen or deactivated. If a concession/PPP is granted for this area, such work could be an integral part of the modernization program. It is in the concessionaire’s best interest to make sure that the equipment is properly protected at the outset, as it will be fully responsible for maintaining and replacing this equipment. In preparing the TOR for the PPP, it is important to specify, with as much clarity as possible, the situation of the grounding network and the effort and investments required to make it up to standard. A technical study is required for this area, even if the PPP option does not come to fruition. Such a study is important, particularly if RioLuz is the implementing entity for LEDs in those areas. 72

For the other areas of the city, one possibility is to liaise with Light, the distribution utility, to identify areas of the city (or particular streets or large avenues) where underground cabling is being planned in the short and medium term, and coordinate with the efforts on underground street lighting (cables and poles). If underground systems are not being planned in the short term, the option is to develop a coordinated effort with Light to identify the technical improvements required by the aerial network to reduce the risk of damage to sensitive equipment connected to the grid. In actuality, the original design of any distribution network includes safety devices. However, over time not all of them are maintained in proper condition, surge arrestors are not always replaced, grounding cables are missing or have been stolen. The study should identify the effort, investment and time required to bring the grid up to standard, making use of the best available technologies.

This would also be in Light’s best interest. The same surge that could potentially damage an LED luminaire could also cause multiple damages to the electronic equipment at customers’ premises located in the vicinity. Current regulations in the power sector, in tandem with support from customer protection agencies (for example, PROCON), impose penalties on the distribution utility for damages caused to their customers’ equipment such as TVs, computers, and fridges. Therefore, it is in Light’s best interest to detect and repair any vulnerability of the grid that may compromise quality of service.

In Summary

The development of a reliable and aesthetically neutral underground network is the ultimate goal of any municipality in the business of street lighting. However, burying cables doubles the modernization investment cost, and requires a concerted effort along with the development of an underground infrastructure for the power distribution utility. In this case, the costs are massive, and unlikely to be passed on to the end-user except under exceptional circumstances, but never on a citywide basis. In addition, the disruption to the city’s life cannot be underestimated. In sum, burying the power distribution infrastructure is

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72 Even if the manufacturer provides an extended warranty covering damages caused by lightning strikes, the labor costs for replacing a defective lamp is still RioLuz’s responsibility.
unlikely to happen on a massive scale for the next 10-15 years (except in some niches or areas of extremely dense load concentration).

RioLuz has a legitimate concern that sophisticated LED equipment should not be installed in a distribution network without proper protection against lightning strikes and voltage fluctuations. Equipment specifications may help, but not suffice. An underground system is much less prone to damage caused by lightning strikes. However, it may not be advisable to postpone the modernization of the lighting infrastructure with underground distribution as a prerequisite. By the same token, the design of a concession/PPP business model should not wait until the system is completely buried underground.

A reasonable trade-off is to ensure that the aerial distribution network is properly protected and maintained by Light. Efforts should be coordinated with Light, which has a regulatory responsibility to provide good quality services not only for street lighting, but for all customers supplied by distribution feeders.

Two studies are recommended as part of the modernization and/or concession/PPP effort:

- For areas served by underground system – an engineering study should be undertaken to determine the extent of work, investment and time required to provide proper grounding to the street lighting infrastructure.
- For the other areas – liaise with Light to determine the areas or avenues where the power network is likely to be buried underground soon; in those cases, street lighting cabling should piggyback on the effort. For the remaining areas where systems are unlikely to be buried underground any time soon, develop a joint study with Light to identify and upgrade medium- and low-voltage distribution lines to ascertain the maximum protection needed against lighting surges. RioLuz (or a concessionaire) could then plan to deploy LEDs in coordination with Light’s improvements to the distribution grid.
Appendix D: Mechanisms for Incentives for EE in Concession Agreements

How will Concessions be Granted?

If Rio de Janeiro (or other Brazilian municipalities) opts to establish a PPP or other form of concessions for the operation and management of public street lighting, the city and the concessionaire will need to agree on what basis the city will make payments to the concessionaire. ANEEL will continue to set rates charged by the utility (B4), but municipalities will be responsible for determining the revenue required to fund public street lighting and for informing the utility of the corresponding tax structure that ratepayers should be charged (that is, the values of COSIP, differentiated by customer group).

Since there are no public street lighting concessions in place today in Brazil, there is no precedent that Rio de Janeiro could draw upon to decide the basis on which to grant the concession and how to regulate a concession for public street lighting. However, as a starting point, one can draw an analogy with concessions for power distribution or other network industries to devise options for granting street lighting concessions. Using this analogy, there could be two ways for municipalities to award concession contracts:

- Municipality sets a price or revenue, which could be denominated as a percentage of the COSIP collected, and awards the concession based on the highest value offered for the concession territory
- Municipality awards the concession based on the lowest offered price or revenue required, which should then be the basis for the municipality to set the COSIP revenue requirements to be collected from ratepayers

In either case, the concession contract should be very detailed in terms of quality of service, goals and time frame for modernization (for example, installation of LED and/or smart system technology), recovery of extraordinary expenditures, rate adjustment and review processes, penalties for noncompliance, review of COSIP proceeds, termination, extension and renewal, and sharing of efficiency gains with ratepayers. “Regulation by contract” is a way to overcome the lack of a traditional regulatory body of knowledge and regulatory institutions for street lighting in Brazil.

Mechanisms to Foster Efficiency

The concession contract should establish a regulatory mechanism that affects how efficiency gains (energy and/or operational savings) will be shared with ratepayers and how often assessment of revenue requirements should take place. In simple terms, there are basically two rate mechanisms, which have very different impacts in fostering efficiency: cost-plus and revenue cap.
Cost-plus (also called “rate of return regulation” or “tarifa pelo custo”): Under this model, revenues required for an operator to run the concession are initially set based on the expected operating and capital costs (depreciation plus a reasonable return on assets), taking into account modernization and expansion. Once set, revenues are reviewed once a year (or more often for noncontrollable costs such as variations in the price of energy). The regulator scrutinizes the costs incurred and may disallow some costs to be passed on to the revenue base. Cost-plus regimes generally discourage efficiency, for two reasons: (a) first, they claw back efficiency gains every year, discouraging investments with long payback periods; and (b) second, since all costs can be recovered provided the regulator believes the investment to be prudent, this model offers low risk for operators but also little incentive to improve energy efficiency. This model has been used extensively in the United States.

Revenue cap (also called “RPI-X” regulation): Under this model, the regulator sets a fixed rate (or, more appropriately, a revenue base) for an extended period of time, such as six or seven years. Rates are adjusted by inflation (the Retail Price Index, RPI). Most gains in efficiency are captured by the operator, except the portion that needs to be contractually passed on to the ratepayer (the “X”). Given the long rate review period, the operator has more incentive to reduce operating costs. The regulator has limited scrutiny over costs in between revenue periods. Some costs (particularly noncontrollable ones such as those resulting from variations in electricity rates) may be passed on in full. Once the review period ends (that is, every six to seven years), the rate (or revenue) goes through a major review. During the review process, the regulator resets rates (or revenues) based on prudent costs, or using efficiency benchmarks from other operators or concession areas. The advantage of the RPI-X is that it fosters efficiency and encourages investments that reduce costs, as long as the payback period is within the review period. The disadvantage of the RPI-X is that operators have fewer incentives to provide good quality service, unless penalties for nondelivery are clearly spelled out in the contract. This model was used in the United Kingdom in the 1980s during privatization of most state-owned companies.

In either case, the regulatory framework of the street lighting concession has to make sure that:

- The system has built-in flexibility to review the COSIP levies to be charged to ratepayers in the following year, based on forecasts for the operational and capital cost components to be passed on through rates
- There are sufficient COSIP funds to enable the concessionaire to fully pay for the costs of energy and O&M expenses; COSIP surplus should be able remunerate the investments in modernization and expansion
- FEIP contains a buffer to smooth out some expected volatility in the COSIP proceeds (see box 7.1)
Appendix E: Detailed Review of Procurement Laws

A. Standard public procurement - Law 8.666/93

Overview

Law 8.666/93 rules out the procurement of goods, services, and engineering works by the Public Administration as well as the sale of public assets. It is among the most commonly used laws for public procurement of goods and services.

One of the most important aspects of this law is that engineering work and service provision can only be contracted once a “Basic Project” has been approved by the competent authority (article 7, §2). According to the Law, a Basic Project is defined as the key specifications that characterize the works or services to be tendered, taking into account preliminary technical, economic, environmental, and social studies, thereby enabling bidders to assess costs and the schedule for execution. This means that no procurement for the provision of services or the performance of engineering work can take place without a Basic Project. The Basic Project may be developed by the Public Administration or by a third party. If the Public Administration decides to contract private agents to execute the Basic Project, it must launch a separate bid. Importantly, Law 8.666/93 prevents the same company or consortium from executing the Basic Project and also bidding for the engineering work.

There are two main models that could be used to implement an energy-efficient public street lighting project: (a) procurement of goods (LED equipment) only; and (b) procurement of goods and services (LEDs plus services, including installation and maintenance).

Selection Criteria

Under Law 8.666/93, the criteria to define the winner of the bid consist of:

- The lowest price
- Best technical proposal
- A combination of technical level and price
- The highest price proposal

Under Law 8.666/93, competitive selection using *concorrência* is required for all engineering contracts over R$ 1.5 million. In addition, bidders on the project design and the execution of the project itself must be prequalified before their bids can be submitted.

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73 This does not necessarily mean that the company or consortium that presents the best technical proposal will be contracted. According to Law 88.666/93, once the Procurement Commission identifies the company or consortium that presented the best technical proposal, it shall undertake negotiations with this bidder with a view to it accepting the contract for the lowest price offered among all the bidders that met the minimum technical requirements according to the invitation to tender.

74 The highest price proposal is associated with the sale of assets or rights by the Public Administration, and means that the Administration shall sell its assets to the bidder that offers the highest bid for them.
Contractual Term

According to article 57 of Law 8.666/93, the tenor of an administrative contract is limited to the duration of budgetary credits (usually up to one year), which must be earmarked upon signing the contract. There are exceptions to this provision, which include (a) projects that are fall within the goals stated in the Pluriannual Plan (Lei do Plano Plurianual), which may be extended in the interest of the Public Administration provided that this has been stated in the invitation to bid; (b) contracts regarding services of a continuous nature, which may be extended for equal and successive periods up to 60 months; and (c) leasing of computer equipment and programs, whose duration may be extended up to 48 months.

Therefore, if a contract involving EE is expected to last more than one year, it must be compatible with the Pluriannual Plan and the Budget Directives Law (Lei de Diretrizes Orçamentárias). Should this be the case, the corresponding disbursements would be included in the Annual Budget Law.

Linking Performance to Payments under Contract

In the case where Law 8.666/93 is used to purchase LED equipment only, the city would be responsible for installation, operation and maintenance. Thus, in this scenario, there would be little room or need to link the contract with overall performance in terms of electricity savings. This is because the manufacturer would not be directly involved in the operation of the equipment and, thus, would have limited ability to guarantee overall system electricity savings. That being said, the equipment supplier should be willing to provide some form of equipment warranty for the performance of the LED equipment itself (LED lifetime, lumen output per watt, and others).

In the case where Law 8.666/93 is used to purchase LED equipment as well as services (installation and maintenance), it will still probably be difficult for Rio de Janeiro to include in the contract metrics to link payments to energy efficiency performance. This is because Law 8.666/93 does not expressly address performance contracts, and the selection criteria for proposals (see above) do not allow the city to adopt the “best energy-saving proposal” as the criterion for selecting the winning bid. An attempt to do so could be challenged by internal and external monitoring bodies of the Public Administration, such as the Municipal Controller General, the Municipal Auditing Court, or even the judiciary.76 Thus, although the city could receive a warranty from the manufacturer, it will be challenging to link payments under a contract using Law 8.666/93 to the actual EE performance of the project.

This does not mean that it would be impossible to include aspects of a performance contract in a bid using Law 8.666/93; however, the process could be delayed by review by the Municipal Controller General. One possible option would be to link payment by the Public Administration to minimum service

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75 Owing to the anticipated size of the contract for this project, this study does not discuss other types of public procurement processes provided in Law 8.666/93, such as convênio, tomada de preços, leilão and concurso, as they are not likely to fit the purposes and amounts involved in EE projects.

76 This is especially true if one takes into consideration that article 45, §5, of Law 8.666/93 voids the use of criteria other than those expressly provided in the law to define the winning bidder; that is, the Public Administration cannot include in an invitation to bid any new selection criteria not stated in the law.
level requirements (service level agreements) according to objective criteria set out in the administrative contract.

It is also worth noting that, owing to budgetary restrictions, it will probably be difficult to directly use the savings in the electricity bill of the city to pay for the goods or services provided under a procurement contracted under Law 8.666/93.

**Process and Timeline**

The standard public procurement process under Law 8.666/93 requires (a) the publication of the invitation to bid in the Official Gazette; (b) the prequalification of bidders,\(^ {77} \) including possible appeals against the Commission's decisions; (c) the opening and ranking of bid proposals; (d) confirmation and award of the contract to the winner of the bid by the competent authority; (e) execution of the contract. Whenever the contract amount is greater than R$ 150 million, a public hearing shall be convened 15 days prior to the issuance of the invitation to bid.

The processing time for procurement under Law 8.666/93 depends largely on the complexity of the goods and/or services being procured and the complexity of the selection criteria. The simplest form of procurement under Law 8.666/93 would involve the procurement of equipment only. A more complex form of procurement under Law 8.666/93 would bundle procurement of equipment with services for installation and/or maintenance of equipment. Based on interviews with local stakeholders, the estimated timeline for procuring equipment only is one to two months. The estimated timeline for procuring equipment and services is three to six months.\(^ {78} \)

**B. Procurement by Auction - Law 10.520/02**

**Overview**

Law 10.520/01 (also known as *Pregão*) is designed to facilitate the purchase of “standard” goods and services by the municipal government through a process known as a reverse auction. The law considers as “standard” goods and services that are widely known in the market and whose characteristics can be objectively described.

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\(^ {77} \) “Prequalification” is being used in this report as a translation of *habilitação*. It shall be noted, however, that article 114 of Law 8.666/93 (on concorrência) as well as RDC law allows for the possibility of a prior “prequalification” of bidders, in which case only companies and consortia previously registered with the Public Administration shall be eligible to participate in the procurement process.

\(^ {78} \) It is hard to provide a precise estimate of the length of a public procurement process, since appeals sometimes suspend the process and there are different levels of authority to which a party may appeal against a decision of the Procurement Commission, including to the judiciary. Also, prior approval of the invitation to bid may sometimes be required from the Municipal Auditing Court and other monitoring bodies. This applies to all the models mentioned in this report; therefore, timeline estimates should be considered as indicative only.
Under Law 10.520/02, the contracting party shall publish the invitation to bid and set a date for receiving the proposals, which shall be at least eight days after the invitation is published in the Official Gazette. During the public session to analyze the proposals, an oral (live) auction shall take place among all the bidders that presented proposals less than 10 percent higher than the lowest bid. In case there are no bidders that fit this criterion, the bidders with the three best proposals shall be invited to the oral auction phase. After the best proposal is identified, the auctioneer shall open the envelope with the documentation of that bidder. If documentation is in compliance, that bidder shall be declared the winner. If the bidder lacks the documentation required in the invitation to bid, the auctioneer shall pass on to the bidder that presented the second-best proposal, and so on.

Bidders for the project design and the execution of the project itself do not need to be prequalified before their bids can be submitted. This allows for a more expeditious procurement process compared to Law 8.666/93. In principle, only the documentation provided by the winner will be reviewed by the public authority; if it does not comply with the bid’s requirements, the second-best bidder shall have its document reviewed and, if compliant, that bidder would be hired.

**Selection Criteria**

The only selection criterion for these procurements is the lowest-price bid. If LED specifications can be objectively described, they may be eligible for procurement under Law 10.520/02. However, it is important that the city be able to unambiguously define the technical specifications for LEDs in order to minimize technical and performance risks.⁷⁹

Given these limitations, this procurement model can only be used for the purchase of LED equipment. It is possible that *Pregão* could be used for the purchase of LED plus smart system technology, but it is much less likely that the complete smart system technology package (transponder, GPS, central control software, and others) will be considered “standard,” particularly not in the near term. The procurement of a package of LED equipment and installation and/or maintenance services would certainly not be possible.

**Contractual Term**

The contractual term under Law 10.520/02 is up to 12 months, or one annual budget. For services provided on a regular basis, this term may be extended up to 60 months (five years).

**Linking Performance to Payments under Contract**

Similar to the situation of using Law 8.666/93 to purchase LED equipment only, under this model it would not be possible to link the contract with overall performance of the project in terms of electricity

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⁷⁹ This would include technical specifications on LEDs and luminaires, such as lifetime, efficiency in lumens per watt, color temperature, CRI, light distribution (isoluminance curves), depreciation factor, terms of guarantee, serviceability, voltage tolerance, surge protection, and others.
savings since no services would be procured and the selection criteria only allows for selection based on lowest price.

**Process and Timeline**

The advantage of this procurement model is that it entails a very simple process, which may be concluded in less than one month after the invitation to bid is launched. The Law also allows the public authority to conduct electronic auctions through the Internet.

**C. RDC regime - Law 12.462/11**

**Overview**

In 2011, Brazil approved a new public procurement law, called the Differentiated Contracting Regime (*Regime Diferenciado de Contratações*, RDC). The basic idea of the RDC regime is to allow for integrated contracting, that is, one single procurement process that can be designed to contract the initial and final project design, as well as the construction on a turnkey basis. The Law also provides for the possibility of a prequalification process, in which case only companies already registered with the public contracting party will be allowed to participate in the bidding.

RDC was originally restricted to contracts for the 2014 World Cup and the 2016 Olympic Games; however, the Law has been amended several times to allow the adoption of RDC to contract engineering works and services in other areas, including public education buildings; public hospitals; projects contracted under the federal Growth Acceleration Program (*Programa de Aceleração do Crescimento, PAC*); and engineering works and services at ports, prisons, and social educational structures. Given the increasing scope of sectors for which the RDC regime is being applied, this new procurement model may become the future general procurement law, should the Brazilian Supreme Court confirm its constitutionality.  

Despite the fact that the list of cases eligible to the contracted under RDC has grown, it still does not expressly mention electricity, EE or public lighting. Therefore, at this time it does not seem possible to use the RDC procurement process for a public lighting EE project. However, the Brazilian Congress is current debating legislation that would allow the RDC regime to be used across a broader range of projects, probably including EE. This new legislation will be rejected or approved by mid- to late-2014.

**Selection Criteria**

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80 This is currently being challenged in two different lawsuits: Direct Actions of Unconstitutionality (ADI) Nos. 4645 and 4655.
81 The RDC regime could be used for EE projects involving public universities, schools, and hospitals. As these are educational and public health entities, according to article 1º of Law 12.462/11, engineering work and the provision of services only to these kinds of structures may be possible under RDC rules. RDC legislation allows for integrated contracting, that is, a single procurement process could be used to contract the design of the Basic Project and the execution of the project, as well as the construction on a turnkey basis. The RDC regime is currently being challenged before the Federal Supreme Court.
Similar to the Pregão regime, one of the benefits of using the RDC regime is that bidders on the project design and the execution of the project itself do not need to be prequalified before their bids are submitted. This allows for a more expeditious procurement process compared to Law 8.666/93.

**Contractual Term**

The rules of Law 8.666/93 apply. Therefore, in the case of service provision, annual contracts could be renewed five times, for a maximum five-year term.

**Linking Performance to Payments under Contract**

Linking performance to payments under RDC contracts is expressly authorized. Thus, if approved for public street lighting projects, this procurement model could allow for the use of energy-efficient performance contracts for LED retrofit projects.

**Process and Timeline**

When the selection criterion adopted is not the highest price or the largest discount (that is, whenever technical and performance issues are used as the criteria), the deadline for receiving proposals shall be at least 30 business days after the invitation to tender is published. A bidding process may be concluded as quickly as 60-90 days.

**D. Concession of Public Services and PPPs**

**Overview**

Since 1995, Brazil has had a general law on concessions for public services, whether preceded or not by engineering work (Law 8.987/95). Under Law 8.987/95 the conceding party is authorized to transfer the execution of a public service to private parties, which shall be remunerated by rates paid by end users of the service. The concession of public services shall follow the concorrência procedure established under Law 8.666/93, or a public auction (for the sale of public assets and rights), also provided for in Law 8.666/93. The selection criteria may involve the highest price paid to the public authority, the lowest rate, the best technical proposal, or a combination thereof.

On December 30, 2004, Law No. 11.079/04 established the general rules applicable to PPPs (subsequently amended by Law 12.766/12). Before this law, under the concession law, the private sector could build and operate public infrastructure, but doubts were raised about whether or not the government could make payments to the concessionaire, as concessionaires were expected to be paid by rates.

Considering that EE projects are not eligible to have rates paid by end users – it is not a specific service provided to consumers, but rather to the municipalities – we see no advantage in investigating the traditional concession legislation further. Therefore, we detail below only the provisions regarding PPPs, which seem to be much more applicable to the case of efficiency in street lighting.
The PPP law defines two types of concessions.

**Sponsored Concessions**

Sponsored Concessions (*Concessões Patrocinadas*) are those in which the revenues arising from the provision of public services by the concessionaire (rates) are not enough to make the project attractive from a financial and economic perspective. In this case, the Public Administration makes the concessionaire whole by providing additional payment for the services, on top of the regular charges.

Under Sponsored PPPs, the private party shall invest the capital required for the project up front. Once the infrastructure is made available to the public, the concessionaire begins to receive compensation via service charges paid by end users and public payments made by the Public Administration.

Considering that public lighting EE projects do not involve the provision of services directly to end users but instead involve the provision of services to the municipal government, it is not envisaged that this form of PPP would be used for a public street lighting PPP.

**Administrative Concessions**

In Administrative Concessions (*Concessões Administrativas*), the Public Administration is the end user of the services to be provided by the concessionaire and, as such, it shall bear all the costs.\(^{82}\)

In principle, the payments to the private investor only commence after the service is made available. The project may be split into different phases, in which case, once a part of the project is made available, payment by the public authority is authorized. Also, after the adoption of Law 12.766/12, public investment can be provided for reversible assets and works before the service is made available, that is, up-front payments by the Public Administration is allowed for those assets that shall revert to the public power upon termination of the concession agreement (article 6, § 2, Law 11.079/04). In the case of an EE project, payment to the concessionaire could be subject to proof that equipment has been changed and/or that the works and services required by the contract to reduce the public lighting bill have been provided. In the case of a public lighting EE project, the end user would be the Public Administration.

Based on the above descriptions, it is clear that an Administrative Concession is the most appropriate PPP model to employ for a public street lighting EE project in Rio. Thus, the remainder of this section will evaluate the characteristics and limitations of Administrative Concessions.

**Selection Criteria**

Selection criteria that can be used when evaluating bids under a PPP are the following:

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\(^{82}\) This contracting structure does not prohibit the concessionaire from seeking alternative sources of revenues from third parties, when feasible, such as by using publicity.
The lowest rate to be charged to the end users of the public service
- The best proposal arising from a combination of the lowest rate and the best technical proposal
- The lowest amount to be paid by the Public Administration
- The best proposal combining the lowest amount to be paid by the Public Administration and the best technical proposal according to the terms of the invitation to bid

Compared to the selection criteria allowed under Law 8.666/93, these criteria offer significant additional flexibility. Importantly, the more flexible criteria can allow the Public Administration to evaluate a project based on the highest expected performance in terms of EE and the robustness of the technical proposal presented.

PPPs must also focus on services; its objective cannot be limited to contracting engineering works, outsourcing, or purchasing equipment. In addition, the value of the contract must be R$ 20 million or higher. According to article 16 Rio de Janeiro’s municipal PPP law (Lei Complementar Municipal 105/2009), the invitation to bid must also contain performance benchmarks.

All companies bidding for the PPP contract must be prequalified.

**Contractual Term**

According to aw 11.079/04, PPP concession contracts must last from five to 35 years and have the potential to be renewed.

**Linking EE to Payments under Contract**

In principle, PPP contracts would require disbursement from the Public Administration to pay for the services or to gross up charges paid by end users. The PPP law also states, “the contract may provide for payment to the private party of a variable remuneration connected to its performance, according to goals and quality and availability standards defined in the contract.” This means that the contract may contain provisions according to which the concessionaire receives greater remuneration if it performs above certain levels, or could be penalized, receiving lower remuneration if the service is not delivered according to the contractual requirements.

PPP projects can be structured in such a way that the concessionaire is paid based on the savings resulting from the reduction of the public lighting bill as a consequence of the EE initiative. If the resulting amount is sufficient to compensate the concessionaire, no additional budgetary credits would be needed.

In Rio’s municipal PPP laws, payment by the Public Administration to the concessionaire may be secured (article 28) by:
The PPP Guarantee Fund (*Fundo Garantidor de PPPs*–FGP) 
Future revenues, except those arising from tax collections 
Special funds provided in the legislation84 
Private insurance policies 
Other means permitted by law

Payment by the Public Administration is also conditioned upon evidence that the PPP will reduce costs. Savings generated by the project may be estimated for inclusion in the annual municipal budget, based on goals established by the municipal Pluriannual Plan, and can be guaranteed by the municipal PPP fund as a performance guarantee.

The amounts paid by the municipality to the concessionaire under a municipal PPP (article 27) may come from:

- The Municipal Treasury or the indirect municipal administration (such as independent agencies and municipal-owned companies)
- The granting of non-tax credits
- The granting of rights exercisable against the government
- The granting of rights to public property
- Other means permitted by law

**Process and Timeline**

In general, a PPP project bid in Rio de Janeiro is subject to several legal requirements, including favorable opinions by certain Secretariats based on technical and economic feasibility studies and evidence of the superiority of the PPP model in comparison with other mechanisms. The project would also need to be approved by the PROPAR-RIO Managing Council.

Based on interviews with local stakeholders, the estimated timeline for executing a PPP project is 15-20 months.

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84 FEIP funds may be eligible, as described below.
## Appendix F: Weighted Average Wattage Calculations

### Technology Data

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<tr>
<th>Technology</th>
<th>Lamp/rated power (W)</th>
<th>Ballast power (W)</th>
<th>Total fixture power (W)</th>
<th>No. of lamps</th>
<th>Equivalent LED rated power (W)</th>
<th>Replacement efficiency</th>
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<td></td>
</tr>
<tr>
<td><strong>Metal halide</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>10</td>
<td>45</td>
<td>27</td>
<td>22</td>
<td>38%</td>
<td></td>
</tr>
<tr>
<td>70</td>
<td>15</td>
<td>85</td>
<td>5,543</td>
<td>28</td>
<td>67%</td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>18</td>
<td>118</td>
<td>3,999</td>
<td>54</td>
<td>54%</td>
<td></td>
</tr>
<tr>
<td>150</td>
<td>18</td>
<td>168</td>
<td>1,695</td>
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<td>44%</td>
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<tr>
<td>175</td>
<td>26</td>
<td>201</td>
<td>186</td>
<td>54</td>
<td>53%</td>
<td></td>
</tr>
<tr>
<td>200</td>
<td>30</td>
<td>230</td>
<td>329</td>
<td>54</td>
<td>59%</td>
<td></td>
</tr>
<tr>
<td>250</td>
<td>23</td>
<td>273</td>
<td>1,561</td>
<td>125</td>
<td>55%</td>
<td></td>
</tr>
<tr>
<td>400</td>
<td>29</td>
<td>429</td>
<td>13,963</td>
<td>159</td>
<td>63%</td>
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</tr>
<tr>
<td><strong>Other</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>160</td>
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<td>160</td>
<td>17,296</td>
<td>40</td>
<td>75%</td>
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<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Weighted Average Calculations

<table>
<thead>
<tr>
<th>Technology</th>
<th>No. of lamps</th>
<th>Existing fixture power (W)</th>
<th>Weighted average power of existing fixtures (W)</th>
<th>Equivalent LED rated power (W)</th>
<th>Weighted average power of existing fixtures (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>HPS</strong></td>
<td></td>
<td>221</td>
<td>112</td>
<td>231</td>
<td>112</td>
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<tr>
<td>39,596</td>
<td>85</td>
<td>9</td>
<td>37</td>
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<td>75,593</td>
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<td>54</td>
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<td>11</td>
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<tr>
<td>116,863</td>
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<td>54</td>
<td>94</td>
<td>29</td>
<td>29</td>
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<tr>
<td>84,759</td>
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<td>159</td>
<td>15</td>
<td>15</td>
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<tr>
<td>28,656</td>
<td>393</td>
<td>30</td>
<td>209</td>
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<td>41</td>
<td>209</td>
<td>19</td>
<td>19</td>
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<tr>
<td><strong>Metal halide</strong></td>
<td></td>
<td>284</td>
<td>110</td>
<td>284</td>
<td>110</td>
</tr>
<tr>
<td>35</td>
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<td>70</td>
<td>15</td>
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<td>28</td>
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<td>100</td>
<td>18</td>
<td>17</td>
<td>54</td>
<td>8</td>
<td>8</td>
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<tr>
<td>150</td>
<td>18</td>
<td>10</td>
<td>94</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>175</td>
<td>26</td>
<td>3</td>
<td>94</td>
<td>1</td>
<td>1</td>
</tr>
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<td>200</td>
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<td>16</td>
<td>159</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>250</td>
<td>23</td>
<td>16</td>
<td>123</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>400</td>
<td>29</td>
<td>219</td>
<td>159</td>
<td>81</td>
<td>81</td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td></td>
<td>160</td>
<td>40</td>
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<tr>
<td><strong>Total</strong></td>
<td></td>
<td>222</td>
<td>111</td>
<td>222</td>
<td>111</td>
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</tbody>
</table>
## Appendix G: Weighted Average Price Calculations

### Pricing Data

<table>
<thead>
<tr>
<th>Technology</th>
<th>Lamp price (R$)</th>
<th>Luminaire price (R$)</th>
<th>Ballast power price (R$)</th>
<th>Total fixture price (R$)</th>
<th>Equivalent LED power (W)</th>
<th>Equivalent LED price (R$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HPS</td>
<td>12.00</td>
<td>252.00</td>
<td>25.00</td>
<td>299.00</td>
<td>37.00</td>
<td>1270.00</td>
</tr>
<tr>
<td></td>
<td>21.50</td>
<td>252.00</td>
<td>39.00</td>
<td>312.50</td>
<td>54.00</td>
<td>1335.00</td>
</tr>
<tr>
<td></td>
<td>22.00</td>
<td>252.00</td>
<td>40.00</td>
<td>314.00</td>
<td>94.00</td>
<td>1745.00</td>
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<tr>
<td></td>
<td>22.50</td>
<td>252.00</td>
<td>34.80</td>
<td>329.80</td>
<td>159.00</td>
<td>1900.00</td>
</tr>
<tr>
<td></td>
<td>29.00</td>
<td>269.80</td>
<td>60.00</td>
<td>338.80</td>
<td>209.00</td>
<td>3150.00</td>
</tr>
<tr>
<td></td>
<td>32.70</td>
<td>269.80</td>
<td>63.20</td>
<td>345.20</td>
<td>209.00</td>
<td>3150.00</td>
</tr>
<tr>
<td>Metal Halide</td>
<td>31.70</td>
<td>252.00</td>
<td>25.00</td>
<td>388.70</td>
<td>28.00</td>
<td>1270.00</td>
</tr>
<tr>
<td></td>
<td>31.70</td>
<td>252.00</td>
<td>25.00</td>
<td>388.70</td>
<td>28.00</td>
<td>1270.00</td>
</tr>
<tr>
<td></td>
<td>31.70</td>
<td>252.00</td>
<td>29.00</td>
<td>322.70</td>
<td>54.00</td>
<td>1745.00</td>
</tr>
<tr>
<td></td>
<td>31.70</td>
<td>252.00</td>
<td>40.00</td>
<td>323.70</td>
<td>94.00</td>
<td>1745.00</td>
</tr>
<tr>
<td></td>
<td>40.00</td>
<td>252.00</td>
<td>45.00</td>
<td>317.00</td>
<td>94.00</td>
<td>1745.00</td>
</tr>
<tr>
<td></td>
<td>45.00</td>
<td>252.00</td>
<td>49.80</td>
<td>342.80</td>
<td>94.00</td>
<td>1745.00</td>
</tr>
<tr>
<td></td>
<td>54.90</td>
<td>252.00</td>
<td>49.80</td>
<td>316.70</td>
<td>123.00</td>
<td>2300.00</td>
</tr>
<tr>
<td></td>
<td>61.70</td>
<td>269.80</td>
<td>63.20</td>
<td>334.70</td>
<td>159.00</td>
<td>2820.00</td>
</tr>
<tr>
<td>Other</td>
<td>11.00</td>
<td>252.00</td>
<td>0.00</td>
<td>263.00</td>
<td>39.91</td>
<td>1079.50</td>
</tr>
</tbody>
</table>

### Weighted Average Calculations

<table>
<thead>
<tr>
<th>Technology</th>
<th>No. of lamps</th>
<th>Existing Total Fixture</th>
<th>Weighted average existing lamp price (R$)</th>
<th>Weighted average existing LED price (R$)</th>
<th>Weighted average LED price</th>
</tr>
</thead>
<tbody>
<tr>
<td>HPS</td>
<td>380,362</td>
<td>321</td>
<td>1,093</td>
<td>1,093</td>
<td>1,093</td>
</tr>
<tr>
<td></td>
<td>39,596</td>
<td>289</td>
<td>1,270</td>
<td>1,270</td>
<td>1,270</td>
</tr>
<tr>
<td></td>
<td>75,953</td>
<td>313</td>
<td>1,350</td>
<td>1,350</td>
<td>1,350</td>
</tr>
<tr>
<td></td>
<td>116,663</td>
<td>314</td>
<td>1,745</td>
<td>1,745</td>
<td>1,745</td>
</tr>
<tr>
<td></td>
<td>84,704</td>
<td>339</td>
<td>1,900</td>
<td>1,900</td>
<td>1,900</td>
</tr>
<tr>
<td></td>
<td>28,856</td>
<td>359</td>
<td>3,190</td>
<td>3,190</td>
<td>3,190</td>
</tr>
<tr>
<td></td>
<td>34,895</td>
<td>365</td>
<td>3,190</td>
<td>3,190</td>
<td>3,190</td>
</tr>
</tbody>
</table>

| Metal halide   | 77,719      | 306                    | 2,210                                     | 2,210                                    | 2,210                      |
|                | 23           | 309                    | 1,270                                     | 1,270                                    | 1,270                      |
|                | 5,543        | 309                    | 1,270                                     | 1,270                                    | 1,270                      |
|                | 3,999        | 323                    | 1,345                                     | 1,345                                    | 1,345                      |
|                | 13,695       | 324                    | 1,745                                     | 1,745                                    | 1,745                      |
|                | 1081         | 337                    | 1,745                                     | 1,745                                    | 1,745                      |
|                | 13,581       | 357                    | 2,300                                     | 2,300                                    | 2,300                      |
| Other          | 17,296       | 263                    | 1,080                                     | 1,080                                    | 1,080                      |
|                | 17,296       | 263                    | 1,080                                     | 1,080                                    | 1,080                      |
| Total          | 424,977      | 322                    | 1,882                                     | 1,882                                    | 1,882                      |
Appendix H: International Pricing Examples

<table>
<thead>
<tr>
<th>City/country</th>
<th>Price (per point)</th>
<th>Smart systems?</th>
<th>Volume</th>
<th>Observations</th>
</tr>
</thead>
</table>
| Los Angeles<sup>a</sup> | US$ 300 for major streets and US$ 245 for smaller streets (2012)  
Average of US$ 400 over a five-year program | Yes | 140,000 to be replaced by LEDs, out of a total of 209,000 lamps | Significant price decline over time  
2008 estimate was US$ 700, dropping to US$ 432 in 2009 |
| 2) Las Vegas<sup>b</sup> | US$ 495 on average | Yes | 42,000 LEDs | Average price resulting from competitive bidding |
| 3) China<sup>c</sup> | US$ 250-350 | Unknown | Project size estimate in Guangdong = 5 million units  
About 200,000-300,000 installed per year | Typically, 10 percent of the project cost is subsidized by Guangdong province, 15 percent by the municipal government.  
Chinese cities represent 3/4 of global market |
| 4) Mexico<sup>d</sup> | US$ 400–500 | No | Ranging from 5,000 to 25,000 points | Average price and lamps procured by the private sector |

Notes:

<sup>a</sup> [http://www.youtube.com/watch?v=i04MjLK8qV0&feature=youtu.be](http://www.youtube.com/watch?v=i04MjLK8qV0&feature=youtu.be).
<sup>d</sup> Interviews with Optima, a Mexican ESCO.
Appendix I: Estimated Revenue Shortfalls in the Electricity Sector and Future Price Increases

<table>
<thead>
<tr>
<th>Electricity sector revenue shortfall (R$, billions)</th>
<th>2013</th>
<th>2014</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subsidies by Treasury</td>
<td>8</td>
<td>10</td>
<td>18</td>
</tr>
<tr>
<td>Costs deferred, to be recovered through rates</td>
<td>10</td>
<td>12 to 24</td>
<td>22-34</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td><strong>18</strong></td>
<td><strong>22 to 34</strong></td>
<td><strong>40 -52</strong></td>
</tr>
<tr>
<td>Expected rate increase (one-year basis)</td>
<td></td>
<td></td>
<td>22-34%</td>
</tr>
<tr>
<td>Additional expected rate revision in 2014</td>
<td></td>
<td></td>
<td>11-17%</td>
</tr>
<tr>
<td><strong>Total expected increase</strong></td>
<td></td>
<td></td>
<td>33-51%</td>
</tr>
<tr>
<td>Expected annual increase over five years</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low range</td>
<td></td>
<td></td>
<td>5.9%</td>
</tr>
<tr>
<td>Base case range</td>
<td></td>
<td></td>
<td>7.0%</td>
</tr>
<tr>
<td>High range</td>
<td></td>
<td></td>
<td>8.6%</td>
</tr>
</tbody>
</table>
Appendix J: O&M Savings Assumptions

Impact of Longer Life (No Smart System)

The longer lifetime of LEDs means that LEDs will need to be replaced less frequently that the current technology. This has a twofold impact on O&M costs: replacement equipment costs and labor costs.

Given that fewer lamps will need to be replaced over time once LEDs are installed, there is a potential for savings on future equipment purchases. However, the reduced frequency of purchases needs to be weighed against the higher unit cost of LEDs compared with the replacement cost of existing technology. This study assumes that the replacement cost for existing failed lamps is 10 percent of its up-front cost (that is, approximately R$30/lamp), as not all parts need to be replaced upon lamp failure. The replacement cost of failed LEDs is estimated to be 30 percent of up-front LED costs (that is, approximately R$360/lamp). Based on these assumptions, this study shows that despite the reduced frequency of lamp purchases, total replaced equipment expenditures will increase by approximately R$17 million over a 15-year period after the installation of LEDs.

However, the longer lifetime of LEDs also allows for reduced labor expenditures, as the reduction in the frequency of lamp replacements means that fewer staff will be needed to administer and maintain the public street lighting system. To calculate the potential maintenance labor savings, this model assumes a fixed cost of R$ 200/lamp in labor costs for each lamp replacement (this assumption applies to the baseline and project scenarios). Keeping the labor cost per replacement the same but taking into account the reduced frequency of replacement, this study estimates an average annual savings of R$7 million and total savings of R$73 million over 15 years. To calculate the potential administrative labor savings, this study assumes a 5 percent decrease in current administrative labor costs after the installation of LEDs. This analysis estimates an average annual savings of R$0.6 million and total savings of R$8 million over 15 years.

Impact of a Smart System

The impact of the inclusion of smart system technology on O&M is significant.

As described in the pricing section above, the addition of smart system technology increases the capital expenditures by approximately 25 percent. This increase in cost also applies to the increased replacement costs, leading to an estimate replacement cost of R$ 450/lamp. Based on these assumptions, this study shows that total equipment expenditures will increase by approximately R$24 million over a 15-year period after the installation of LEDs.

However, smart systems bring substantial benefits in terms of labor costs. In addition to the savings accrued from the longer lifetime of LEDs, the smart system allows for further reductions in labor costs because the entire public street lighting system can be monitored from a central control system. This eliminates the need to employ staff to monitor the public street lighting system from the street. The central control system can also streamline other aspects of public street lighting operations, such as increased lighting during special events, decreased lighting during an electricity shortage, or timing of
traffic lights. As a result, to calculate the potential maintenance labor savings, the analysis assumes that the smart system can provide administrative labor savings of 30 percent.\textsuperscript{85} This reduction represents a need for fewer administrative staff to oversee the maintenance work, which can be significantly reduced with the inclusion of a central control system. The study assumes a low-case savings potential of 15 percent in maintenance labor costs; the high-savings case assumes savings of 45 percent. Both assumptions refer to LEDs with smart systems.

Keeping the labor cost per replacement the same but taking into account the reduced frequency of replacement, this study estimates an average annual savings of R$ 7.5 million and total savings of R$ 79 million over 15 years. The potential administrative labor savings are on average R$ 3.3 million per year and total savings of R$ 50 million over 15 years.

\textsuperscript{85} The assumption is based on stakeholder interviews and expert opinions and has been cross-checked with information reported from international examples.
Appendix K: PROCEL/RELUZ Evaluation Criteria

The approval process involves presentation of the project by the DISCO to the Department of Development of Special Projects (DPE). If the project is approved, a technical analysis is prepared by the DPE and submitted to the Director of Special Projects and Technological and Industrial Development (DP), to which the DPE is subordinate. The project is then forwarded to the Department of Investments (DFI) for an analysis of the credit standing of the DISCO, the guarantees offered, as well as the availability of funds in the RGR.

Following the analysis by the DFI, the process is submitted to the Executive Board of Eletrobrás (DEE) and the Board of Directors of Eletrobrás (CAE). If approved, the Legal Department of Eletrobrás (PRJ) starts preparation of the financing agreement.

After the signing of the financing agreement by the DISCO and review by the PRJ of the additional documents, the contract is then signed by the president of Eletrobrás and a director (any director of Eletrobrás, but usually the Director of the DP), and returned to the PRJ for validation and instructions to DFI to proceed with funding of the first tranche. The first installment is the only one to be released prior to the completion of the related stages of the project. The funding of the following tranches depends on proof of physical progress of the projects.

Upon funding of each tranche, the DISCO also signs a promissory note with a maturity date of the last day of the tranche grace period. The Eletrobrás Treasury Department holds custody of the promissory notes.

The funding of each subsequent tranche depends on the results of the monitoring and evaluation process and physical inspection, as well as the analysis of the DISCO’s reports carried out by the DPE. The report of physical supervision prepared by the DPE is submitted to the DP for approval. Verification by DFI that the resources (including counterpart disbursements) have been used to cover the direct costs of the program is a condition for funding the next tranche.

The final monitoring and evaluation process and physical inspection take place just before the funding of the last tranche. Upon funding the last tranche, the DISCO replaces the promissory notes deposited with the Eletrobrás Treasury Department with a new note corresponding to the outstanding amortization schedule of the financing (which can occur in up to 60 installments). If the DISCO fails to appear before Eletrobrás to proceed with the replacement of the notes, Eletrobrás initiates the collection process of the promissory notes related to the funded tranches.

The eligibility criteria for the allocation of funds under the program include technical aspects (equipment, material), agreed objectives, time frames and deadlines, and evaluation of the economic and financial viability of the proposed action, among other factors.
### Appendix L: BNDES Facilities Applicable to EE Projects

<table>
<thead>
<tr>
<th>Type</th>
<th>Use</th>
<th>Financing amount limit</th>
<th>Funding cost</th>
<th>BNDES fees</th>
<th>Financial agent fee</th>
<th>Accredited financial institution fee</th>
<th>Maximum participation of BNDES</th>
<th>Tenor</th>
<th>Guarantees</th>
</tr>
</thead>
<tbody>
<tr>
<td>PROCESO</td>
<td>Funding for EE projects executed by ESCOs, utilities and end users. Resources are applied in lighting, motors, process optimization, pumping, air-conditioning and ventilation, refrigeration and cooling, production and distribution of steam, heating, automation and control, power distribution and energy management. The facility finances the studies and projects as well as plants, machinery and equipment, specialized technical services, information systems, monitoring, control and surveillance of EE projects.</td>
<td>None</td>
<td>TJLP²</td>
<td>0.9% per year plus credit risk fee of up to 4.18% per year</td>
<td>n.a.</td>
<td>Negotiated between borrower and financial institution, capped at 4% per year</td>
<td>90%</td>
<td>Up to 72 months with up to 24 months grace (included)</td>
<td>ESCOs’ tangible assets and the pledge of savings arising from the EE project</td>
</tr>
<tr>
<td>PMAT</td>
<td>Resolution CNN 2 827/20 exempts municipalities from considering this facility in the calculation of debt limits. Available for projects related to modernization of tax collection systems, human resource management, bids and purchases, contracts, energy management, health, education, social action, services to citizens, and, possibly (to be confirmed), for EE projects.</td>
<td>R$ 60 million</td>
<td>TJLP</td>
<td>0.9% per year plus credit risk fee of up to 1% per year</td>
<td>n.a.</td>
<td>Negotiated between borrower and the Financial Institution</td>
<td>up to 100%</td>
<td>Up to 96 months with up to 24 months grace (included)</td>
<td>not applicable</td>
</tr>
<tr>
<td>FNAME (K)</td>
<td>Acquisition of new machinery and equipment manufactured domestically.</td>
<td>None</td>
<td>TJLP</td>
<td>0.9% per year</td>
<td>0.5% per year</td>
<td>Negotiated between Borrower and the Financial Institution</td>
<td>70%</td>
<td>Up to 60 months</td>
<td>not applicable</td>
</tr>
<tr>
<td>Fundo Clima</td>
<td>To finance the acquisition and production of energy-efficient machines and equipment contributing to reduction of greenhouse gas emissions.</td>
<td>None</td>
<td>Up to 2.9% per year</td>
<td>0.9% per year</td>
<td>0.5% per year</td>
<td>n.a.</td>
<td>90%</td>
<td>Up to 96 months with up to 24 months’ grace (included)</td>
<td>n.a.</td>
</tr>
<tr>
<td>BIDES PSII</td>
<td>For distribution substations and technological modernization.</td>
<td>None</td>
<td>3.5% per year</td>
<td>n.a.</td>
<td>n.a.</td>
<td>70-90%</td>
<td>Up to 120 months with up to 48 months’ grace (included)</td>
<td>To be defined upon analysis of the proposal</td>
<td></td>
</tr>
<tr>
<td>BIDES FIENAI</td>
<td>For leasing companies to acquire new machinery and equipment manufactured domestically upon signing of leasing contracts.</td>
<td>None</td>
<td>TJLP + 1%, TJLP on the acquisition of goods and automation, Currency basket (BNDES funding cost in US$) for the acquisition of machinery and equipment with a nationalization index of less than 60%</td>
<td>n.a.</td>
<td>0.5% per year</td>
<td>Negotiated between lessor and lessee</td>
<td>50%</td>
<td>Up to 72 months with up to 6 months’ grace (included)</td>
<td>To be defined upon analysis of the proposal</td>
</tr>
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1. BNDES long-term interest rate (currently 5% per year.)
2. The amount of work performed and inputs produced in Brazil is determined by BNDES.

Appendix M: FIDCs Backed by Utility Assets as of September 2013 and Respective Administrators

1. FIDC CEEE III-GT / BTG PACTUAL SERVIÇOS FINANCEIROS S/A DTVM
2. FIDC CEEE IV-D / BTG PACTUAL SERVIÇOS FINANCEIROS S/A DTVM
3. FIDC CEEE V-GT / CAIXA ECONOMICA FEDERAL
4. FIDC CESP IV / BEM - DISTRIBUIDORA DE TÍTULOS E VALORES MOBILIÁRIOS LTDA.
5. FIDC DA COMPANHIA ESTADUAL DE ÁGUAS E ESGOTOS – CEDAE / CAIXA ECONOMICA FEDERAL
7. FIDC ENERGISA / INTRAG DTVM LTDA.
8. FIDC ENERGISA 2008 / CAIXA ECONOMICA FEDERAL
9. FUNDO DE INVESTIMENTO EM DIREITOS CREDITÓRIOS CEEE VI-D / BTG PACTUAL SERVIÇOS FINANCEIROS S/A DTVM
10. FUNDO DE INVESTIMENTO EM DIREITOS CREDITÓRIOS DA SANEAMENTO DE GOIÁS / SANEAGO - INFRAESTRUTURA II - BEM DTVM
11. SUPERA INTEGRAL - FUNDO DE INVESTIMENTO EM DIREITOS CREDITÓRIOS DE DESENVOLVIMENTO URBANO / CRV DTVM
12. VINCI CRÉDITO E DESENVOLVIMENTO I - FUNDO DE INVESTIMENTO EM DIREITOS CREDITÓRIOS / CAIXA ECONOMICA FEDERAL
13. BRASIL GOVERNMENT SENIOR DEBT FIDC-NP / OLIVEIRA TRUST DTVM S.A.
### Appendix N: Regulatory models in selected Latin American Countries and the Role of the Power Sector Regulator

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<td>Brazil</td>
<td>The municipality in 19 states, utilities in 8 states</td>
<td>Allowed by legislation, but so far no concessions granted</td>
<td>ANEEL regulates utility assets and prucent costs passed through tariffs. Municipalities in charge of economic and technical regulations - economic regulation.</td>
<td>Yes, utility charges a service fee and transfers COSIP proceeds to municipality.</td>
<td>RELUX from PROCIN/Eletrobrás, currently, a large percentage (70-80%) is HPS. LEDs not yet certified.</td>
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<td>Mexico</td>
<td>Municipalities</td>
<td>Yes</td>
<td>Municipality, subject to federal norms</td>
<td>Yes, DNER and CONINEE launched a national EE program in 2011.</td>
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<tr>
<td>Colombia</td>
<td>Municipalities (1,021)</td>
<td>Yes</td>
<td>Power sector regulator</td>
<td>Yes, if concessionaire agrees to set rates on a cost-plus basis.</td>
<td>Program launched 15 years ago to replace mercury lamps, but not fully implemented owing to lack of funding. Modernization taking place under concessions regime.</td>
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<td>Peru</td>
<td>Utility company (before service was provided by municipalities)</td>
<td>Under the General Law on Concessions, utilities are responsible for provision of public lighting. This is a requirement both for private utilities (working in the Lima region) and public utilities (working in the rest of the country).</td>
<td>OSINERGMIN, power sector regulator, sets prices and quality standards</td>
<td>Yes. Municipalities pay bills for Alumbrado Público Complementario for public lighting of recreational areas (parks, stadiums). These facilities are metered and operate under a special rate schedule.</td>
<td>In Lima, 87% of lamps are HPS.</td>
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Appendix O: Brazilian Lighting Standards and Labeling

Technical standards are set in Brazil by INMETRO (Brazilian Association of Technical Standards), the equivalent to the UL in the United States. INMETRO regulations are mandatory and have the power of law; they are the reference for every product installed in Brazil today. Technical standards for LED lamps are still pending.

INMETRO launched a public consultation for Regulation 478 on November 24, 2013. This document defines the testing procedures for LED luminaires and the control devices to be used in public lighting. The document includes a variety of procedures to test such elements as light depreciation, UV effects on covers, reduction in the life of LEDs and drivers due to the effects of temperature on electrolytic capacitors, protection against electrical hazards and leakage, vibration and wind effects, internal temperature measurements, and others. A real concern is to ascertain whether approved luminaires are able to withstand a variety of site conditions throughout the country.

The phase of collecting contributions was finalized in March 2014. The official final text should be published for approval of prototypes for both discharge and LED lamps in the next few months. There is market expectation that this regulation will be in effect by the end of 2014. The document is based on the IEC (International Electrotechnical Commission) equivalent standards. It is not clear at this point if the standards will be mandatory or not. If the former, they will require close monitoring of INMETRO to ensure that the products on the market meet the standards.

Manufacturers are optimistic that this regulation will be effective in 2014, giving suppliers and service companies a secure environment in which to work in Brazil. In the meantime, INMETRO has made available some basic LED standards to be followed by municipalities when preparing bid packages for street lighting. INMETRO has been testing a variety of products to ascertain whether they meet minimal specifications, including photometric data (Norm NBR 5101), efficiency of the luminaire in lumens per watt (measure using a goniophotometer), color rendering index, color temperature, lifetime, and other parameters. INMETRO tested 14 luminaires against those specifications and made the results available to the municipalities. A seminar was convened in August 2013 to share results.

There are other ad hoc testing initiatives, such as the one under development by the University of Juiz de Fora. A wide range of LED luminaires were tested (57 in total), including brands without any market tradition. It was proved that there are a great variety of products on the market, including poor quality ones with components that will not last more than 10,000 hours (electrolytic capacitors), or even no protection against voltage surges. This reinforces the need to expedite the testing and certification based on international norms.