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VALUE ENGINEERING PLANNING CONCEPT FOR STREET LIGHTING (MYSINAR+) THROUGH THE PUBLIC-PRIVATE PARTNERSHIP (PPP) SCHEME

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Abstract

Urban environments face complex challenges, including security concerns, rising energy costs, and environmental degradation, while cities are simultaneously required to modernize infrastructure within budgetary constraints and ambitious climate commitments. Weak value creation in municipal governance, coupled with inadequate street lighting infrastructure, further exacerbates these problems. Addressing such challenges requires innovative and cost-effective solutions that enhance urban safety and sustainability. This study examines MYSinar+, a sustainable street lighting solution developed using a value engineering approach. The research evaluates its impact on urban safety and sustainability by identifying the key functions of street lighting systems and optimizing their design to improve performance. The findings demonstrate that MYSinar+ supports climate action objectives, strengthens urban resilience, and enhances public safety. By integrating advanced technology and innovative financing within the framework of Public-Private Partnerships and leveraging carbon trading mechanisms, MYSinar+ provides a scalable solution to urban infrastructure challenges. Focusing on the initial conceptual phase, this study highlights the need for further research on prototype development and investment cost estimation, offering valuable insights for policymakers.

Keywords: Climate Action; Innovation; PPP; Street Lighting; Value Engineering

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INTRODUCTION

Urbanization is rapidly accelerating worldwide, placing significant pressure on cities to provide adequate infrastructure and public services (Ahmed et al., 2018; Mangal et al., 2024). Governments are expected to enhance the quality of life for their citizens while managing constrained budgets and fulfilling global environmental obligations (Ekardt & Bärenwaldt, 2023; Ekardt et al., 2018). As urban areas expand, the challenges they face also intensify, including outdated infrastructure, rising energy costs, insufficient public safety measures, and increasing demand for sustainable development (Mangal et al., 2024). In this context, inadequate street lighting plays a critical role, as insufficient lighting not only compromises road safety but also contributes to higher crime rates and a diminished sense of security among residents (Qin et al., 2024; Steinbach et al., 2015). Enhancing urban security is therefore closely linked to improving city infrastructure, particularly through street lighting, which has been shown to increase safety and reduce crime (Erturk et al., 2024). Simultaneously, cities are expected to play a central role in addressing climate change by reducing carbon emissions. Commitments under the Paris Agreement require the adoption of greener technologies and more sustainable practices (Ekardt & Bärenwaldt, 2023; Ekardt et al., 2018). However, many cities lack the financial resources, technical expertise, and innovative solutions necessary to achieve these ambitious targets. This challenge is further compounded by weak value creation within municipal governance, where infrastructure projects often fail to deliver optimal economic, social, and environmental benefits, resulting in underutilized resources and missed opportunities for growth (Erk et al., 2023; Alghamdi et al., 2022).

Value Engineering (VE) provides a systematic approach to maximizing functionality while minimizing costs (Almarri, 2023); however, its application within urban planning and Public-Private Partnership (PPP) frameworks for street lighting remains limited. This study addresses this gap by applying VE principles to the conceptual design of a multifunctional PPP-based street lighting system, termed MYSinar+. The contribution of this research lies in linking VE methodology with urban infrastructure planning and PPP models, demonstrating how innovative procurement and design can generate social, environmental, and economic benefits. The novelty of this study lies in operationalizing VE within a PPP context to reconceptualize street lighting as a multifunctional system, offering transferable insights for policymakers, practitioners, and scholars engaged in sustainable urban development.

LITERATURE REVIEW

Value Engineering (VE)

According to The Value Society (2007), VE is a structured and cost-effective method for evaluating project value. It is widely applied to achieve key benefits,

including value addition, time efficiency, quality improvement, and the identification of design deficiencies. VE operates as a structured decision-making process that employs a systematic and multidisciplinary approach, assessed through functional analysis to optimize project outcomes. Optimal value is achieved by identifying the functions necessary to meet the desired target value (Arumsari & Tanachi, 2018). Moreover, VE investigates potential alternatives and design options to fulfill project objectives by integrating the client's value criteria, refining functions, enhancing quality, addressing needs and requirements, and developing technical solutions to achieve optimized designs (CIDB Malaysia, 2022).

Public-Private Partnership (PPP)

In the provision of public infrastructure, governments frequently encounter challenges such as budget constraints, limited innovation and technological capacity, and inadequate operational and maintenance practices (Sunandar & Indiyati, 2023; Sunandar, et al., 2025a). The involvement of private entities or investors with the necessary expertise and resources can therefore provide a breakthrough in infrastructure development. Such collaboration, conducted under specified requirements, is referred to as a PPP (Sunandar et al., 2024; Sunandar, et al., 2025b). The advantages of PPPs have been widely documented in the literature, particularly regarding improvements in efficiency (Mat Aron et al., 2024), value for money (Izebhor, 2022), generation of social benefits (Qingbiao et al., 2024), enhancement of time and cost performance (Verweij & van Meerkerk, 2021), and increased investment (Chen, 2021).

RESEARCH METHODOLOGY

This study employed a qualitative research design and adopted a VE methodological approach. The framework was adapted from Arumsari and Tanachi (2018); CIDB Malaysia (2022); The Value Society (2007). The methodology comprised four sequential phases: the information phase, the function analysis phase, the creative phase, and the evaluation or validation phase. The process began with the information phase, which established a shared understanding of the relevant issues. During this stage, qualitative insights were primarily gathered from secondary sources and policy documents, with the objective of consolidating existing knowledge and ensuring alignment among stakeholders.

The function analysis phase was subsequently undertaken using the Function Analysis System Technique (FAST). This approach enabled a systematic examination of both core and supporting functions, clarifying how each function contributes to addressing infrastructure challenges. The outcome was a structured understanding of functional relationships, providing the

analytical foundation for the subsequent phase. The creative phase focused on generating innovative solutions. In this study, the PPP mechanism was integrated into the VE process to stimulate creative and strategic alternatives. This phase emphasized the development of conceptual strategies that illustrate how PPPs can enhance value creation in infrastructure projects, rather than producing numerical outputs.

The final stage, the evaluation or validation phase, aimed to assess the robustness of the proposed framework. This was operationalized through participation in the Petronas Innovation Challenge 2024, which offered an external platform for independent critique and validation of the conceptual outcomes. To ensure methodological rigor, established criteria for qualitative validity and reliability were applied. Credibility was reinforced through reference to authoritative VE and PPP literature and the systematic application of the FAST technique. Transferability was supported by providing detailed descriptions of the methodological process, enabling replication in other contexts. Dependability was achieved through transparent documentation of all phases, while confirmability was maintained by grounding interpretations in documented evidence and securing external validation through the competition platform.

ANALYSIS AND DISCUSSION

Information Phase

The challenges facing contemporary urban environments are complex and multifaceted, encompassing issues such as public safety, rising energy costs, and environmental impacts. Cities are under increasing pressure to modernize their systems while simultaneously operating within constrained budgets and striving to meet ambitious environmental targets, including Nationally Determined Contributions (NDCs). Limited value creation within municipal governance and insufficient infrastructure, particularly in the provision of street lighting, further exacerbate these challenges.

Addressing these interconnected issues is essential to ensure the safety, sustainability, and economic vitality of urban areas. Effective solutions are required to enhance public safety through improved street lighting, reduce energy consumption and associated costs, and support cities in achieving their climate action commitments. By harnessing innovative technologies and financing mechanisms, such as MYSinar+, cities can respond more effectively to these pressing concerns and create more resilient, secure, and sustainable urban environments for their residents. A summary of the MYSinar+ information issues is presented in Table 1.

Table 1: Recapitulation of MYSinar+ Information Issues Phase

No	Issue	Description
1	Inadequate Urban Lighting	Many cities face challenges arising from inadequate street lighting, which heightens safety risks for both pedestrians and motorists. Insufficiently illuminated areas are associated with increased crime rates and diminished perceptions of security, thereby reducing the accessibility and usability of public spaces, particularly during nighttime (Erturk et al., 2024; Steinbach et al., 2015)
2	Urban Security and Crime Prevention	Insufficiently illuminated streets elevate the risk of accidents and increase the vulnerability of certain areas to criminal activities, including theft, vandalism, and assault. Enhancing street lighting is therefore essential for improving public safety and mitigating crime rates, particularly in areas with high traffic volumes or elevated crime incidence (Erturk et al., 2024; Qin et al., 2024)
3	High Energy Costs	Traditional street lighting systems frequently depend on non-renewable energy sources, which impose substantial operational costs on local governments. This financial burden constrains their capacity to allocate resources toward other essential public services and infrastructure development (Kaminsky, 2022; Velásquez et al., 2024)
4	Environmental Impact	Reliance on fossil fuels for energy generation contributes substantially to carbon emissions, thereby intensifying the impacts of climate change. Cities are therefore required to adopt measures that reduce their carbon footprint to fulfil both national and international climate commitments (Ahamer, 2019; Facchini et al., 2021)
5	Pressure to Meet NDC Targets	As part of the global commitment to addressing climate change, countries have established NDCs aimed at reducing carbon emissions. However, many cities encounter substantial challenges in meeting these targets, including limited adoption of sustainable energy solutions and inadequate financial resources (Ekardt & Bärenwaldt, 2023; Ekardt et al., 2018)
6	Limited Budget and Funding Constraints	Governments often encounter budgetary constraints that limit their capacity to finance essential infrastructure projects. With the continuous growth of urban populations, the demand for improved public services intensifies, thereby exerting additional pressure on already scarce financial resources (Sunandar & Indiyati, 2023; Zulu et al., 2023).
7	Weak Value Creation in City Governments	Many municipal governments struggle to generate substantial value from their investments in infrastructure projects. Inefficient resource allocation and reliance on outdated operational models often lead to missed opportunities for economic development and the enhancement of public services (Erk et al., 2023; Li & Love, 2022)
8	Need for Innovation in Urban Infrastructure	There is an urgent need for modern and smart solutions that can adapt to the evolving demands of urban environments. Traditional infrastructure models are frequently inadequate to address contemporary challenges, particularly those related to technological integration and sustainability (Asumadu et al., 2023; De Paula et al., 2023).
9	Challenges in Public-Private Collaboration	Although PPPs offer significant potential to alleviate funding pressures, they are frequently constrained by challenges related to stakeholder alignment, risk-sharing, and accountability (Sunandar et al., 2024; Sunandar & Indiyati, 2023).

Source: Author's Own Creation (2024)

Function Analysis Phase

The VE methodology was applied to maximize the efficiency and functionality of the MYSinar+ street lighting system using the FAST diagram. This structured approach facilitated the systematic breakdown of core and value-added functions of the street lighting system, ensuring that it addresses urban needs such as energy efficiency, environmental sustainability, and public safety, while simultaneously providing additional value to the city. The primary role of street lighting is to illuminate urban spaces, including roads, parks, and public areas. MYSinar+, however, advances this core function by integrating energy-efficient and environmentally sustainable technologies that contribute to citywide objectives, such as reducing energy consumption, promoting renewable energy adoption, and minimizing the overall environmental footprint. The core functions of the MYSinar+ street lighting system are summarized in Table 2.

Table 2: Core Street Lighting Functions

No	Core Street Lighting Functions	Description
1	Decrease Energy Consumption: Use LED Technology	● Objective: Traditional street lighting systems, which frequently rely on incandescent or high-intensity discharge lamps, consume substantial amounts of electricity. ● Solution: MYSinar+ adopts LED technology, which provides higher luminous efficiency (producing more light per watt) and significantly reduces energy consumption compared with conventional lighting technologies.
2	Decrease Environmental Impact: Use Solid Plastic Recycle	● Objective: Cities produce substantial amounts of plastic waste, while traditional lighting poles made of metal contribute to environmental degradation. ● Solution: MYSinar+ utilizes streetlight poles constructed from recycled solid plastic materials, thereby reducing the environmental footprint of street lighting infrastructure.
3	Increase Renewable Energy: Use Solar Panel	● Objective: Street lighting systems powered by conventional electricity grids contribute to the reliance on non-renewable energy sources. ● Solution: MYSinar+ incorporates solar panels into the street lighting system, enabling it to operate using renewable solar energy.

Source: Author's Own Creation (2024)

Beyond its basic lighting function, MYSinar+ provides a wide range of value-added features that deliver benefits across multiple urban domains, including public safety and revenue generation. These enhancements extend the utility of the street lighting system, transforming it into a multifunctional asset that supports the broader objectives of smart city development. The value-added functions of the MYSinar+ street lighting system are summarized in Table 3.

Table 3: Value-Added Street Lighting Functions

No	Value Added Street Lighting Functions	Description
1	Increase Telecommunication: Create Wi-Fi Spots	● Objective: Cities are increasingly adopting smart infrastructure to enhance service delivery, including the expansion of public access to the internet. ● Solution: MYSinar+ streetlights can be equipped with Wi-Fi hotspots, enabling the establishment of public Wi-Fi zones in strategic urban locations.
2	Increase City Tax Revenue: Create Advertising Business	● Objective: Cities are continually seeking innovative approaches to generate revenue, particularly from non-tax sources such as advertising. ● Solution: MYSinar+ streetlights can be equipped with digital advertising panels, enabling municipalities to monetize strategic urban locations through the display of advertisements.
3	Increase Other City Revenue: Create Carbon Trade Mechanism	● Objective: As cities work toward achieving their climate action goals, opportunities arise for generating financial returns through participation in carbon markets. ● Solution: By reducing carbon emissions through the use of solar energy and energy-efficient LED technology, MYSinar+ supports the city's overall carbon reduction targets, thereby creating opportunities to engage in carbon trading schemes.
4	Increase Security Monitoring: Create Safety Cameras	● Objective: Urban security remains a critical concern, with increasing demand for enhanced surveillance in public spaces to prevent crime and facilitate timely emergency responses. ● Solution: MYSinar+ can be equipped with safety cameras, enabling continuous monitoring of public spaces and supporting improved security management.
5	Increase City Beautification: Create Street Furniture	● Objective: Public spaces must be both functional and aesthetically appealing to attract residents and tourists, thereby fostering a vibrant urban environment. ● Solution: MYSinar+ poles can be designed to integrate street furniture such as seating areas, planters, and decorative elements, enhancing the visual quality and usability of urban spaces.
6	Increase Traffic Management: Create Traffic Cameras	● Objective: Effective traffic management is essential for reducing congestion, preventing accidents, and ensuring the smooth flow of vehicles in urban environments. ● Solution: MYSinar+ streetlights can be equipped with traffic cameras that enable real-time monitoring and management of traffic conditions.

Source: Author's Own Creation (2024)

The functions of the MYSinar+ street lighting system, analyzed using the FAST diagram, are summarized in Figure 1.

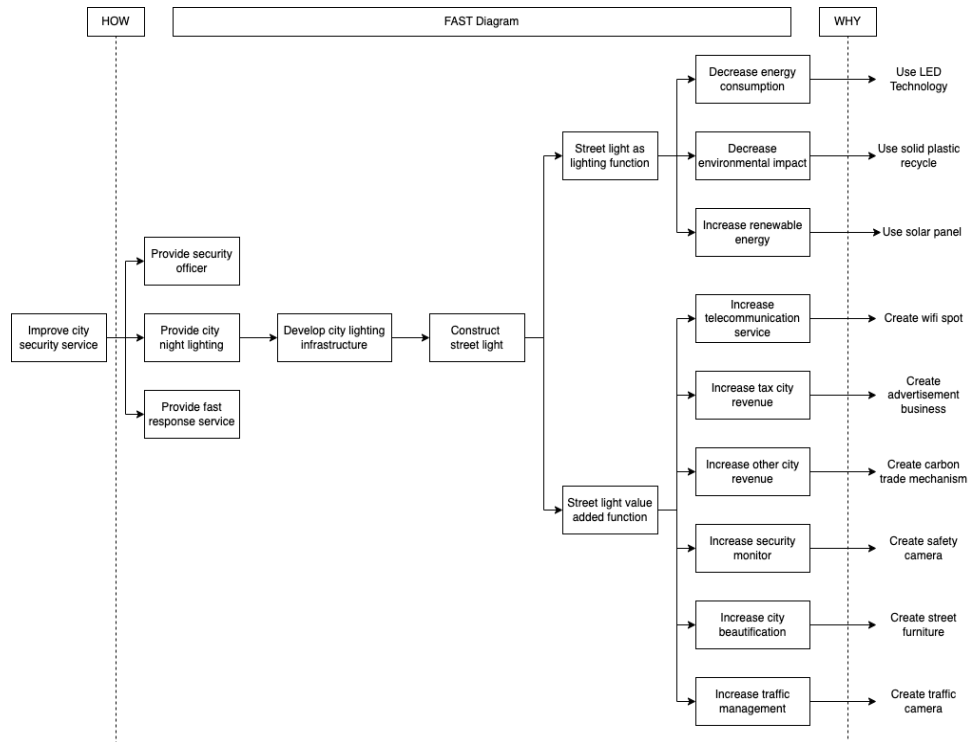


Figure 1: MYSinar+ Function Analysis System Technique (FAST) Diagram
Source: Author's Own Creation (2024)

Creative Phase

The PPP mechanism offers an innovative and strategic approach within this value engineering analysis, enabling city governments to implement the MYSinar+ street lighting system without imposing excessive pressure on public budgets. This financing arrangement is particularly beneficial for cities experiencing funding constraints, as it allows them to leverage private sector investment to address public safety and infrastructure needs. The stakeholders involved in the MYSinar+ PPP scheme are summarized in Table 4.

Table 4: Stakeholders involved in the MYSinar+ PPP

No	Stakeholder	Description
1	City or Central Government	Role: Government Contracting Agency (GCA) Responsibilities: Approve projects and provide necessary permits and monitor compliance with regulations.
2	Investors/ Sponsor/ SPV (Special Purpose Vehicle)	Role: Provide equity funding for the project. Responsibilities: Financial backing and risk management and ensure project viability and return on investment.

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No	Stakeholder	Description
3	Lenders (Financier)	Role: Provide debt funding for the project. Responsibilities: Loan disbursement and setting loan terms
4	Residents	Role: End-users benefiting from improved urban lighting and safety. Responsibilities: Provide feedback on lighting needs and safety concerns and participate in community engagement initiatives.
5	Local Business non-core	Role: Local businesses that may benefit from enhanced lighting and business non-core opportunities. Responsibilities: Engage in local business non-core.
6	Carbon Trading Exchange	Role: Facilitate the trading of carbon credits generated through MYSinar+'s sustainability initiatives. Responsibilities: ● Provide a marketplace for the buying and selling of carbon credits. ● Promote market participation by connecting buyers and sellers of carbon credits
7	REC Issuers	Role: Certify and facilitate the trading of renewable energy attributes associated with MYSinar+'s solar-powered lighting solutions. Responsibilities: ● Verify and issue Renewable Energy Certificates (RECs) for energy generated from renewable sources. ● Ensure compliance with national and international renewable energy standards.

Source: Author's Own Creation (2024)

Drawing on the explanation of the stakeholders outlined in Table 4, the MYSinar+ PPP conceptual framework is constructed as illustrated in Figure 2.

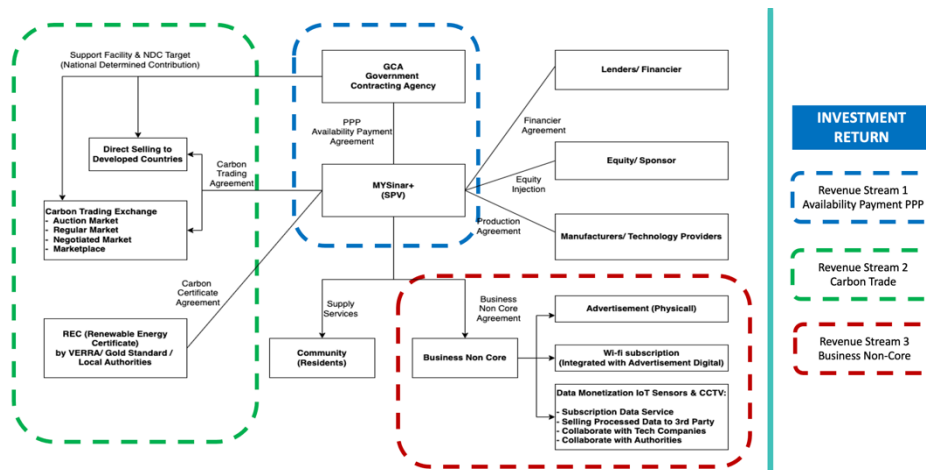


Figure 2: MYSinar+ PPP Conceptual Framework

Source: Author's Own Creation (2024)

The conceptual framework presents an integrated financial and operational model for the MYSinar+ street lighting value engineering initiative within the PPP scheme. The government, through a contracting agency, ensures financial sustainability via a PPP agreement with a SPV, which receives equity contributions from sponsors and loans from lenders. The carbon trading mechanism functions through various market platforms, including auctions and negotiated transactions, with direct sales to developed countries supporting national climate commitments. Additionally, the inclusion of RECs enhances market credibility and ensures compliance with international sustainability standards.

Beyond the core PPP operations, the model incorporates non-core revenue streams to improve financial viability. These include the monetization of Internet of Things (IoT) sensor data, subscription-based Wi-Fi services, and integrated physical and digital advertising. The diversified revenue structure, categorized into availability payments, carbon trading revenues, and non-core business income, mitigates financial risks and reinforces the long-term sustainability of the project.

Evaluation or Validation Phase

The evaluation and validation phase involved assessing the MYSinar+ street lighting value engineering conceptual framework at the PETRONAS CHESS Innovation Challenge 2024, a competition among university participants across Malaysia. The conceptual framework was selected for presentation in the grand finale at the Kuala Lumpur Convention Center after successfully passing two preceding rounds. In the grand finale, it was awarded Second Runner-up in the Sustainability category. Feedback on the conceptual framework was provided by three expert judges during the grand finale, as summarized in Table 5.

Table 5: Summary Feedback Evaluation

No	Expert	Summary Feedback
1	Senior Leader Petronas 1 in Sustainability	This conceptual framework is highly robust and comprehensive; however, further analysis is required to provide a more detailed calculation of the investment, particularly regarding the market-accepted rate of return.
2	Senior Leader Petronas 2 in Technology & Commercialization	The PPP approach employed in this study is highly commendable; however, it could be further enhanced by incorporating commercialization aspects for the retail market. This addition would make the framework more comprehensive.
3	Chief Amazon Web Service Malaysia & Cambodia	This conceptual framework is highly commendable, as it integrates revenue commercialization from the digital and IT sectors with carbon trading, which is particularly noteworthy.

Source: Author's Own Creation (2024)

MYSinar+ Prototype Development

After undergoing a value engineering study, followed by evaluation and validation in an innovation challenge forum with three relevant experts, the MYSinar+ product concept, encompassing both core and value-added functions, is presented in Figure 3. This process demonstrates the systematic integration of expert judgment and structured analysis to refine the proposed solution. Future research should extend beyond the innovation contest by conducting technical piloting and feasibility assessments. Such efforts are essential for evaluating implementation readiness in real-world contexts, including operational performance, cost efficiency, and scalability. These steps will facilitate the transition of the MYSinar+ prototype from a conceptual model to a practical solution that contributes to sustainable urban infrastructure development.

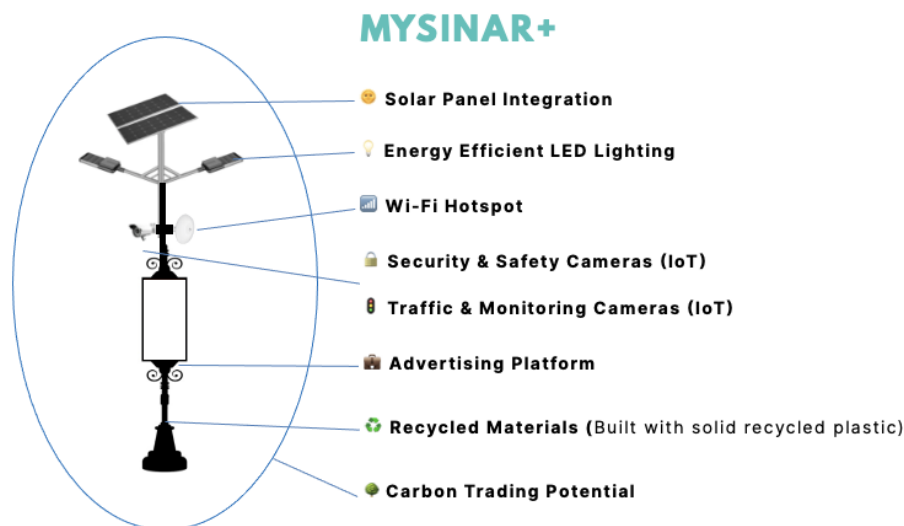


Figure 3: MYSinar+ Prototype Development
 Source: Author's Own Creation (2024)

CONCLUSION

Through the application of value engineering, the MYSinar+ street lighting system extends beyond its core function of illumination to provide a range of value-added services that address critical urban challenges, including energy efficiency, environmental sustainability, public safety, and revenue generation. By integrating advanced technologies such as solar power, LED lighting, Wi-Fi hotspots, safety cameras, and traffic management systems, MYSinar+ becomes an essential component of smart, sustainable, and secure urban infrastructure. Furthermore, features such as carbon trading, advertising opportunities, and street

beautification create new avenues for municipal revenue while enhancing residents' quality of life. Ultimately, MYSinar+ represents a forward-looking solution that not only improves urban lighting but also supports broader objectives, including climate action, economic development, and public safety.

This study primarily focuses on the conceptual planning phase. Further research is required to advance prototype development and conduct detailed investment cost analyses, providing critical insights for municipal stakeholders and investors. Although the current model was developed within a specific local context, many of its components—including renewable energy integration, multifunctional infrastructure design, and revenue diversification—are transferable to other jurisdictions facing similar urban challenges. However, contextual variations in governance structures, financing mechanisms, and regulatory frameworks may influence implementation, limiting the model's immediate applicability across all settings. Addressing these limitations will require comparative studies, cross-regional pilot projects, and structured stakeholder engagement to adapt the model to diverse urban environments. In this way, the study lays the groundwork for a comprehensive multifunctional street lighting system with international relevance and offers policymakers valuable guidance in designing sustainable and socially responsible infrastructure strategies.

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DISCLOSURE

The authors declare that there is no conflict of interest associated with this research.

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