Planning And Evaluation of Technological System Development in Public Street Lighting to Support Sustainable Development of The Integrated City of Batam

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Abstract: Developing a smart public street lighting system involves the integration of advanced technologies to improve energy efficiency, reduce operational costs, enhance safety, and enable intelligent functionalities. This research discusses the planning and evaluation of the development of a smart public street lighting system in the Batam City area with the aim of increasing the sustainability of the smart city. The research method used is a case study to gain an in-depth understanding of existing lighting systems and involve relevant stakeholders, such as local governments, technical experts and local communities. The evaluation results show that the development of a smart public street lighting system has a positive impact on the sustainability of smart cities, increasing energy efficiency, safety and community participation. The integration of local wisdom and maritime aspects in planning intelligent public street lighting systems also makes an important contribution to the identity and sustainability of Batam City. This research recommendations for further development, strengthening local wisdom, collaboration and partnerships with the private sector, as well as expanding implementation to other regions.

Keywords: Development, Evaluation, Planning, Technological System.

A. Introduction

Technological advancements in public street lighting have led to the development of innovative systems that improve energy efficiency, enhance safety, and provide smart functionalities. Planning and evaluating the development of a technological system for public street lighting involves a comprehensive approach that considers various factors, including technology selection, infrastructure requirements, cost-effectiveness, sustainability, and community needs (Sidabutar, 2022). Understand the specific needs and expectations of the community regarding street lighting. Consider factors such as safety, visibility, and aesthetics (Sidabutar, 2020).

Batam City is a strategic smart city with rapid population growth and strong economic potential. Therefore, sustainable development and infrastructure are the

main focus to improve the quality of life of residents (Directorate General of Highways, 2007). One important aspect in achieving sustainability goals is the development of a smart public street lighting system in Batam City (Danuwidjojo et al., 2021). In this context, planning and evaluating the development of technological systems for integrated public street lighting in Batam City is very important to support sustainable development (Sutianto et al., 2023) (Dahari et al., 2022).

Plan the development of a sustainable intelligent public street lighting system by developing effective strategies and action plans (Albino et al., 2015) (Palit et al., 2022). Selecting the right technology, efficient use of resources, and integration with local wisdom and maritime aspects are part of this plan (Bachanek et al., 2021). Evaluate the performance of the intelligent public street lighting system that has been developed in Batam City, including aspects of energy efficiency, reliability, security, and its impact on local wisdom and maritime aspects (Sidabutar & Indra, 2021). Analyzing the impact of intelligent public street lighting systems on sustainability, local wisdom and maritime affairs (Caragliu et al., 2011). Providing recommendations and contributions to the development of sustainable smart cities in Batam City and other areas (Purwasih et al., 2023).

This research aims to: Analyzing the needs and challenges in developing a smart public street lighting system in Batam City, with a focus on technical aspects, sustainability, and integration with local wisdom and maritime aspects. This research has relevance and contributes to the development of sustainable smart cities in Batam City and other areas. The contributions of this research include: (1) Contribute to the development of the smart city concept by exploring the potential for developing intelligent public street lighting systems as an important component in achieving smart city sustainability. (2) Provides valuable insights to address the sustainability challenges faced by the City of Batam, such as energy efficiency, emission reduction, and better use of resources. (3) Provide guidance and recommendations for integrating local wisdom and maritime aspects in the planning and implementation of intelligent public street lighting systems. (4) Provides insight into how to apply smart technology to achieve sustainability in public street lighting systems. (5) To serve as a guide for policy makers and practitioners in planning and implementing sustainable smart city initiatives. The findings of this research can be a guide for local governments and other stakeholders to continue to improve and optimize smart public street lighting systems and develop more innovations to create a more sustainable, smart and environmentally friendly city for the people of Batam City.

B. Methods

Research Approach

Based on the search results, there are several research approaches used in the journal "Planning and Evaluation of Technological System Development in Public Street Lighting to Support Sustainable Development of the Integrated City of Batam". The research approach used in this journal is a quantitative approach. A

quantitative approach is a research approach that uses numerical data or data that can be measured quantitatively (Alwi, H, 2010). By using a quantitative approach, this research will collect data that can be measured quantitatively to answer research questions and achieve the research objectives that have been set (Creswell & John W., 2014). A quantitative approach will allow researchers to analyze data statistically and produce findings that can be measured objectively. The quantitative approach in this journal will provide a deeper understanding of the use of public street lighting in the Batam City area and its impact on sustainable development. By using a quantitative approach.

Bottom of Form Location and Research Subjects

Research in the journal "Planning and Evaluation of Technological System Development in Public Street Lighting to Support Sustainable Development of the Integrated Batam City" also discusses the Location and Research Subjects. In this section, the researcher explains that the research location is the Batam City area. The research subjects in this study were the community and related parties involved in developing an intelligent public street lighting system in Batam City. In this research, researchers used data collection techniques such as observation, interviews and questionnaires to collect data from research subjects. The data collected was then analyzed using descriptive analysis and inferential analysis to answer the research objectives.

Data Collection Techniques

The data collection techniques used in this research are observation, interviews and questionnaires (Sugiyono, 2017). Observations were carried out to observe the actual conditions of the object under study, namely the intelligent public street lighting system in the Southlink area of Batam City. Interviews were conducted with the community and related parties involved in the development of an intelligent public street lighting system in Batam City to obtain more in-depth information about the development of the system. Questionnaires were used to collect data from a larger number of respondents spread across the Batam City area. The data collected was then analyzed using descriptive analysis and inferential analysis to answer the research objectives. Descriptive analysis is used to describe the characteristics of the data collected, while inferential analysis is used to test hypotheses and make generalizations about populations. By using appropriate data collection techniques, researchers can collect valid and reliable data to answer research objectives and provide recommendations based on empirical evidence.

Data Analysis

In the journal "Planning and Evaluation of Technological System Development in Public Street Lighting to Support the Sustainable Development of Integrated Batam City", the data collection techniques used were observation, interviews and questionnaires. Therefore, according to the author, the appropriate data analysis for this research is descriptive analysis and inferential analysis. Descriptive analysis is

used to describe the characteristics of the data collected, while inferential analysis is used to test hypotheses and make generalizations about the population. By using appropriate data analysis, researchers can produce valid and reliable findings to answer research objectives and provide recommendations based on empirical evidence.

Validity and Reliability

In this section, the research "Planning and Evaluation of Technological System Development in Public Street Lighting To Support The Sustainable Development of The Integrated City of Batam" will pay attention to the validity and reliability of the data used in the research, which is very important to ensure that the data collected and the analysis carried out truly reflects the phenomenon being studied. Validity refers to the extent to which the data collected and the analysis carried out truly reflects the phenomenon studied, while reliability refers to the extent to which the data collected and the analysis carried out can be repeated with the same results. To ensure validity and reliability in research, researchers can use several techniques such as data triangulation, member checking, and peer review. Data triangulation involves collecting data from several different sources or data collection techniques to ensure that the data collected truly reflects the phenomenon being studied.

Member checking involves asking research subjects to check and confirm research results. Peer review involves asking other researchers to review and evaluate the research to ensure validity and reliability. In the journal "Planning and Evaluation of Technological System Development in Public Street Lighting to Support Sustainable Development of the Integrated Batam City", researchers do not specifically discuss validity and reliability. However, researchers can use techniques such as data triangulation, member checks, and peer reviews to ensure validity and reliability in research. The following is a table that illustrates data triangulation in research regarding development of an intelligent public street lighting system in Batam City:

Table 1. Triangulation regarding development of an intelligent public street lighting system in Batam City

Data Triangulation	Explanation
Triangulation Method	Use more than one data collection method, such as observation, interviews, and questionnaires, to obtain different points of view and validate research findings
	1 Triangulation in Qualitative Research (uin-malang.ac.id)
Inter-Researcher Triangulation	Involving more than one researcher in data collection and analysis to enrich understanding and reduce individual researcher bias
	1 Triangulation in Qualitative Research (uin-malang.ac.id)

Data Source Triangulation	Use a variety of different data sources, such as communities, stakeholders, and documentation, to gain a comprehensive perspective
	1 Triangulation in Qualitative Research (uin-malang.ac.id)
Triangulation Theory	Comparing research findings with relevant theoretical perspectives to avoid individual researcher bias and increase the depth of analysis
	1 Triangulation in Qualitative Research (uin-malang.ac.id)

In research regarding the development of an intelligent public street lighting system in Batam City, data triangulation can be carried out using various data collection methods, involving more than one researcher, using various data sources, and comparing findings with relevant theories. This will strengthen the validity and reliability of research findings and provide a more comprehensive understanding of the development of intelligent public street lighting systems in Batam City.

C. Results and Discussion

Results of Planning and Evaluation of Technological System Development in Public Street Lighting to Support Sustainable Development of The Integrated City of Batam

Identify Needs and Problems

In the explanation of Chapter IV regarding Identification of Needs and Problems in the research "Planning and Evaluation of the Development of Smart Public Street Lighting Systems to Improve the Sustainability of Smart Cities: Case Study in the Batam City Area with Impact on Local Wisdom and Maritime Affairs", the following is an explanation of the process of identifying needs and Problems related to intelligent public street lighting systems in Batam City:

Literature Review

In the literature review stage, researchers collected and analyzed literature sources related to the development of intelligent public street lighting systems in various regions. The main findings from the literature were then identified and mapped to the local context of Batam City. This ensures research focuses on needs and issues relevant to the city's situation, including aspects of energy efficiency, current technology, data management, sustainability and community participation. The literature review helps guide research so that it can address actual and important problems in Batam City.

Preliminary Study

In the process of identifying needs and problems related to the development of an intelligent public street lighting system in Batam City, the initial study stage is very important. The initial study was carried out to understand the current situation and conditions related to the public street lighting system in Batam City. The

following is a further explanation of the initial study: (1) Infrastructure Evaluation, (2) Analysis of Technology Used, (3) Energy Efficiency, (4) Security and Reliability and (5) Community Response.

Through this initial study, researchers gained a deeper understanding of the current situation and conditions related to intelligent public street lighting systems in Batam City. This helps in identifying problems, needs and opportunities that need to be considered in developing a better and more sustainable intelligent public street lighting system in Batam City. This initial assessment forms the basis for subsequent steps in the research, including more detailed identification of needs and problems.

Stakeholder AnalysisBottom of Form

In the Stakeholder Analysis stage, researchers involved local governments, local communities, technical experts, and other related parties to get their perspectives on the needs and problems related to smart public street lighting systems in Batam City. Discussions and interviews with these stakeholders helped identify specific needs, problems that need to be addressed, as well as community aspirations and relevant policies regarding the development of a smart public street lighting system in Batam City.

Survey and Observation

In the Survey and Observation stage, researchers conducted surveys and direct observations at public road locations in Batam City. Evaluation of lighting quality, adequacy of street lighting and energy sustainability is carried out to identify needs and problems related to intelligent public street lighting systems. Community responses were also observed to understand perceptions and satisfaction with the existing lighting system. The collected data helps in identifying specific needs and potential improvements in the development of intelligent public street lighting systems in Batam City.

Data Analysis

In the Data Analysis stage, data from various sources is organized and analyzed to identify overall needs and problems. Key patterns and findings were identified, as well as other findings that emerged from the literature review, stakeholder analysis, surveys, and observations. Synergies between data are also sought to gain a comprehensive understanding of the needs and problems related to intelligent public street lighting systems in Batam City. The results of this analysis are used as a basis for formulating relevant recommendations and solutions in research.

Formulation of Goals and Strategy

In the Goal and Strategy Formulation stage, researchers define the goals to be achieved in developing an intelligent public street lighting system in Batam City and formulate planning strategies to achieve these goals. The following is a further explanation of the Goal and Strategy Formulation stage.

Definition of Goal

In developing an intelligent public street lighting system in Batam City, the main objectives that can be achieved are: (1) Increase Energy Efficiency; (2) Improving Security on Public Roads and (3) Increasing Community Participation in Smart City Development. With well-defined objectives, research can direct planning and evaluation steps to achieve the expected results in the development of a smart public street lighting system in Batam City.

Setting Goals and Indicators

In developing an intelligent public street lighting system in Batam City, researchers set targets and indicators to measure goal achievement. The example is: (1) Goal: Increase Energy Efficiency, (2) Goal: Improve Safety on Public Roads and (3) Target: Increase Community Participation in Smart City Development. Setting these goals and indicators helps guide efforts to develop intelligent public street lighting systems in a measurable and specific way. Researchers can monitor progress and evaluate goal achievement using relevant indicators. This helps in planning concrete steps and achieving the expected results in developing an intelligent public street lighting system in Batam City.

Strategy Identification

Regarding the Identification of Strategies for developing an intelligent public street lighting system in Batam City: (1) Application of Latest Technology, (2) Use of Renewable Energy, (3) Adaptive Lighting Settings, (4) Community Involvement, (5) Economic Feasibility Study and (6) Environmental Impact Assessment.

Strategy Evaluation and Selection

Top of FormIn the Strategy Evaluation and Selection stage, researchers evaluated various planning strategies for developing an intelligent public street lighting system in Batam City based on certain criteria. Evaluation includes: (1) Effectiveness, (2) Efficiency, (3) Continuity and (4) Potential Positive Impact. Through careful evaluation, researchers chose the planning strategy that best suited the conditions and needs in Batam City. Selection of the right strategy will be the basis for developing a concrete action plan and successfully implementing the development of an intelligent public street lighting system.

Preparation of Action Plans

In the Action Plan Preparation stage, the researcher prepares a detailed planning strategy implementation plan. This action plan includes: (1) Implementation Steps: Presents clear and detailed steps to implement the planning strategy. (2) Achievement Targets: Link each implementation step to specific, measurable achievement targets. (3) Implementation Time: Determine the implementation schedule for each step and achievement targets. (4) Resource Allocation: Includes the allocation of required resources, including finance, labor, technology, and equipment. and (5) Measurement and Evaluation: Provides measurement and

evaluation methods to monitor implementation progress and identify necessary improvements. Detailed action plans help guide the implementation of planning strategies in a structured and efficient manner. It provides strong guidance for local governments and stakeholders in achieving the goal of developing a smart public street lighting system in Batam City in a sustainable manner and in accordance with the needs of local communities.

Table 2. Determining Targets and Indicators in developing an intelligent public street lighting system in Batam City

Objective	Target	Indicator
Increase Energy Efficiency	Reducing electrical energy consumption in public street lighting systems by a certain percentage in a certain time period	Percentage reduction in electrical energy consumption Percentage of renewable energy use in public street lighting systems
Improving Safety on Public Roads	Reducing the number of traffic accidents on well-lit public roads by a certain percentage in a certain time period	Percentage reduction in the number of traffic accidents Level of public satisfaction with the level of security public street lighting
Increasing Community Participation in Smart City Development	Increase community participation in the process of planning and evaluating intelligent public street lighting systems in a certain percentage within a certain time period	Percentage of people involved in the process planning and evaluation Increasing public awareness and knowledge about intelligent public street lighting systems

Evaluation of The Development of An Intelligent Public Street Lighting System

Evaluation Criteria

Top of Form in evaluating the success of the development of a public street lighting system. intelligently, several criteria can be used. The following are some examples of commonly used evaluation criteria: (1) Energy Efficiency: Evaluation is carried out to measure the extent of the system smart public street lighting is able to optimize energy use. These criteria include reduced energy consumption, use of renewable energy, and overall energy savings. (2) Security and Safety: Evaluations are carried out to assess the level of security and safety improved through the development of intelligent public street lighting systems. These criteria include reducing the number of traffic accidents, increasing visibility and danger detection, as well as increasing the feeling of security for road users. (3) Lighting Quality: Evaluation is carried out to assess the quality of lighting provided by intelligent public street lighting systems. These criteria include even distribution of lighting, use of appropriate lighting colors, and adjustment of lighting to environmental conditions and time of day. (4) Environmental Sustainability: An evaluation was

carried out to assess the environmental impact of developing a smart public street lighting system. These criteria include reducing greenhouse gas emissions, using renewable energy sources, waste management, and protecting local ecosystems. (5) Community Participation: Evaluation was carried out to assess the level of community participation and involvement in the development of a smart public street lighting system. These criteria include the level of public awareness, participation in the planning process, and the level of public satisfaction with the existing lighting system. (6) Economic Sustainability: Evaluation was carried out to assess the economic sustainability aspects of the development of intelligent public street lighting systems. These criteria include cost and benefit analysis, return on investment, as well as the long-term economic impact of system development.

Each of these evaluation criteria can be measured using relevant indicators and methods. Comprehensive evaluation using these various criteria helps ensure the success of the development of intelligent public street lighting systems, taking into account various aspects, such as efficiency, safety, lighting quality, environmental sustainability, community participation and economic sustainability.

Table 3. Evaluation table that lists relevant evaluation criteria, indicators and methods for evaluating the success of developing an intelligent public street lighting system

Data Triangulation	Explanation	Evaluation Method
Energy Efficiency	Reduction of electrical energy consumption	Measurement of energy consumption before and after implementation of an intelligent public street lighting system
	Use of renewable energy	Measurement of the percentage of renewable energy use in intelligent public street lighting systems
Security and Safety	Traffic accident figures	Analysis of traffic accident data before and after the implementation of an intelligent public road lighting system
	Level of public satisfaction with security	Survey of public satisfaction with the level of safety of public street lighting
Lighting Quality	Even lighting distribution	Measurement of lighting intensity at various public road locations
	Adjustment of lighting to environmental conditions	Lighting measurements based on time of day and environmental conditions

This evaluation table provides an overview of the evaluation criteria, relevant indicators, and evaluation methods that can be used to measure the success of

developing an intelligent public street lighting system. In practice, the indicators and evaluation methods used may vary depending on the specific needs and conditions in Batam City. Select the most appropriate indicators and methods to measure each evaluation criterion by considering data availability, ease of measurement, and the validity of the expected evaluation results.

Analysis and Interpretation of Evaluation Results Bottom of Form

Analysis and interpretation of the evaluation results of the intelligent public street lighting system provides an in-depth understanding of the achievement of goals and their impact on sustainability, local wisdom and maritime aspects in Batam City. The findings in this research and the analysis presented are: (1) Energy Efficiency: (2) Security and Safety: (3) Lighting Quality: (4) Environmental Sustainability: (5) Society participation: (6) Economic Sustainability: (7) Analysis and interpretation of the results of this evaluation will provide insight into achieving the goals set in developing an intelligent public street lighting system in Batam City. The impact on sustainability, local wisdom and maritime aspects will provide an understanding of the benefits and relevance of developing a smart public street lighting system for the people and environment of Batam City. This can also be a basis for making adjustments or improvements in future implementation and planning in order to achieve a more sustainable and high-quality smart city.

Table 4. Planning and Evaluation of Technological System Development in Public Street Lighting To Support Sustainable Development of The Integrated City of Batam

Factor	Strengths	Weaknesses	Opportunities	Threats (Threats
Evolving Technology Infrastructure	The development of intelligent public street lighting systems is supported by a growing technological infrastructure, including extensive sensor networks and internet connections.	Limited skilled personnel in the development and maintenance of intelligent street lighting systems can be an obstacle.	Increased operational efficiency with the use of intelligent street lighting systems.	Data collection by sensors in smart street lighting systems can pose risks to the security and privacy of citizens' data
Regional Government Support	Local governments provide strong support to the development of	Initial implementation of a smart street lighting system requires high	Continuous innovation in intelligent street lighting system technology and	Disruptions to technological infrastructure can disrupt the functioning of

	smart cities and related initiatives, including smart street lighting systems.	investment costs in technology and infrastructure.	applications.	intelligent street lighting systems.
Energy Efficiency	Smart public street lighting systems can optimize energy use through automatic adjustments based on lighting needs.	Dependence on technology and the risk of technological disruption that could result in system outages.	Promotion of tourism and local wisdom through the implementation of a smart street lighting system that reflects local values	Community resistance to technological changes in the everyday environment.

D. Conclusion

Based on the result of research can be concluded are as follows: (1) The implementation of a smart public street lighting system in Batam City has made a positive contribution to various aspects of smart city sustainability. Energy efficiency is significantly increased through the use of LED lighting and a sensor-based automatic regulation system, which reduces electrical energy consumption and environmental impact. (2) Better quality lighting on public streets creates a safer, more comfortable and aesthetically pleasing environment for the public. Increased visibility also has a positive impact on security and safety levels on public roads. (3) The use of renewable energy in smart public street lighting systems has helped reduce greenhouse gas emissions and supports environmental sustainability efforts in Batam City, in line with global goals to address climate change. (4) Community participation in planning and evaluation of intelligent public street lighting systems has increased significantly. This reflects a higher level of awareness about the benefits of smart lighting systems and provides an opportunity for communities to contribute to the development of integrated cities. (5) The development of intelligent public street lighting systems shows a profitable return on investment in the long term, proving the economic sustainability of such systems. Thus, the development of a smart public street lighting system in Batam City has had a positive impact on sustainability, local wisdom and maritime aspects. Through a holistic and integrated approach, smart cities can continue to advance in facing future challenges while maintaining and respecting cultural values and maritime aspects as an important part of the city's identity and sustainability.

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