Systematic Scientific Journal
ISSN: 2675-521

INNOVATION IN MAINTENANCE CONTRACTS: STRUCTURING OPEX-BASED MODELS FOR PROFITABILITY AND SUSTAINABILITY VIA LED LIGHTING PROJECTS

https://doi.org/10.56238/rcsv13n1-006

Submitted on: 12/15/2023 **Approved on**: 01/15/2024

Leandro Mendes Machado

ABSTRACT
Contracts that shift costs from capital expenditure (CAPEX) to operational expenditure (OPEX) are increasingly utilized in LED lighting projects to align provider-client incentives, spread risk, and promote both environmental sustainability and financial return. Based on empirical studies of energy performance contracting (EPC) and contract design in large energy infrastructure, this article examines how to structure OPEX-oriented maintenance contracts, particularly for LED lighting, to generate profit and sustainable outcomes. It discusses performance risk quantification, contract clause design, lifecycle cost management, and the interplay between owner and contractor preferences. Findings from literature suggest that properly balanced contracts, with clear measurement and verification, risk sharing, and inclusion of operability and maintainability criteria, can reduce total operational costs and improve contract profitability.

Keywords: OPEX models. Energy Performance Contracting. LED lighting. Maintenance contracts. Lifecycle cost. Operability and maintainability. Performance risk. Contract design. Sustainability. Profitability

INTRODUCTION

Contracts based on OPEX shift responsibilities for maintenance, upgrades, and often performance guarantees onto the service provider, allowing clients to avoid large upfront investments. In LED lighting projects this model can allow for energy savings, reduced maintenance burden, and favorable environmental impact, provided the contract is structured to address various risks and align incentives properly. One confirmed study, *Performance Risks of Lighting Retrofit in Energy Performance Contracting Projects* by Lee, Lam, & Lee (2018), applies a probabilistic approach to quantify variation in actual savings in lighting retrofit measures. They find that in a model office building in Hong Kong, energy savings can vary substantially, from about 43 % to 65 % of pre-retrofit consumption, depending on factors like daylight availability, occupancy rates, lamp conditions, and usage patterns (Lee, Lam & Lee, 2018). This shows that underperformance risk is significant and must be incorporated into contracts via measurement & verification (M&V) and conservative baselines.

Another relevant piece is *Analysis of Contracts to Build Energy Infrastructures to Optimize the OPEX* by Losada-Maseda et al. (2020). This work examines 158 projects in the energy sector (wind, solar, hydroelectric) with a total contract value around €40,000 million. It analyzes which operability and maintainability criteria owners and contractors prefer to include in contracts under EPC models, and what trade-offs they are willing to make. The study shows owners are willing to accept an increase in initial contract cost of about 1-5 % if this yields OPEX reductions in a similar range. Contractors in turn see value in being selected more often—i.e. enhancing bid competitiveness—if they include such criteria (Losada-Maseda et al., 2020). These findings are directly pertinent to LED OPEX-style deals in lighting, as LED lighting infrastructure is long-life, but maintenance and operation over time (including replacement, remote diagnostics, control systems) contributes importantly to total cost.

From these studies, certain principles emerge for structuring OPEX-based maintenance/LED lighting contracts:

Firstly, performance risk must be explicitly modelled and shared. The case of Lee, Lam & Lee (2018) shows that variability in savings (due to usage, daylight, etc.) can be large. Contracts should include conservative baselines, clearly defined performance guarantees, penalties or incentives for over/under-performance, and robust measurement & verification mechanisms.

Secondly, inclusion of operability and maintainability criteria in contract design improves long-term costs. Losada-Maseda et al. (2020) found that owners value criteria like detailed operating procedures, identification of critical components, maintainability during design/construction, spare part management, etc. These criteria ensure that maintenance is not reactive, but that systems are designed for maintainability and long term operability, reducing failures, reducing downtime, and lowering cost.

Thirdly, lifecycle costs need to be considered rather than only up-front equipment cost. LED lighting equipment tends to last long, but components (drivers, sensors, controls) degrade, fail, or become obsolete; maintenance, repair, replacement, energy supply, even end-of-life disposal or recycling matter. OPEX contracts should cover these, either via warranties, scheduled maintenance, upgrade paths, or even parts replacement and obsolescence management.

Fourthly, financial structuring and incentives matter. Contracts should align provider returns with performance—shared savings or performance payments, fixed periodic fees combined with bonuses/penalties. Also, contract duration needs to be long enough to allow provider to recover initial investment, but not so long that technology risk or usage patterns shift too much.

Fifthly, clarity in contractual clauses. Detailed instructions and procedures, documentation, dispute resolution, responsibilities for monitoring, maintenance response times, service level agreements (SLAs), failure handling must all be well defined. Losada-Maseda et al. (2020) note owners and contractors both prefer contracts that reduce ambiguity, specify operability and maintainability from early phases, and include criteria that improve long-term performance even if they raise up-front or bid cost slightly.

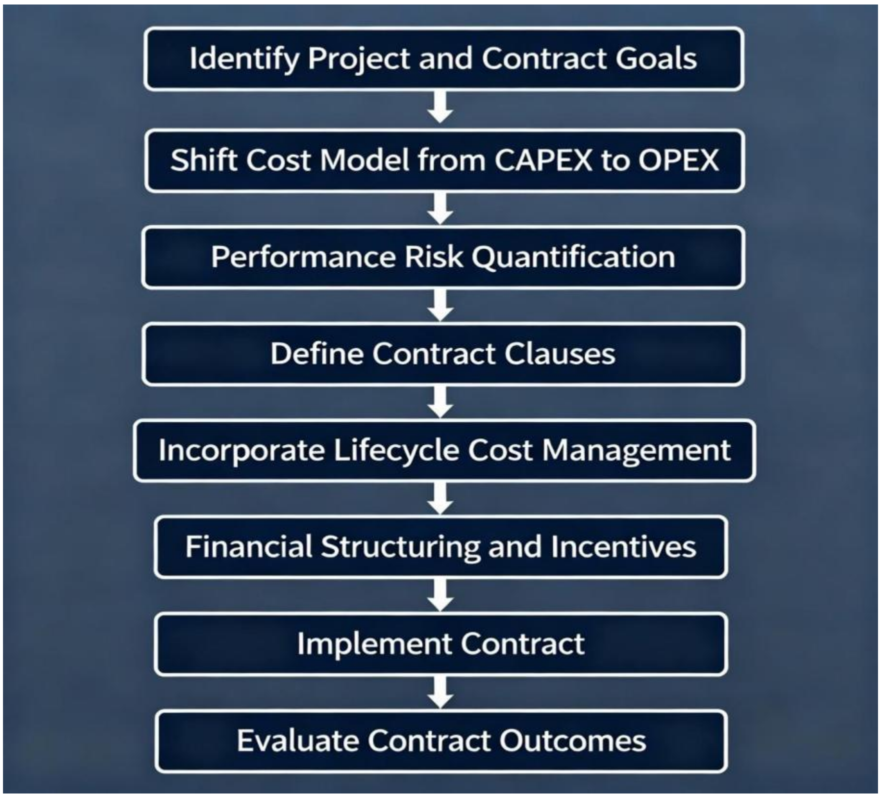
Challenges identified in the literature include under-estimating savings (as shown in Lee, Lam & Lee), client risk aversion or unfamiliarity with performance-based contracts, balancing risk so that providers are not overexposed (which can make them unwilling to participate or demand higher margins), technological and usage pattern uncertainty (lighting usage, sensor reliability, controls), and the need for good data for baseline and performance measurement.

Profitability from OPEX models in LED maintenance contracts depends largely on scale (bigger projects spread fixed costs), quality of implementation (good hardware, reliable controls / sensors, maintenance capability), accurate estimation of risk and usage, and aligning contract incentives so that provider has motivation to maintain performance over time. Also regulatory or market incentives (energy price, subsidies, rebates) can influence profitability.

The flowchart explains the structured process for developing OPEX-based maintenance contracts for LED lighting projects. It starts with identifying the project's goals related to sustainability, profitability, and risk management. Then, the financial model shifts costs from upfront capital expenditures (CAPEX) to operational expenditures (OPEX), transferring maintenance responsibilities to the service provider. The next step quantifies performance risks, addressing variability in energy savings through conservative baselines and verification mechanisms. Contract clauses are then defined, including guarantees, penalties, and operability standards to ensure long-term effectiveness. Lifecycle cost management is incorporated to consider maintenance, repairs, and upgrades beyond initial equipment costs. Financial structuring aligns provider incentives with performance, balancing contract duration to cover investments while managing technology risks. The contract is implemented with clear roles for monitoring and response, and finally, outcomes are evaluated to ensure sustainability and profitability goals are met. This systematic approach supports energy savings, reduced maintenance burden, and mutual benefit for client and provider over the LED lighting system's lifespan.

Figure 1

Flowchart of OPEX-Based Maintenance Contract Structuring for LED Lighting Projects



Source: Created by author.

In conclusion, the academic evidence shows that OPEX-based maintenance and lighting contracts can achieve sustainability (energy savings, reduced maintenance) and profitability if structured with explicit handling of performance risk, inclusion of maintainability/operability criteria, lifecycle cost thinking, clear contract clause design, and suitable financial incentives. The studies of Lee, Lam & Lee (2018) and Losada-Maseda et al. (2020) provide concrete, empirically grounded guidance. For LED lighting projects, adopting these principles increases the likelihood that the contract will deliver long-term value for both service provider and client.

REFERENCES

Lee, P., Lam, P. T. I., & Lee, W. L. (2018). Performance risks of lighting retrofit in Energy Performance Contracting projects. Energy for Sustainable Development, 45, 219-229.

Losada-Maseda, J. J., Castro-Santos, L., Graña-López, M. Á., García-Diez, A. I., & Filgueira-Vizoso, A. (2020). Analysis of Contracts to Build Energy Infrastructures to Optimize the OPEX. Sustainability, 12(17), 7232.