

Final Project 1

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OPTIMIZING PPE INVENTORY MANAGEMENT IN POWER PLANTS

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1. Chapter 1: Introduction

1.1. Research Background

The operations in the sector of power generation industry involves workers exposure to high-risk environments such as, high- voltage electricity, chemicals, toxic gases and heavy machinery. This hazardous environment leads the country authorities to enforce safety and compliance standards to limit the accidents in the workplace. The occupational safety and health administration (OSHA) ensures safe and healthy working conditions for the workers by setting a non-negotiable standard, including providing personal protective equipment (PPE) which is last defense line against injuries [1]. In order to provide the PPE for the workers some companies rely on reactive procurement systems where they either order the equipment after the accidents accours or overstocking the warehouse regularly which increases the costs and leads to material waste [2]. This study aims to implement, evaluate and optimize inventory control methods for PPE management at a power plant to reduce costs and accidents.

1.2. Research Problem

Many power plants and factories maintain traditional inventory models where it provides a certain amount of inventory stocks each month without making track of what was used and what is needed [3]. PPE comes in deferent sizes and hazard-ratings where it makes it difficult to track, and many components have shelf lives where it can be overdue and cause waste and additional costs. The main challenge is to create a tracking and ordering system model that guarantee availability of the PPE all the time and provide better logistic communications.

1.2.1. Theoretical Gaps

The main problem in power plants is the lack of inventory management systems that provide tracking of the equipment availability and expiry dates. This traditional system is not synced where the inventory must be updated manually from the supervisor.

1.2.2. Practical Gaps

The reliance on the traditional method of manual inventory keeping prevents the introduction of a new more efficient method of stock upkeep since it is the standard throughout all powerplants of the company.

In addition, the lack of effective communication between employees and inventory managers makes it difficult to provide appropriate feedback on the traditional stocking method.

1.3. Research Significance

The aim of this study is to minimize safety hazards associated with lack of PPE inventory, as well as lowering the expenses and waste produced due to expired inventory and overstocking.

1.3.1. At the theoretical level

Implementing a digital automatic system for inventory management would greatly decrease the risk of injury due to PPE shortage or expired equipment, in addition, it would increase the stocking efficiency with automatic updates of available inventory and alerts of any PPE shortage.

1.3.2. At the practical level

The proposed method would be easy to implement in all company powerplants due to its ease of use and simple user-friendly interface.

The automated updates of available PPE stock would save time on inventory monitoring, as well as provide alerts for specific stock shortages so it could be remedied immediately.

1.4. Research Questions

- How do we decrease expenses on unnecessary inventory?
- How do we eliminate the risks arising from PPE shortage?
- How can we improve PPE inventory logistics?

1.5. Research Objectives

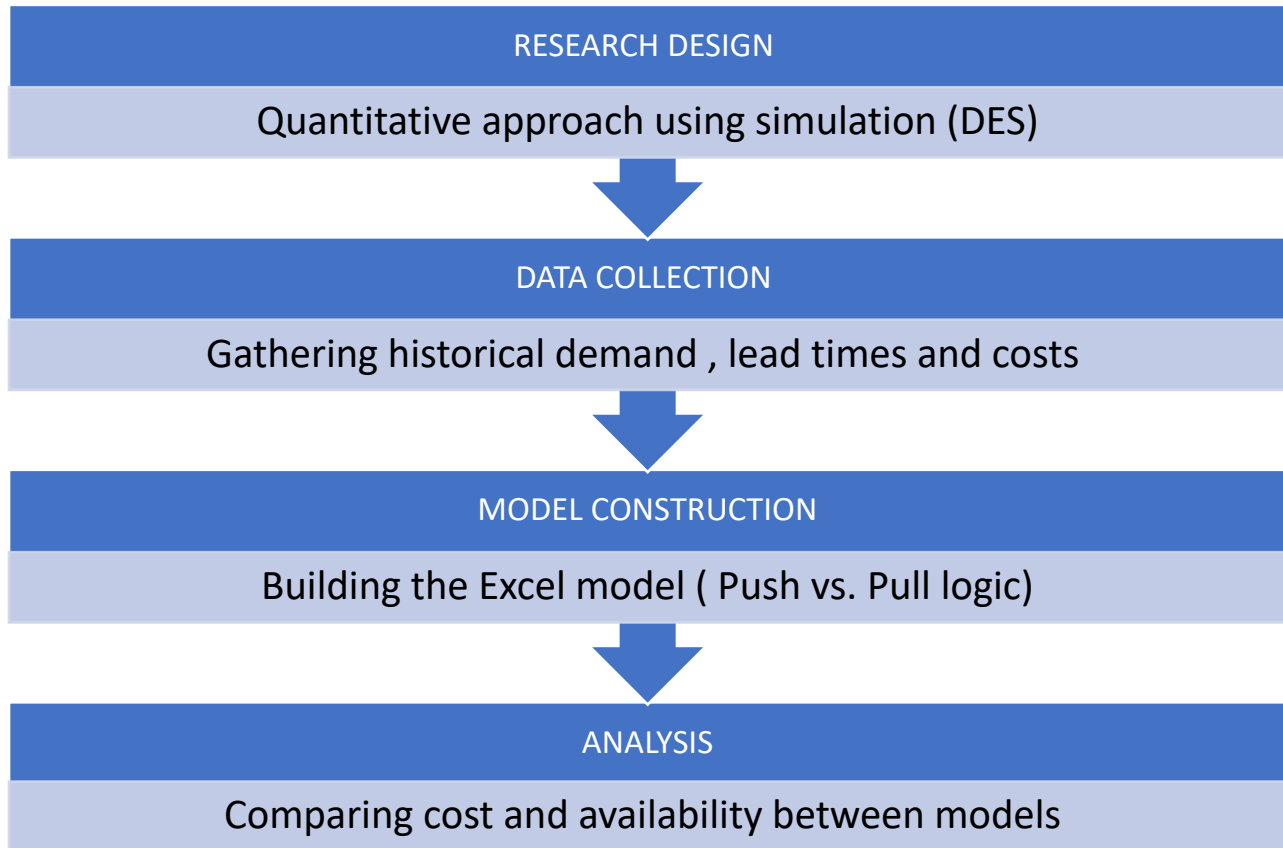
- To provide a new and improved method of inventory management.
- To decrease inventory waste and stock expiry.
- To increase the efficiency of inventory and stock monitoring.
- To provide user-friendly communication tool.
- To maintain safety standards throughout the power plant.

1.6. Research Hypotheses

Transitioning from a manual push-inventory model to a digitized, consumption-based tracking system and adding an expiry monitoring will ensure consistent PPE availability and eliminate waste and procurement costs in power plants.

1.7. Research Model

The research model follows simulation framework (Figure 1).

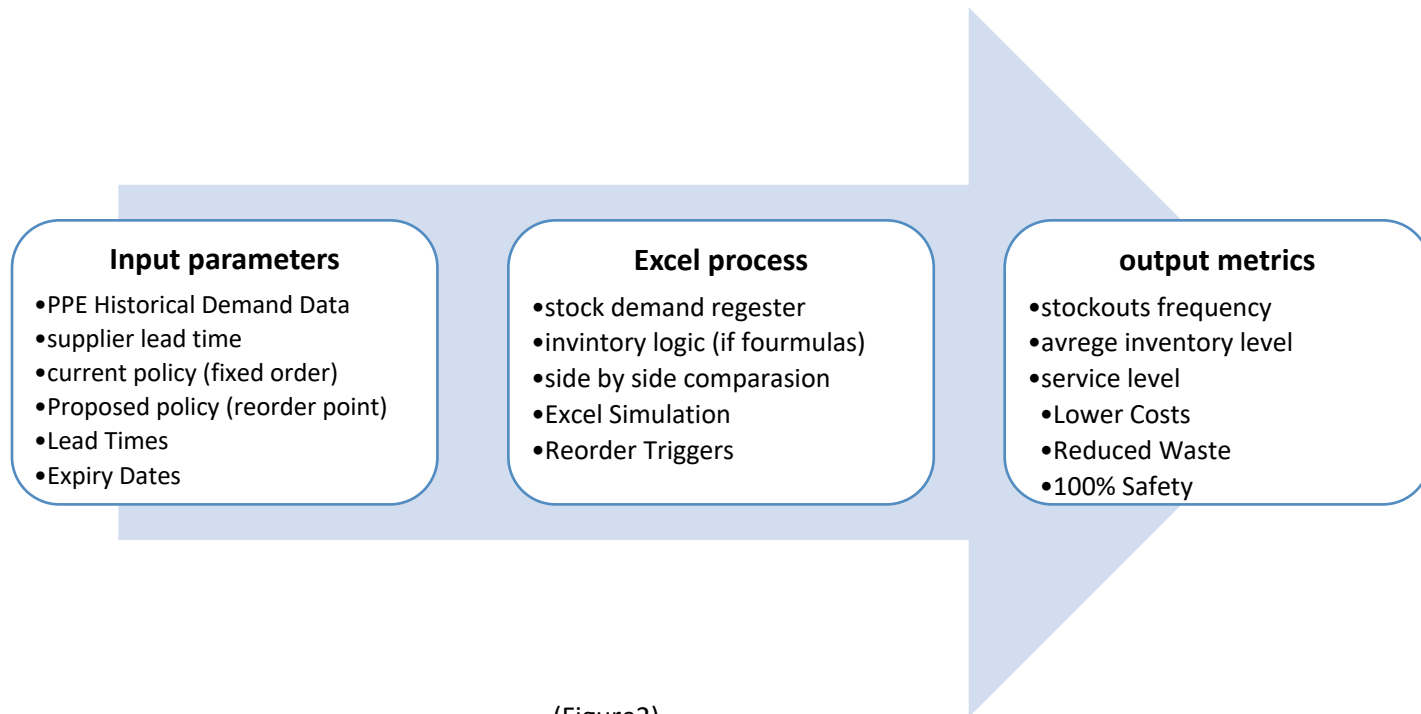


(Figure 1)

1.8. Research Methodology

For this study, a quantitative approach using Discrete Event Simulation (DES) within a Microsoft Excel environment. The study is to the modeling and simulation of an improved inventory system to demonstrate theoretical efficiency. Data will be collected from an industrial power plant inventory reports which provides an insight into how the push (traditional) model works. The data collection will focus on three key categories of Personal Protective

Equipment (PPE): (e.g., disposable masks, gloves), Durable Goods (e.g., helmets, safety boots), and Stables (items with limited shelf lives). In this study the main focus is to utilize Microsoft Excel to construct a digitized consumption-based system. The method of the excel process is explained in (Figure 2).



(Figure2)

1.9. Scope of The Study

This research takes place in power planet within al Jubail, in Saudi Arabia eastern region. The scope of this study focuses internal logistics control of the inventory management of general goods and Personal Protective Equipment (PPE). It specifically addresses the challenges of tracking stock levels, monitoring expiry dates, and optimizing reordering schedules.

1.10. The Suggested Project Structure

The proposed structure for the research project is as follows (Midocean University, 2025):

1. Introduction: it provides an overview of the study including the background information, research problem, objectives, and the significance of the research.

1.1. Research background: it illustrates the historical roots of the project idea.

1.2. Research problem: it reflects the gap in the current literature or practice that the project seeks to investigate and address.

1.3. Research significance: it clarifies the importance of the study at the theoretical level, and the empirical level.

1.4. Research questions: it presents the specific hypotheses that will be tested in the project.

1.5. Research objectives: it identifies the specific goals and outcomes that the project aims to achieve.

1.6. Research hypotheses: it presents the specific hypotheses that will be tested in the project.

1.7. Scope of the study: it defines the scope of the project work.

2. Literature review: it presents a critical analysis of existing research and literature relevant to the project on optimizing PPE inventory management in

power plants and the challenges and opportunities in applying digitized tracking and controlling inventory system.

3. Research methodology: it details the methods and procedures used to conduct the research including information about the research design, data collection methods, sample selection, and data analysis techniques.

4. Analysis and results: it describes and discusses the statistical analysis for the research findings.

5. Discussion: it connects the project findings with literature.

6. Conclusion and recommendations: it summarizes the key findings and provides suggestions for future research

7. References: it provides comprehensive list of academic sources and references

used throughout the study.

8. Appendices: it contains additional material and any other relevant documents, where applicable.

2.Chapter 2: Literature Review

2.1. Introduction

The management of Personal Protective Equipment (PPE) in power plants which considered a high-risk environment. Faces challenges that overcomes simple cost minimization. A stockout in a power plant facility can risk the workers safety and threaten operational continuity. There for, the literature about inventory control has improved from traditional manual records to more digitized, quantitative-based approaches designed to guarantee availability while reducing waste. This section reviews and analyze existing research on digitizing inventory management where they are related to this study.

2.2. The independent variable

The Inventory Control Strategy is the independent variable in this study. In contrast to traditional manual estimation, this methodology uses quantitative and selective inventory models to manage stock.

A variable's definition goes beyond counting. (Minal (2016)) defines the independent variable as the material management process, which is an integrated approach to sourcing and handling raw materials. In this framework, a control strategy is successful if it provides the "right material, at the right place, at the right time, and in the right quality."

In (Sugiyono and Senda's (2025)) paper, Quantitative-Based Methods are used to further operationalize this variable. They demonstrate that economic

order quantities (EOQ) and reorder points (ROP) can replace subjective purchasing with mathematical models.

In addition, (Madgi and Vanakudari (2018)) and (Mehrotra and Sehgal (2024)) include Selective Control Policies in this variable. They argue that effective management requires classifying inventory by criticality using HML (High, Medium, Low) and ABC (Always Better Control) analyses. This ensures that the independent variable prioritizes high-value and "Vital" components over generic stock, which is essential for complex industrial environments like power plants.

2.3. The dependent variable

Inventory Performance was the Dependent Variable used in this research study for determining the three separate outcomes of Financial Efficiency, Operational Continuity, and Waste Reduction.

- **Project Cost & Financial Efficiency:** The primary measure is Project Cost. (Minal (2016)) defined the ultimate objective (dependent variable) as minimizing the total cost of the project. The independent variable would fail if the materials were not processed properly and the additional costs incurred would be unnecessary. (Senda and Sugiyono (2025)) supported this and measured the dependent variable based on the reduction of Total Inventory Cost (TIC). Additionally, (Madgi and Vanakudari (2018)) noted that one of the major results of optimized stock releases would be improved financial liquidity and that it would free up funds from being tied up.

- Operational Continuity (Service Level): In industries with high risk, there is a significant need for available materials. (Mehrotra and Sehgal (2024)) identified minimizing stock-outs as a dependent variable to minimize. This measures the system's ability to provide immediate access to critical spares, therefore eliminating down-time associated with "work-stoppage" (Madgi and Vanakudari, (2018)).
- Sustainability & Waste: The dependent variable of waste was identified by (Senda and Sugiyono (2025)) as a reduction of physical waste. They relate inventory results to Sustainable Development Goals (SDG 12) and define the volume of wasted/obsolete PPE that is prevented by the system as a measure of the variable.

2.4. The relationship between the independent and the dependent variables

Current investigations highlight a definitive relationship between inventory control methods (the Independent Variable) and the general efficiency of the system (the Dependent Variable). (Minal (2016)) asserts that the answer lies in effective "Material Management" from the outset; by refining the process of material procurement, firms can significantly resolve subsequent challenges with handling and availability. This assertion is backed by empirical evidence from (Madgi and Vanakudari (2018)), who discovered that utilizing mathematical logic (EOQ) can diminish administrative tasks by up to 75% and lower overall costs by 4%. This indicates that replacing unreliable predictions with mathematical precision effectively boosts efficiency. Similarly, (Senda and Sugiyono (2025)) confirm that moving away from reactive "push" systems to data-driven ordering models (like EOQ and

ROP) results in enhanced stock availability and a notable reduction in waste. Finally, in terms of operational reliability, (Mehrotra and Sehgal (2024)) identify that selective control is crucial. Their study found that imposing stricter oversight on important "Class A" items guarantees smoother operations without incurring the hefty costs associated with overstocking non-essential items.

2.5. Conclusion

A comprehensive review of existing literature reveals a significant transformation in industrial management, moving away from manual, experience-based estimations toward data-driven and quantitative approaches.

Research consistently shows that conventional "push" inventory models fall short in high-risk settings, such as power plants, where stockouts can lead to severe consequences, including compromised worker safety beyond mere financial repercussions.

(Mehrotra and Sehgal (2024)) illustrate that the adoption of selective control strategies, such as ABC and VED analyses, goes beyond enhancing efficiency; it is essential for safeguarding critical operational elements. Additionally, (Senda and Sugiyono (2025)) present empirical data indicating that quantitative methods like Economic Order Quantity (EOQ) and dynamic Reorder Points effectively enhance cost efficiency and minimize waste. Their research connects these inventory management practices to wider Sustainable Development Goals (SDGs), showing that digitized tracking can

significantly reduce expired material waste. Nevertheless, there is a notable gap in the practical application of these advanced simulation models for managing Personal Protective Equipment (PPE) in power plants situated in the Eastern Province. This study, is theoretically relevant, as it builds on the established relationship between quantitative inventory controls and operational efficiency to introduce a specific Discrete Event Simulation (DES) model. This method seeks to address the localized issues of PPE shortage and waste, connecting theoretical inventory optimizations with real-world safety practices in the energy industry.

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