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SYSTEM DYNAMICS SIMULATION OF MAIN MATERIAL INVENTORY CONTROL POLICY FOR ELECTRICITY DISTRIBUTION NETWORK OPERATIONS

Diajeng Anjarsari Rahmadani[1], and Niniet Indah Arvitrida[1]

[1]Dept. of Industrial Eng., Institut Teknologi Sepuluh Nopember, Surabaya, INDONESIA

ABSTRACT

Inventory management needs coordinated efforts among internal and external stakeholders. An electric power distribution service unit faces challenges in the inventory management. Operational constraints include ordering cycle, fluctuating lead times, and the absence of buffer stock must be managed while adhering to mandatory service standards. This study adopts a system dynamics simulation to identify key stakeholders and map their interdependencies. The objects of study are power cable, cubicle, insulator, and lightening arrester. A causal loop diagram (CLD) is employed to visualize and analyze the dynamics of the problem. Inventory system is modeled into ten sub models. It is material request sub model, purchasing order, order receipt, material issued transaction, inventory level, coordination, service level, inventory turnover, budget - total cost, and service duration day. Continuous review policy is integrated in the model as proposed policy and combination with supplier improvements gives best results in 26,12% increase in service level.

1 INTRODUCTION

This study explores the complexities of inventory management at PT UP3 X, a power distribution service unit in West Java, Indonesia, responsible for meeting growing electricity demands through efficient material handling, particularly for network expansion when existing infrastructure is inadequate. Inventory has a vital role in supporting timely power connections, which are key performance indicators for the company, yet delivery delays and stakeholder interdependencies often challenge material availability. Using a system dynamics approach, this research aims to understand the interactions within the system, the influence of stakeholder decisions, existing policy, and find the best policy based with continuous review. The study focuses on model development, contributing to the limited literature on inventory management in electricity distribution, and serves as a foundation for further research and strategic improvement in the sector.

2 METHODOLOGY

A system is a set of interconnected elements with dynamic behavior shaped by feedback and environmental boundaries (Schoenenberger et al. 2021). The system dynamics approach analyzes complex problems using Causal Loop Diagrams (CLDs) to visualize cause-effect relationships, which are then developed into stock and flow diagrams. This method supports policy design and optimization, particularly in inventory and distribution management, as demonstrated in omni-channel retail and humanitarian supply chains.

Optimizing stock management using inventory policy can reduced inventory level by managing service level (Sridhar et al. 2021). The (s, S) inventory policy is effective for managing uncertainty in demand and lead time. Under this approach, orders are placed when inventory drops to or below the reorder point (s), and stock is replenished up to the maximum level (S). This method helps balance stock availability and cost efficiency, especially when combined with safety stock and continuous or periodic review strategies. The values of (s) and (S) can be approximated using reorder point and economic order quantity formulas, making (s, S) suitable for environments with variable demand and lead time.

This two approach is integrated in the simulation model. It is used binary auxiliary variables which becomes the switch to activate the continuous review policy in inventory level sub model.

3 SIMULATION MODEL DEVELOPMENT

The complexity is built in material request sub model, purchasing order sub model, order receipt sub model, material issued transaction sub model, inventory level sub model, coordination sub model, service level sub model, inventory turnover sub model, budget - total cost sub model, and service duration day sub model. Material request sub model has two main internal stakeholders (Construction and Logistics section). It reflects the demand management in the service unit. Purchasing order sub model involves the output from material request sub model and interaction by Connection Planning Section at higher service unit with supplier. Order receipt sub model involves interaction of Logistics Section and Supplier. Material issued transaction sub model involves interaction of Construction Section and Installation Vendor. Inventory sub model is main sub model which consists the management of stock and used in another sub model. Service level sub model, inventory turnover sub model, budget - total cost sub model, and service duration day sub model are performance indicator used for inventory system in the service unit studied.

Scenario development is built by changing procedure in internal stakeholders (Logistics and Construction Sections) called internal coordination, activation of continuous review using two alternatives parameter, and supplier improvement. Supplier improvement is a policy that requires suppliers to send the purchase orders in the same month. From these components, eight policy scenario is tested and analyzed to find recommendations. After testing the scenarios, three alternatives is eliminated. It is existing procedures with internal coordination, continuous review - alternative (s, S) 1 without supplier improvement, continuous review - alternative (s, S) 2 without supplier improvement, continuous review - alternative (s, S) 1 with supplier improvement, and continuous review - alternative (s, S) 1 with supplier improvement.

4 CONCLUSION

The inventory control policy tested is modifications to internal procedures through coordination between the Construction and Logistics Sections, the implementation of the continuous review (s,S) policy, and proposed improvements from suppliers. Simulation results show that the combination of continuous review (s,S) with supplier improvement delivered the best performance, marked by up to 26% budget savings and increased service levels in several material categories, such as power cables (26.2%), cubicles (5.89%), and insulators (16.73%). This policy also results in the shortest service durations for the cubicle, insulator, and lightning arrester (LA) categories. Among the two tested alternatives, alternative (s,S) 1, which uses a lower maximum stock level, gives better performance service level (92.1%) and budget efficiency compared to alternative (s,S) 2. Therefore, alternative (s,S) 1 is recommended for application across all four material categories, with the note that (s,S) values must be regularly evaluated and updated in accordance with changing demand patterns.

REFERENCES

Schoenenberger, L., Schmid, A., Tanase, R., Beck, M., & Schwaniger, M. (2021). Structural Analysis of System Dynamics Models. *Simulation Modelling Practice and Theory*. doi:https://doi.org/10.1016/j.simpat.2021.102333

Sridhar, P., Vishnu, C., & Sridharan, R. (2021). Simulation of inventory management systems in retail stores: A case study. *Materials Today: Proceedings*, 5130-5134. doi:10.1016/j.matpr.2021.05.314