WAREHOUSE LAYOUT OPTIMIZATION: HV POWER

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SAMARDEEP RAI
22176389

Executive Summary:

In this comprehensive report, we delve into the intricate dynamics of HV Power's warehouse operations, offering a strategic roadmap that harnesses the power of innovative technologies and lean warehousing principles. Our investigation into HV Power's unique operational needs has led to the development of customized picking strategies, notably cluster picking and wave picking, and those tailored to the company's project-based demand. Emphasizing advanced inventory management, we explore the integration of data-driven tools, such as MYOB software, to enhance inventory accuracy and facilitate informed decision-making.

A significant focus of the thesis is the adoption and implementation of RFID technology, poised to revolutionize inventory tracking and management at HV Power, offering real-time data accessibility and significantly reducing manual errors. We also propose optimized storage solutions, including block stacking and bin location strategies, specifically designed for smaller items to maximize space efficiency while ensuring safety and accessibility. A cornerstone of our analysis is a detailed mathematical approach to space utilization, equipping HV Power with actionable insights for optimizing warehouse layout and efficiency. The culmination of these recommendations promises a transformation in HV Power's warehouse operations, leading to marked improvements in efficiency, accuracy, and productivity. This sets the stage for HV Power not only to address its immediate operational challenges but also to lay the groundwork for long-term strategic growth and innovation in warehouse management, positioning the company at the forefront of industry advancements.

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1.0 Introduction:

Warehousing, a critical component in the smooth operation of any business, serves as the backbone of efficient supply chain management. Its role is pivotal, especially in today's complex and dynamic market where timely and accurate movement of goods is paramount. The implementation of lean warehousing methods, as outlined in recent studies like Baglio et al. (2023), has become a necessity for businesses seeking to streamline operations and prevent costly delays. This report delves into the multifaceted world of warehouse management, particularly under the scope of lean supply chain principles. It aims to dissect the intricate dynamics, identify prevailing challenges, and explore potential opportunities for improvement. This overview sets the stage for an in-depth examination of the principal issues, research questions, and objectives within the broader context of this field.

At the heart of this study is HV Power, a company with a unique position in the market, specializing in the assembly and distribution of high-voltage products. This specialization dictates distinct warehousing needs and practices, differing markedly from standard warehousing models often associated with Fast-Moving Consumer Goods (FMCG) companies. Through a comprehensive evaluation of HV Power's Onehunga facility, this report uncovers the nuances of their warehousing operations, including current practices and future expansion plans. A key finding is the identification of inefficiencies primarily related to space utilization, a challenge compounded by the unique size and handling requirements of their products. This presents a unique opportunity to collaboratively explore and apply a blend of lean and innovative warehousing practices tailored to their specific needs.

The report chronicles the journey of our collaboration with HV Power, detailing how a deep understanding of their operational challenges has led to the formulation of strategic solutions. These solutions aim not just to address current inefficiencies but also to equip HV Power's warehouse for future growth and scalability, ensuring they remain agile and competitive in an ever-evolving marketplace.

1.1 AIM:

The aim of this study is two-fold, addressing both specific and broad objectives in the realm of warehousing. Primarily, this study seeks to furnish HV Power with actionable and practical recommendations, tailored to enhance their warehouse management practices. The focus is on aligning these practices with the overarching sector goals of lean and efficient supply chain performance. In doing so, the study aims to make a substantial contribution to the wider conversation on warehouse management, particularly within the inbound and outbound logistics sector. It endeavours to present insights and methodologies that can be adopted not only by HV Power but also by other organizations and researchers facing similar warehousing challenges.

Furthermore, the study is dedicated to assisting HV Power in improving their warehouse layout and operations through the application of lean management principles. By conducting a comprehensive analysis and integrating advanced RFID technology, the objective is to refine HV Power's warehouse processes, enhancing efficiency in the picking and placement of goods, and optimizing space utilization. This approach is designed not only to bolster HV Power's operational efficiency but also to ensure effective and safe handling of their specialized high-voltage products. The culmination of this study is to deliver a suite of actionable recommendations that support HV Power's efficiency goals, elevate its operational capabilities, and solidify its adherence to the principles of lean warehousing. This dual aim underscores the study's commitment to practical impact and theoretical advancement in the field of warehouse management.

1.2 RESEARCH QUESTIONS:

How can the warehouse layout and operations of HV Power New Zealand be optimized to enhance efficiency in picking and movements of goods within the warehouse?

To address this multifaceted problem, this thesis will systematically analyse the current warehouse practices and identify key areas for improvement. By applying lean management principles and integrating efficient inventory management techniques such as different picking and placing techniques, the study aims to enhance the efficiency of picking and movement processes within the warehouse. The feasibility and potential benefits of advanced technologies, such as RFID systems, will also be evaluated. In doing so we aim to answer several critical research questions.

How can advanced picking methods like cluster picking and wave picking be effectively integrated into HV Power's warehouse operations to align with lean warehousing principles?

What are the potential benefits and challenges of integrating RFID technology with HV Power's existing Warehouse Management System and MYOB software?

What advantages can be expected from the transition from handwritten SAP codes to a barcode system in terms of accuracy and efficiency?

How can block stacking methods be optimized for smaller, unfinished goods and components in HV Power's warehouse?

What insights can be gained from assessing the warehouse's total capacity and how can this information be used for strategic planning?

1.3 Key findings and Results:

HV Power's significant focus on the assembly and distribution of high-voltage products presents both challenges and opportunities in warehouse management. The unique aspects of their operations, particularly the slow inventory turnover rates and the substantial size of products, necessitate a specialized approach to warehouse layout optimization. The initial examination of their Onehunga facility highlights key inefficiencies, especially in space utilization and the handling of large, infrequently ordered products. This situation underscores the need for a strategic overhaul of their warehouse practices to enhance efficiency and productivity.

The company's intention to expand its facility and establish a new storage area opens doors to implementing innovative warehousing solutions. This report aims to detail the progress made in collaboration with HV Power, focusing on understanding their specific needs, providing expert guidance, and proposing effective solutions to tackle the identified challenges.

A critical aspect of this project is addressing the inefficiencies in their current system. For instance, the practice of extracting all products before selecting those for dispatch is identified as a key area for improvement. This approach, while routine, is counterproductive to the principles of a lean warehouse system, leading to increased handling time and reduced space efficiency. The large product sizes and their close stacking method pose additional challenges, limiting the space for forklift operations and contributing to the overall inefficiency in the warehouse.

In response, this study explores various lean and contemporary warehousing practices that can be adapted to HV Power's unique operational context. The aim is to transform their warehouse into a model of efficiency, optimizing space usage, streamlining product handling processes, and ultimately, accelerating the delivery of products to end customers. Through this comprehensive approach, the report will present a set of tailored recommendations that align with HV Power's expansion plans and operational goals, ensuring a more efficient and effective warehouse system.

2.0 Literature Review:

This literature review is dedicated to examining critical components of warehouse layout optimization, encompassing lean warehousing methodologies and the implementation of technological advancements like RFID. The objective is to shed light on the effective application of lean tools and their critical role in maintaining competitiveness and efficiency within the dynamically evolving global warehousing sector. Our initial research at HV Power's facility signalled a significant shift in focus. Originally tailored to optimize layouts for rapidly moving consumer goods, the scope of our study adapted to meet the distinct demands posed by HV Power's slower-moving, larger products. This adaptation required an in-depth analysis of specialized warehousing strategies, with a particular emphasis on lean warehousing principles, picking techniques, and the stacking of products. Our goal is to assimilate insights from diverse scholarly sources to formulate comprehensive and robust solutions that address these challenges effectively.

2.1 Lean Warehousing:

Cost Implications and Efficiency in Warehouse Operations

Warehouses are critical components of supply chains, yet they often harbour inefficiencies that significantly impact operational costs. Research indicates that activities like picking, and order fulfilment can constitute over 50% of warehouse operating expenses (Anđelković et al., 2016). This high cost underscores the necessity of optimizing these processes. Studies have shown that implementing lean tools can effectively identify and eliminate non-value-added activities, thereby streamlining warehouse operations and significantly reducing costs (Prasetyawan & Ibrahim, 2020).

Lean Tools and Techniques in Warehouse Layout Design

Effective layout design is crucial for achieving warehouse optimization goals, including efficient space utilization and minimal handling costs. Traditional mathematical optimization methods can be complex and less effective for finding optimal layouts and item allocations due to the NP-hard nature of these problems. However, heuristic approaches like simulated annealing have proven more effective, with some studies demonstrating a reduction in travel distances by up to 30%, leading to notable cost savings (Raghuram & Arjunan, 2021).

The integration of lean concepts with computational optimization algorithms, such as storage policy considerations and simulated annealing, has been shown to improve space utilization while reducing picking and travel distances. These integrated approaches offer tangible operational improvements, aligning with the lean goal of continuous efficiency enhancement (Salman Mustafa, 2020).

Incorporating Lean Principles in Warehouse Redesign

The iterative implementation of lean solutions in warehouse design is crucial for sustained long-term benefits. Research emphasizes the development of comprehensive frameworks that adapt lean analysis to complex warehouse environments. Case studies in this area demonstrate productivity improvements from lean warehouse redesign, including increased storage density and labour productivity. These improvements are not just tangible but also extend to intangible benefits like improved workflow and employee satisfaction (Prasetyawan et al., 2020).

2.2 Picking Strategies for Slow-Moving Goods:

The concept of 'Orders-to-picker' picking, as discussed by de Koster et al. (2007), emerged as highly relevant to HV Power's operational style. This method, aligning with Just-In-Time (JIT) principles, focuses on minimizing picker travel time and labour requirements while enhancing accuracy and product safety. It is particularly advantageous in settings like HV Power's, where orders are significant but infrequent, and products are substantial in size.

Furthering this exploration, Gue and Meller (2009) investigated various warehouse picking policies, emphasizing the significance of matching these strategies with specific warehouse characteristics. Their work provides a comprehensive framework for analysing and selecting the most suitable picking methods for different types of products and order profiles.

2.3 Slotting and Profiling in Warehouse Layout:

In warehouse operations, the implementation of slotting and profiling is crucial for enhancing efficiency. Slotting involves strategically placing items based on factors like pick frequency, while profiling groups items based on similar characteristics for easier access. Thai Young Kim et al. (2023) highlight the effectiveness of these practices in omnichannel warehouses, noting their significant impact on space utilization and productivity. Additionally, Cardona and Gue (2020) discuss the benefits of ray-bins and multiple block stacking methods, particularly valuable in warehouses with large products and high volumes. These techniques are instrumental in maximizing storage space and improving operational efficiency, essential for modern, dynamic warehouse environments.

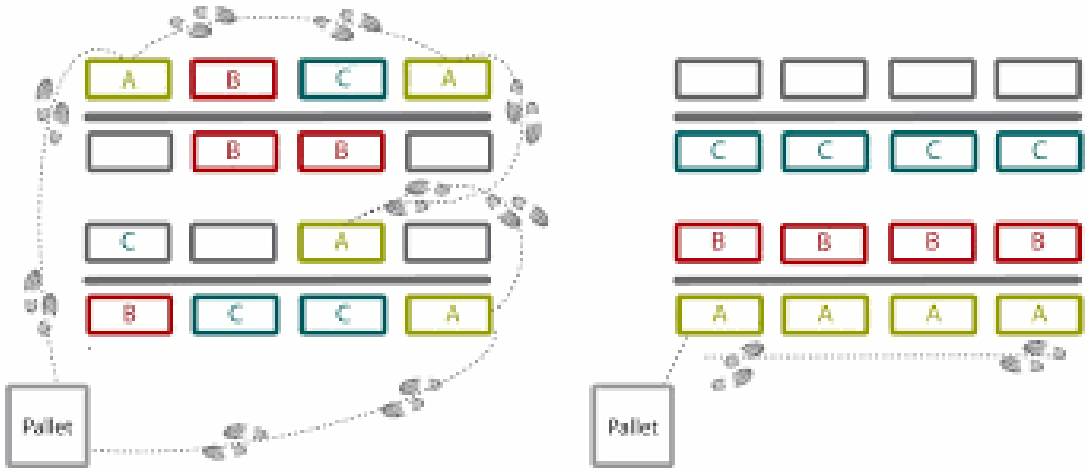

Figure 1- Impact of Slotting & Profiling (Kofler et al., 2014)

2.3 Space Utilization and Warehouse Layout Optimization:

The Role of Warehouses in Global Logistics and Productivity Assessment

Warehouses serve as vital nodes in the global logistics system, enhancing the value added by logistics services. The productivity of these warehouses can be assessed using various indicators, including labour, equipment, space, and information systems. System theory offers a perspective to identify these productivity indicators, integrating insights from both academic literature and industrial practices. The Analytical Hierarchy Process (AHP) is highlighted as a method to analyse and evaluate these indicators, aiding in effective decision-making (Mohamud et al., 2023).

Throughput as a Key Indicator in Warehouse Productivity

The concept of throughput emerges as a pivotal metric in the context of warehouse management, playing a significant role in the strategic planning of replenishments, effective inventory level management, and the judicious allocation of human resources. This indicator is fundamentally linked to meeting consumer demands and reflects the operational proficiency of a warehouse setting (Raghuram & Arjunan, 2021).

Key determinants influencing warehouse productivity and efficiency include the availability of labour, the efficacy of material handling equipment, the optimization of storage space, and the robustness of information systems, particularly Warehouse Management Systems (WMS). These elements are crucial in determining the smooth functioning of warehouse operations. Moreover, the integration and effective utilization of WMS can significantly enhance the decision-making process, streamline workflows, and lead to improved accuracy in inventory management (Gagliardi et al., 2007).

This comprehensive understanding of throughput and related factors underscores the importance of a holistic approach to warehouse management. It necessitates a focused consideration of each element – from workforce management to technological infrastructure – to bolster overall efficiency and responsiveness to market demands. This approach is particularly relevant in the context of HV Power's warehouse operations, where the effective management of these components can lead to substantial improvements in operational effectiveness and customer satisfaction.

Optimizing Space Utilization in Warehouse Settings

In the context of optimizing warehouse space utilization, the research by Shi et al. (2020) presents specialized models aimed at enhancing the efficiency of space usage within warehouse environments. These models are particularly pertinent to the operational context of HV Power, given the distinctive characteristics of their high-voltage products which necessitate innovative approaches to space management. The methodologies proposed by Shi et al. provide a systematic framework to maximize space utilization in warehouses, ensuring that space is optimized, product accessibility and the efficiency of operational workflows are maintained.

Complementing this perspective, the work of Bartholdi and Hackman (2016) highlights the critical role of thoughtful warehouse layout design in achieving space efficiency. Their research delves into an array of layout configurations, examining their respective impacts on the operational efficacy of warehouse settings. The practical guidelines derived from their study are particularly adaptable to HV Power's unique needs. Implementing these guidelines can lead to a warehouse layout that not only optimizes the use of space but also supports the seamless execution of operational activities.

The amalgamation of these research insights offers a comprehensive approach for HV Power to refine its warehouse space utilization. By integrating the structured models for space optimization with strategic layout design principles, HV Power can enhance the functionality and efficiency of its warehouse operations. This approach aligns with the objective of creating a warehouse environment that is not only space-efficient but also conducive to the operational dynamics of handling and storing high-voltage products (Ren et al., 2023).

2.4 RFID Technology in Warehouse Management:

Benefits of RFID Technology in Warehousing

The incorporation of RFID (Radio Frequency Identification) technology into warehouse operations presents numerous operational advantages. Foremost among these are the significant enhancements *in inventory management accuracy, the bolstering of supply chain transparency, and the elevation of overall operational efficiency*. RFID technology's capacity for real-time tracking and sophisticated data management marks a substantial evolution from conventional inventory management approaches. This shift fosters a more streamlined and precise operation within warehouse environments (Vijayaraman & Osyk, 2006).

The implementation of RFID systems effectively transforms traditional methodologies, introducing a level of precision and speed previously unattainable. By enabling the instantaneous tracking of products and materials within the warehouse, RFID technology optimizes the inventory process, reduces the likelihood of errors, and accelerates the flow of goods. This advancement is particularly beneficial in complex warehouse settings, where managing a large volume of diverse products can be challenging. Additionally, RFID technology's impact extends beyond mere inventory control; it enhances the entire supply chain's responsiveness and agility, enabling HV Power to quickly adapt to market demands and operational challenges. The integration of this technology is expected to yield substantial long-term benefits, including cost savings, improved customer satisfaction, and a robust competitive edge in the market (Chanchaichujit et al., 2020).

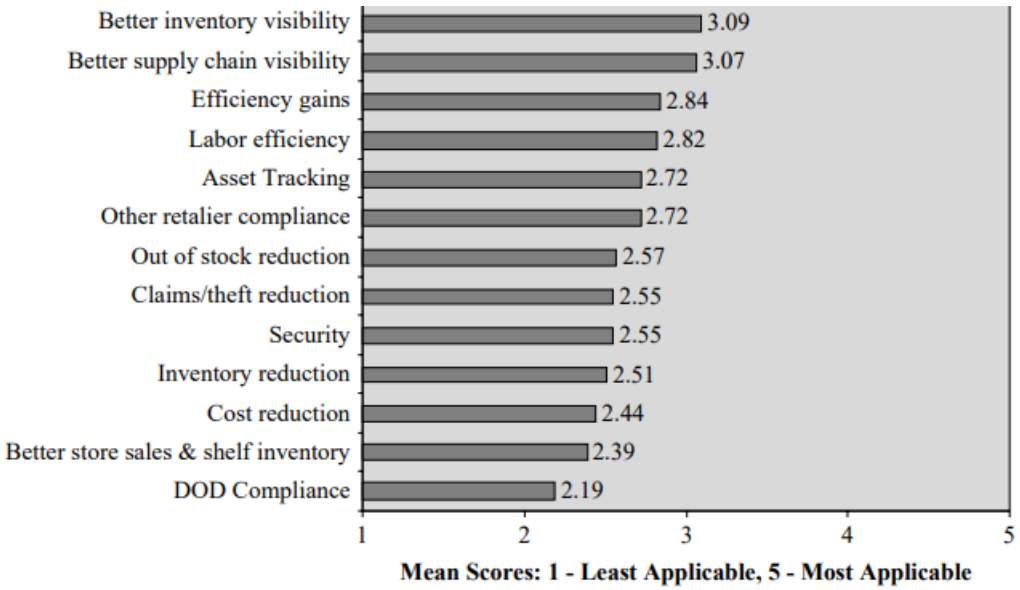

Figure 2- Benefits of RFID (Vijayaraman & Osyk, 2006)

Challenges and Limitations of RFID Implementation

While the incorporation of RFID technology in warehouse operations offers significant benefits, it also presents certain challenges that must be addressed for successful implementation. Key among these are the financial implications of adopting such technology, the intricacies involved in integrating RFID systems with pre-existing warehouse management frameworks, and the technical obstacles that may arise. Addressing these challenges requires meticulous planning and strategic foresight (Vijayaraman & Osyk, 2006).

The cost factor, in particular, demands a thorough analysis to ensure that the investment in RFID technology is justified by the anticipated improvements in operational efficiency and inventory management. Furthermore, the technical complexities of merging RFID systems with existing operations necessitate a detailed approach to system integration. This integration must be executed in a way that minimizes disruption to current processes while maximizing the benefits of the new technology (Landaluce et al., 2020).

In addition, overcoming technological barriers is crucial for the effective functioning of RFID systems within the warehouse environment. This involves not only ensuring compatibility with existing infrastructure but also adapting to the unique operational requirements of the warehouse. Training for staff and continuous technical support are vital components in surmounting these challenges. While the introduction of RFID technology into warehouse operations promises to enhance efficiency and accuracy, its successful implementation hinges on a well-considered strategy that comprehensively addresses cost, integration complexities, and technical challenges (Liukkonen, 2014).

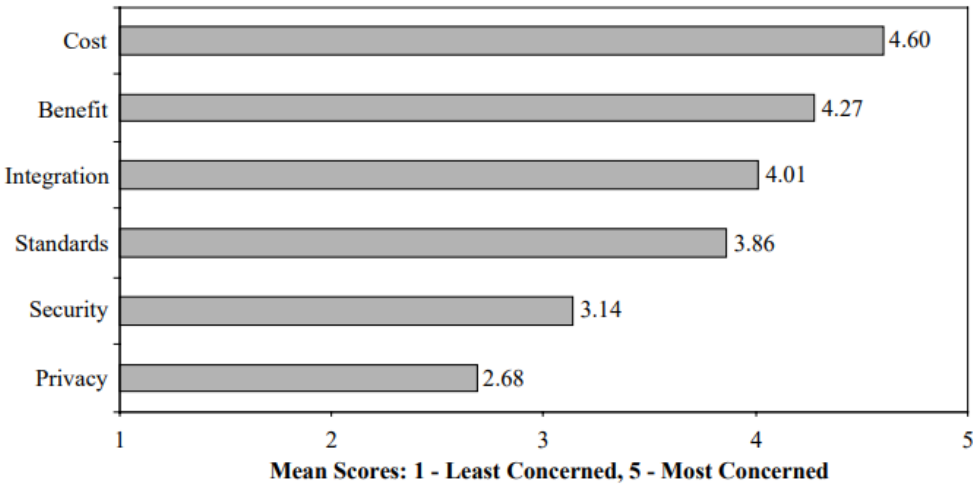

Figure 3- Limitation Analysis of RFID (Vijayaraman & Osyk, 2006)

Industry Applications and Academic Contributions

The diverse and significant applications of RFID technology within logistics and warehousing contexts cannot be overstated. This technology plays a crucial role in multiple areas, including asset management, bolstering security protocols, and curbing losses by improving inventory management. The realm of academic research has been pivotal in shedding light on the adoption and practical implementation of RFID in warehousing environments. These scholarly contributions have provided a wealth of knowledge regarding the tangible benefits and versatile applications of RFID, thereby guiding its effective utilization in the logistics sector.

Furthermore, studies have shown that RFID technology can streamline warehouse operations, leading to enhanced efficiency in product tracking and supply chain transparency. The integration of RFID systems has been noted to expedite the processing of goods, from intake to dispatch, thereby reducing turnaround times and increasing overall throughput. Additionally, the implementation of RFID has demonstrated potential in facilitating real-time data collection, offering critical insights for decision-making and strategic planning in warehouse management. This technological advancement, therefore, represents a significant leap forward in modernizing warehousing practices and aligning them with the evolving demands of the logistics industry (Chanchaichujit et al., 2020).

RFID in Manufacturing and Supply Chain Management

RFID technology has shown substantial promise in enhancing manufacturing efficiency, optimizing internal operations such as warehousing, and improving overall supply chain management. Its ability to identify individual items automatically and wirelessly in production adds immense value to manufacturing and warehousing operations. The technology finds applications in warehouse management, process management, tool management, and supply chain management. The survey also outlines the primary manufacturing branches that have utilized RFID, highlighting the current industrial practice and potential future applications. Challenges in implementation and future research directions, including integrating RFID with emerging technologies, are discussed, providing a comprehensive perspective on the technology's role in modern manufacturing and warehousing (Sriram et al., 2021).

Figure 4- RFID integration with warehouse efficiency (Vijayaraman & Osyk, 2006)

3.0 Methodology:

This section outlines the methodology developed to provide HV Power with tailored recommendations for improving their warehouse operations. The approach combines collaborative scrum sessions with HV Power and academic supervisors, focusing on the integration of advanced analytical methods and technological tools. It is designed to comprehensively assess HV Power's current practices and develop strategies that enhance efficiency and streamline operations, leveraging both theoretical insights and practical industry knowledge. The aim is to offer actionable solutions that align closely with the unique operational needs of HV Power.

3.1 Picking and Placing strategies:

In the HV Power warehouse, manual picking processes are utilized up to the docking area, where forklifts then transport products to their next destination. During a recent inspection of the facility, significant modifications were observed. Components like nuts, bolts, and wires have been moved to a new facility, freeing up space in the existing warehouse for more efficient product arrangement. This reorganization has resulted in a more spacious and effectively organized warehouse compared to previous visits. However, there is still room for improvement to fully achieve lean warehousing standards (Amorim-Lopes et al., 2020).

Integration of Advanced Picking Methods: The relocation of components to a separate facility opens opportunities to explore alternative picking methods such as cluster picking and wave picking, aligning with lean warehousing principles. HV Power is also in the process of redesigning its racking system to optimize product placement based on picking frequency. This strategy, known as profiling, ensures that commonly picked items or those frequently picked together are in proximity, ideally in the same aisle. This approach is a key aspect of lean warehousing (Baglio et al., 2023).

To further enhance picker efficiency, the report suggests focusing on slotting in conjunction with profiling. Slotting involves strategically positioning items that are frequently used or require regular restocking near the pick-face area of the warehouse. Although like profiling, slotting complements to reducing picker travel time and effort. The optimization of the racking system, informed by profiling strategies, will ensure that items picked together are stored in proximity, reducing movement within the warehouse. This report will examine how these strategies can be integrated to boost efficiency in HV Power’s warehousing operations (Wang et al., 2020).

3.2 Data Driven Inventory Management and MYOB Software Integration:

Comprehensive Analysis for Inventory Categorization

The methodology employed in this study includes a detailed analysis of data on HV Power's most frequently sold products, as provided by Mike Strong, General Manager and Director of HV Power. Utilizing the robust capabilities of the MYOB software, this approach methodically categorizes the company's inventory. The information was collated through a combination of digital and face-to-face interactions with Mike and the personnel of HV Power. This crucial process involves the classification of each product and component, considering key factors like usage frequency and their overall importance to HV Power's operations. The results of this analysis are instrumental in creating a structured hierarchy of inventory items. This hierarchy will play a significant role in guiding the prioritization of various management and operational strategies within the warehouse, ensuring that resources are allocated effectively and efficiently.

Strategic Application of Data for Warehouse Optimization

Following the analysis, the gathered data becomes a cornerstone for developing targeted strategies focused on slotting and profiling within the warehouse. This process entails a detailed examination of the best possible placement for each product category, ensuring that high-priority items are easily accessible (Le et al., 2021). By optimizing the product placement, the goal is to streamline the picking process, thereby reducing time and effort required for order fulfilment. The strategies derived from this analysis are expected to significantly enhance the efficiency of the warehouse's operational flow.

Enhancing Operational Efficiency through Improved Product Accessibility

In line with the findings from the analysis, the methodology aims to refine the warehouse layout to promote better accessibility and handling of inventory. This involves reassessing the current storage configurations and making informed adjustments to the layout, ensuring that the most frequently used items are positioned strategically for quick access (Kofler et al., 2014). The integration of these strategies is anticipated to lead to a reduction in picking times and an overall improvement in warehouse efficiency.

Leveraging MYOB Software for Data-Driven Decision Making

The utilization of MYOB, GreenTree software in this process underscores the commitment to a data-driven approach. This software not only facilitates the foundation for the analysis but also serves as a tool for ongoing inventory monitoring and management. The insights gained from this software will be continuously used to make informed decisions about inventory placement, helping to maintain an optimized warehouse environment that is responsive to changing operational needs.

3.3 RFID Technology Implementation and Labelling Enhancement:

In the methodology for incorporating RFID technology into HV Power's warehouse operations, a systematic approach, grounded in the findings from the literature review, is adopted. This involves conducting a feasibility assessment of possible pros and cons to determine the practicality and financial viability of RFID implementation. The approach includes suggesting a RFID system that integrates with HV Power's existing Warehouse Management System, particularly focusing on compatibility with MYOB software. This system design can complement process of HV Power's warehouse and would focus to optimize inventory tracking and product handling. The primary objective of this initiative is to implement automation within the warehouse, thereby addressing and resolving the challenges associated with the labelling of products and components. This endeavour is underscored by a commitment to ongoing improvement, ensuring sustained effectiveness and enhanced operational efficiency throughout the warehouse operations (Liukkonen, 2014).

1. Strategic Product Placement with RFID Technology: In the new facility, as suggested by Mike, GM & Director of HV Power, RFID technology can be leveraged to strategically place products for seamless entry and exit. This report aims to streamline the process of locating and moving products within the warehouse with the help of RFID technology.

2. Transition from SAP Codes to Barcodes: This report proposes the replacement of HV Power warehouse's existing handwritten SAP code system with a barcode framework. This transition is identified as a crucial step towards addressing current inefficiencies in the warehouse's operations. The introduction of RFID technology is central to this strategy, aimed at significantly improving both transparency and precision in the tracking and identification of products (Chetouane, 2015).

3. Integration with MYOB System: The enhancements in labelling and monitoring systems can be seamlessly amalgamated with the current MYOB framework, notably the GreenTree system. This amalgamation is strategically planned to elevate the efficacy of tracking methodologies, thereby streamlining the procedure of identifying products in the warehouse. Moreover, it aims to address and resolve the challenges linked to the unavailability of components during the picking process (KHAZETDINOV et al., 2020).

3.4 Block Stacking and Bin Location Management:

In the methodology for block stacking at HV Power's warehouse, a tailored approach is proposed, acknowledging the challenge posed by the size of their high-voltage products which makes traditional block stacking infeasible. The focus will be on optimizing the block stacking method for smaller, unfinished goods and components like nuts, bolts, and smaller assembly parts. This categorization will inform the development of a block stacking layout that maximizes space utilization while ensuring easy access and efficient movement within the warehouse. Special attention will be given to safety and accessibility, particularly important in handling smaller yet critical components. This approach aims to integrate block stacking into HV Power's warehouse operations in a manner that complements their existing storage and handling processes for larger products, ultimately enhancing overall space efficiency and operational workflow.

1. *Examination of Block Stacking Methods:* The research will continue to delve into the practices of block stacking, particularly for pre-assembly products and smaller items such as nuts and bolts. This examination is directed towards gaining a deeper understanding of efficient bin location management, which is crucial in enhancing efficiency and movement of goods within the warehouse. By studying these practices, the research aims to develop strategies that streamline the handling and accessibility of these smaller yet vital components, thereby improving overall warehouse efficiency (Derhami et al., 2019).

2. *Strategies for Enhanced Space Management:* The focus of the study will also extend to optimizing the utilization of space within HV Power's warehouse. This aspect of the research entails a comprehensive evaluation of the current warehouse layout, identifying areas where space can be used more effectively. The aim is to develop a layout that optimally utilizes available space across various warehouse zones, including storage, assembly, and quality control areas. By reconfiguring these spaces and possibly introducing innovative storage solutions, the goal is to create a more organized, efficient, and productive warehouse environment (Popović et al., 2021).

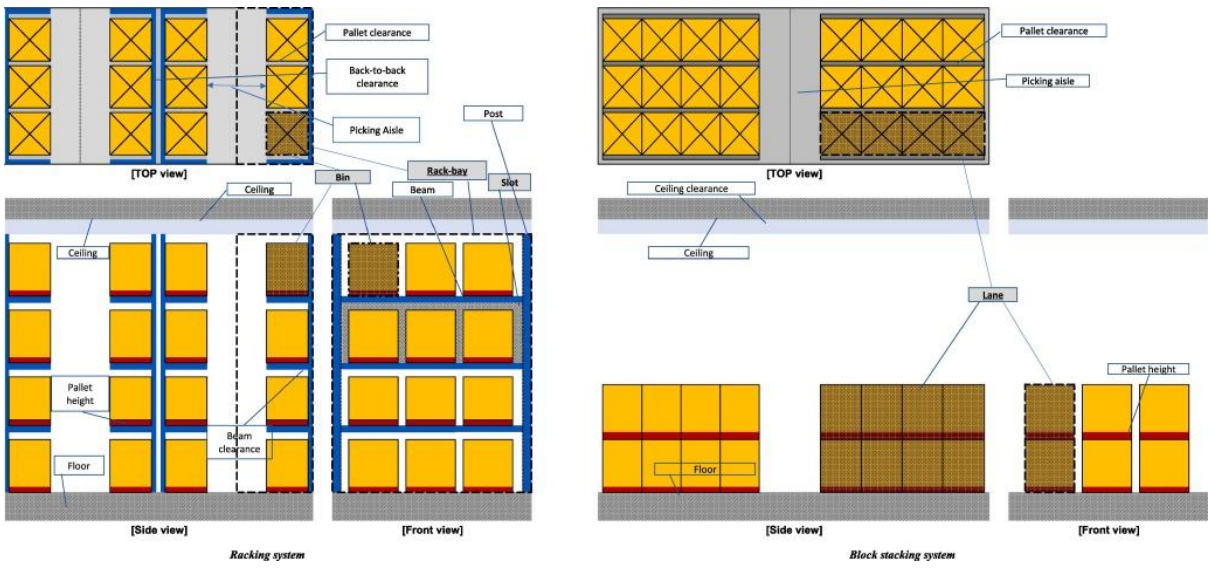

Figure 5- Block Stacking in warehouse (Derhami et al., 2019)

3.5 Calculations:

This section of the report provides an in-depth analysis of the intricacies associated with enhancing warehouse management efficiency. Emphasis is placed on the utilization of mathematical formulas designed to optimize space usage, taking into account both the size of HV Power's most popular products and the physical dimensions of their storage facility. *Measurements for this analysis were gathered during our team's evaluation of the HV Power premises.* The implementation of these mathematical models offers a quantitatively grounded perspective, delineating the ideal operational model for HV Power. This method is instrumental in identifying and rectifying existing operational shortcomings, while simultaneously setting a standard for the ideal functioning of the warehouse (Sadeghi et al., 2024).

1. *Space Requirement for Storage:*

This calculation is essential for determining the space needed for storing each type of product.

Formula: Space Required per Product = Product Length × Product Width × Product Height

This formula helps in planning the allocation of warehouse space for different products, ensuring efficient use of available storage.

2. *Storage Capacity of the Warehouse:*

This formula assesses the total volume capacity of HV Power's warehouse.

Formula: Warehouse Capacity = Warehouse Length × Warehouse Width × Warehouse Height

Understanding the warehouse's total capacity is crucial for strategic planning and maximizing storage efficiency.

3. *Utilization Rate of Warehouse Space:*

This calculation determines the proportion of warehouse space actively used for storage.

Formula: Utilization Rate = (Total Space Required for All Products / Warehouse Capacity) × 100%

By calculating the utilization rate, HV Power can gauge the effectiveness of their current storage practices and identify areas for improvement.

4.0 Analysis:

4.1 Observation of HV Power warehouse:

In the process of assessing HV Power's warehouse operations, our team had the opportunity to conduct an on-site evaluation, providing valuable insights into the current operational dynamics of the facility. Our initial visit to HV Power's premises offered an informative introduction to their warehousing procedures, the variety of products handled, and the general business operations. This firsthand observation was instrumental in understanding the intricacies of their warehouse functioning.

Data collection was a key component of our visit, where we meticulously gathered relevant information and photographic evidence to substantiate our analysis. A detailed briefing by HV Power's CEO, Mike Strong, on retrieving data from the MYOB software, GreenTree, was particularly enlightening. This session equipped our team with the necessary knowledge to accurately extract and utilize data in our subsequent analysis and recommendations.

During a subsequent visit, the focus shifted towards a more in-depth understanding of specific warehouse functionalities and their alignment with HV Power's overall operations. We paid particular attention to areas such as the newly developed facility, the assembly line, and the dispatch areas. Engaging in comprehensive discussions with the HV Power staff, we gained a clearer perspective on their future plans and current operational challenges, information that was crucial for the development of this report.

To supplement these discussions, our team conducted physical measurements of the warehouse space and of the frequently sold products. This exercise was critical in providing a tangible sense of the spatial dynamics we were working with. Understanding the dimensions and storage requirements of these products was vital in formulating effective placement strategies within the warehouse.

Figure 6- Stacking of Products/components in HV Power warehouse

4.2 Inefficiencies in the warehouse:

Understanding the unique characteristics of HV Power's warehouse is essential in contextualizing its operational challenges. Distinct from typical warehousing scenarios, HV Power's specialization in high-voltage products significantly impacts inventory dynamics. Notably, the turnover rate of their inventory is considerably slower, leading to extended storage durations and subsequently, delays in product delivery to final customers.

An additional observation pertains to the order patterns at HV Power. The company receives orders that are infrequent yet large in volume. This ordering pattern, combined with the substantial size of the products, necessitates a densely packed storage arrangement in the warehouse. Such dense stacking, while space-efficient, poses limitations for efficient forklift manoeuvrability and accessibility.

A critical operational practice identified during our interactions involves the extraction of all products from storage, followed by the selection of items for immediate dispatch. This method, while straightforward, is inefficient and counterintuitive to the principles of lean warehousing. It results in increased handling time and potential disruptions in workflow.

HV Power has expressed concerns regarding the optimization of space utilization within their existing warehouse setup. This concern is especially relevant given their plans for facility expansion, which opens avenues for exploring innovative storage solutions and operational improvements. The accompanying photographs provide a visual representation of the current warehouse layout and storage practices, further illustrating the need for strategic enhancements in space management and operational efficiency.

4.3 Problems regarding labelling and storing:

In the analysis of HV Power's warehouse operations, a significant inefficiency identified by GM and Director, Mike Strong pertains to the labelling process of products and components. The customization of products to meet individual customer requirements necessitates a unique identification system for each item. Currently, this labelling process is manually executed, involving the printing, and affixing of numbers to each product. According to Mike, this manual approach to generating and entering new codes into the MYOB system for each customized product is not only time-consuming but also detracts from the lean warehousing principles that this project aspires to achieve.

Further discussions with the HV Power team revealed additional challenges related to the storage of smaller components such as pipes, nuts, and bolts. A recurring issue mentioned was the frequent instances of empty racks at the time of picking, resulting in delays as pickers need to replenish the racks before obtaining the required items. This inefficiency in the storage and retrieval process contributes to unnecessary time expenditure in the warehouse operations.

It is evident from these identified problems that technological intervention could provide effective solutions. The implementation of RFID technology has the potential to significantly streamline these processes. By automating the identification and tracking of products, RFID can facilitate a more efficient, accurate, and lean approach to warehousing at HV Power. This technological upgrade would not only address the current inefficiencies in labelling and inventory management but also align the warehouse operations with the principles of lean management, ultimately enhancing overall productivity and operational efficiency.

4.4 Measurements:

During our second visit to the HV Power warehouse, the team conducted detailed measurements to bolster our research with a calculation-based approach. This step was critical in formulating precise and practical solutions for warehouse optimization. We focused on measuring products that are frequently sold by HV Power, particularly those awaiting dispatch but not scheduled for shipment for another 2-3 months. This aspect of warehouse management demanded our attention, as these products not only require safe storage but also efficient placement due to their prolonged stay in the warehouse.

In addition to product measurements, we thoroughly measured the warehouse space itself. This comprehensive evaluation was essential to underpin our methodology with a mathematical and data-driven perspective. By quantifying both the dimensions of the key products and the available warehouse space, we aimed to develop a well-informed strategy for optimizing storage and space. These precise measurements allowed us to consider spatial constraints and possibilities more accurately, leading to recommendations that are both feasible and effective.

Furthermore, this meticulous approach enabled us to address the dual challenge of maximizing space utilization while ensuring the safe and proper storage of products. This careful consideration of both product and warehouse dimensions was instrumental in crafting a set of recommendations designed to enhance the overall efficiency and functionality of the warehouse.

Table 1- Volume Calculation for High-Turnover Products

SKU (Product ID)	*Length (Inches)*	*Breath (Inches)*	*Height (Inches)*	*Volume (m^3) {L*B*H}*
10K+L	160	90	160	2,304,000 Cube Inches or ***37.76 m^3***
10S-RRLL-06	230	90	160	3,312,000 Cube Inches or ***54.27 m^3***
10S-RRT	194	85	166	2,737,340 Cube Inches or ***44.86 m^3***
10K-RRRT-067	192	90	166	2,868,480 Cube Inches or ***47.01 m^3***
10K-RRT-07	105	75	120	945,000 Cube Inches or ***15.49 m^3***
10K-RRTT-007	185	90	166	2,763,900 Cube Inches or ***45.29 m^3***
Warehouse	***94 feet***	***72 feet***	***35 feet (approx.)***	236,880 cubic feet Or ***6707.70m^3***

5.0 Discussions:

A thorough and critical analysis of HV Power's current warehouse operations, informed by both empirical observations and theoretical insights from the literature, reveals several key areas that present opportunities for substantial improvements. This analysis incorporates a holistic view of the warehouse's operational framework, identifying areas where strategic changes can lead to increased efficiency and effectiveness.

The examination of HV Power's warehouse operations has revealed several areas where strategic modifications can lead to significant improvements in efficiency and operational effectiveness. This analysis, informed by both on-site observations and data-driven insights, critically evaluates various aspects of the current warehousing practices.

5.1 Picking Process and Warehouse Layout:

The analysis of HV Power's warehouse operations highlights a bottleneck in the manual picking process, particularly when evaluated against lean warehousing principles. The recent relocation of smaller components, which freed up space in the warehouse, presents an opportunity for optimization not yet fully exploited. Implementing efficient picking methods like *cluster picking* and *wave picking* could significantly enhance operational efficiency. These methods, which align with reducing waste and improving workflow, can streamline the picking process by reducing picker travel time and better coordinating warehouse activities. Such strategic improvements promise to increase productivity and order handling efficiency, aligning HV Power's operations with enhanced service levels and customer satisfaction (Schiffer et al., 2022).

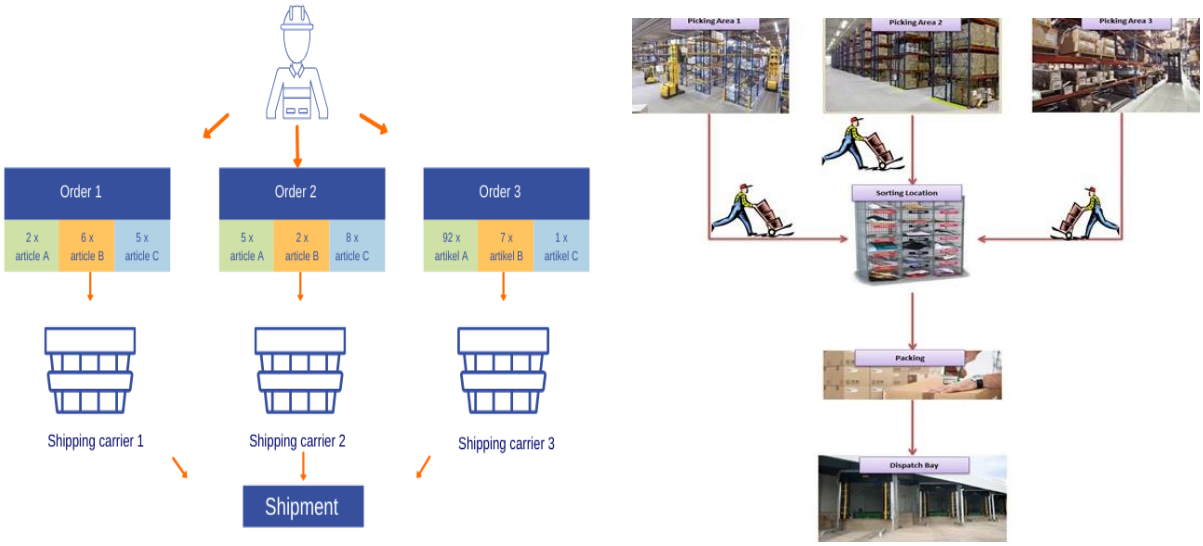

Figure 7- Cluster & Wave picking (Schiffer et al., 2022)

5.2 Space Utilization and Inventory Management: A Mathematical Approach:

The reorganization and relocation have positively impacted space utilization, but there is room for further enhancement in HV Power warehouse. Inventory Analysis, a key component of our methodology, has highlighted an opportunity for better positioning of high-priority items. Efficient space utilization goes beyond mere storage; it requires strategic placement of items to enhance accessibility and reduce picking time. This is particularly important for HV Power, which handles a variety of product sizes, and must balance the need for space with the accessibility of high-frequency items.

In this section of the report, we will conduct a series of calculations aimed at comprehending the mathematical outcomes related to the spatial utilization of selected high-frequency products within HV Power's inventory. This analysis will focus on evaluating how these items occupy space within the warehouse environment. The objective is to gain a quantitative understanding of space efficiency, which is critical for optimizing warehouse layout and management. This assessment will not only provide insights into current space utilization but also guide future strategies for inventory arrangement, particularly for items with high turnover rates (Jamili et al., 2022).

Calculations:

Table 2- Space Utilization Calculations

Calculation	***Formula***	***Application***	***Result***
Total Space Requirement ***(∑Volume)***	Total Volume of each product (V_1+V_2+V_3….)	37.76 m^3 + 54.27 m^3 +44.86 m^3 + 47.01 m^3 + 15.49 m^3 + 45.29 m^3	***244.68 m^3***
Total Storage Capacity ***(Warehouse Volume)***	L*B*H	94 feet + 72 feet + 35 feet (approx.)	236,880 cubic feet Or ***6707.70 m^3***
Warehouse Utilization Rate (%)	(Total Space Requirement/ Total Storage Capacity) * 100	(244.68/6707.70) *100	***3.65%***

The calculated Utilization Rate for HV Power's warehouse stands at 3.65%, based on the space required for a single Stock Keeping Unit (SKU) of each product. To gain a more realistic understanding of space utilization, it is pertinent to consider the quantity of each product likely to be stored at any given time. Assuming an *estimated average of five units per product SKU* is stored in the warehouse, the Utilization Rate can be adjusted accordingly. By multiplying the initial rate by five, the revised estimate for the total warehouse utilization, accounting for the selected products, is approximately **18.25%.**

5.2.1 Explanation:

In the recent assessment of HV Power's warehouse, a utilization rate of 18.25% was identified. This figure represents the proportion of the warehouse dedicated to the storage of high-turnover products. Furthermore, measurements taken during the team's second site visit revealed that the volume of the ***receipt and dispatch area*** is 598.75 m^3 (Length = 8.90m, Width = 6.90m, Height = 9.75m). This area accounts for approximately *8.3%* of the total warehouse space.

According to standard warehouse operational norms, typically known as the 70/30 rule, about 70% of a warehouse's floor space is usually allocated for storing physical inventory, while the remaining 30% is maintained as open space for movement and operational activities (Logistics Cluster, 2022). In HV Power's case, this suggests that approximately ***56.55%*** (18.25+8.3+30) of the total warehouse area is currently utilized, including the area for movement and Receipt and dispatch area.
The remaining space, roughly ***44%***, could be strategically allocated for the storage of various finished and unfinished products. This indicates a need for a strategic reallocation of resources, including space and labour, to prioritize the management of high-revenue generating products. Optimizing storage and handling of these key items could substantially enhance operational efficiency and increase overall profitability.

A revaluation of the warehouse's design and organization is recommended to ensure expedited and effortless access to these critical products. Streamlining the layout to minimize travel paths and reduce picking times for these items will lead to quicker order processing and elevated warehouse efficiency. Implementing these modifications adheres to lean warehousing principles, which emphasize reducing waste and augmenting productivity (Alsahfi et al., 2019).

Such a strategic approach not only leads to more efficient warehouse operations but also contributes to a more agile and responsive supply chain. By focusing on these high-value products, HV Power can ensure optimal resource utilization, thereby improving the company's operational effectiveness and strengthening its competitive position in the market.

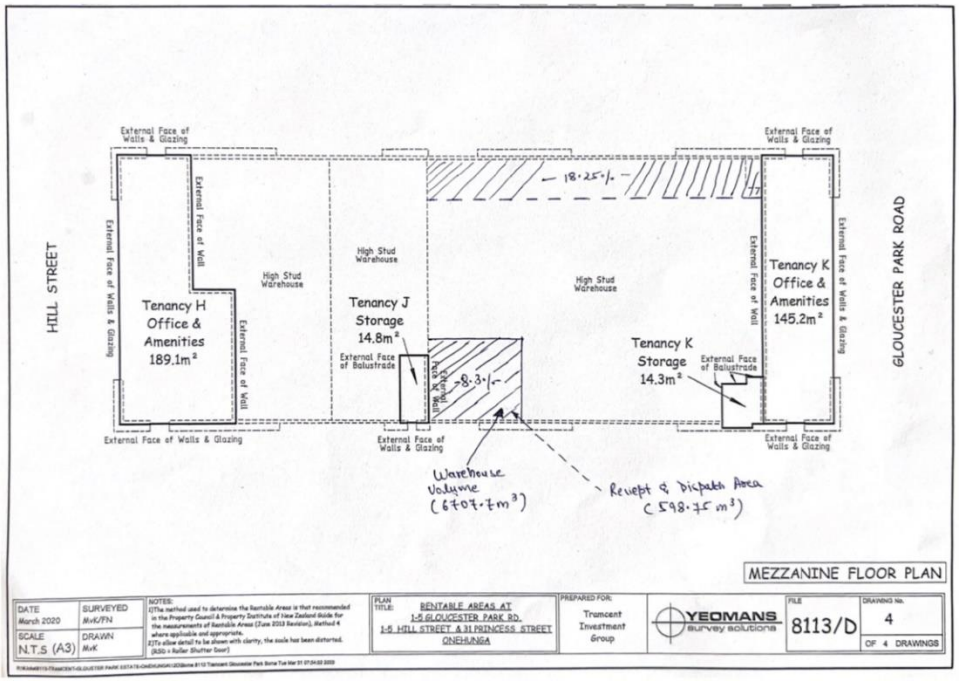

Figure 8- Blueprint of HV Power warehouse (pre-edited courtesy- HV Power)

5.3 RFID and Process Efficiency:

Currently, HV Power's warehouse leans heavily on manual processes, which, while reliable, do not maximize efficiency. The introduction of technologies such as RFID and a transition to a barcode system stands as a significant opportunity for improvement. These technological integrations are not just about modernizing operations; they are about transforming the inventory management process into a more efficient, accurate, and streamlined system. This aligns with the broader trends in warehousing and logistics, as identified in the literature review, where technology plays a pivotal role in enhancing operational efficiency.

Potential Benefits for HV Power

The integration of RFID technology into HV Power's warehouse operations is poised to revolutionize their inventory management, aligning seamlessly with their objective to modernize and enhance operational efficiency (Sriram et al., 2021). Here's an in-depth look at how RFID can fundamentally transform HV Power's inventory management:

1. Advanced Tracking and Enhanced Visibility

Instantaneous Inventory Updates: RFID tags facilitate real-time monitoring, providing HV Power with immediate updates on the whereabouts and status of their high-voltage products.

Deeper Inventory Insights: The implementation of RFID offers HV Power an enhanced understanding of their inventory levels, greatly reducing the risks associated with overstocking or stock shortages.

2. Precision and Error Reduction

Diminished Manual Errors: Manual inventory processes are inherently error-prone. By automating these processes, RFID significantly cuts down on human errors in inventory counting and handling.

Accurate and Reliable Data Capture: The precision of RFID technology in data collection is critical for effective inventory management and strategic decision-making.

3. Boosted Efficiency and Productivity

Expedited Inventory Handling: RFID's ability to be scanned swiftly and without a direct line-of-sight accelerates various warehouse operations such as receiving, sorting, and dispatching.

Labour Optimization: By automating inventory tracking, RFID decreases the need for manual labour in these tasks, redirecting workforce efforts towards more strategic tasks.

4. Security Enhancement and Loss Mitigation

Theft and Loss Deterrence: RFID's tracking capabilities extend to in-warehouse product tracking, substantially lowering the risk of theft or misplacement.

Stronger Asset Management: Utilizing RFID tags for high-value items ensures meticulous monitoring and handling, reinforcing asset security.

5. Smooth System Integration

MYOB System Compatibility: Echoing Jones and Chung (2018), RFID can be seamlessly integrated into existing systems like MYOB, facilitating a smooth transition without disrupting ongoing operations.

Unified Data Ecosystem: RFID's ability to sync data across multiple platforms offers HV Power a consolidated, real-time view of their inventory, enhancing operational coherence.

6. Informed Strategic Decisions

Actionable Data Insights: Analysing the extensive data amassed through RFID equips HV Power with valuable insights for optimizing inventory layout, management strategies, and operational planning.

Enhanced Forecasting Capabilities: The precise and current data provided by RFID systems supports more accurate forecasting and inventory planning.
The adoption of RFID technology is set to transform HV Power's warehouse operations, leading to a paradigm shift characterized by heightened efficiency, accuracy, and streamlined processes. This move is in line with the broader trend in warehousing and logistics, where the adoption of cutting-edge technologies is critical in advancing operational effectiveness (Vijayaraman & Osyk, 2006).

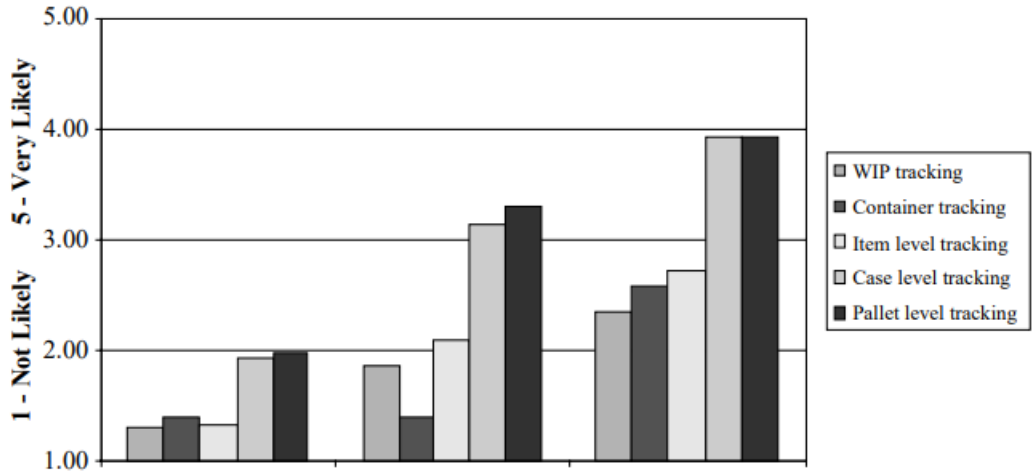

Figure 9- Potential Benefits of RFID for HV Power (Vijayaraman & Osyk, 2006)

5.4 Optimization in Block Stacking and Racking for Smaller Items:

Considering HV Power's range of product sizes, traditional block stacking methods are not universally applicable. However, for smaller, unfinished goods and components, there is a clear opportunity to optimize the stacking method. This optimization needs to carefully balance the efficient use of space with the safety and accessibility of these items. The approach must be tailored to the unique requirements of HV Power's operations, ensuring that even the smaller components are stored in a manner that maximizes space and enhances overall warehouse efficiency (Saderova et al., 2021).

Our analysis has previously explored various picking methodologies suitable for HV Power, including cluster picking and wave picking. However, we understand that HV Power's picking is project-driven, rather than regular. This irregularity offers an opportunity to develop a bespoke picking strategy that minimizes errors and optimizes efficiency, aligning with the specific needs of HV Power's project-based operations. Implementing this tailored approach will enhance accuracy and adaptability in the warehouse, leading to improved overall productivity. We will discuss more about the implications in the recommendations section.

6.0 Recommendations for HV Power:

6.1 Short-term Recommendations:

1. Advanced Picking Strategies

Rationale: Traditional picking methods often lead to inefficiencies in warehouses. By adopting cluster and wave picking, as supported by de Koster et al. (2007), HV Power can enhance its picking process. These methods are particularly effective in reducing the travel time of pickers and improving overall throughput.

Implementation: Implementing cluster picking by grouping orders with similar items, which can be picked in a single warehouse pass, reduces movement and time. Introducing wave picking by scheduling picking activities at specific times to consolidate picking orders during the day would optimize picker's time and increase efficiency.

For scenarios where frequent picking is not a necessity, the creation of a list detailing product IDs and their corresponding shelf numbers would significantly aid pickers in efficiently locating and retrieving components. This approach streamlines the picking process, ensuring a more organized and time-effective method of handling items within the warehouse.

2. Placement Efficiency: Profiling and Slotting

Rationale: Effective placement strategies such as profiling and slotting optimize the location of items within the warehouse. This method ensures that items with high picking frequencies are positioned in the most accessible areas, reducing travel time, and improving order fulfilment speed.

Implementation: Undertake an in-depth analysis of sales and picking data to determine the most frequently accessed items. Rearrange these items to be closer to the dispatch and packing areas. Slotting involves placing high-demand and frequently restocked items in strategic locations, such as near warehouse entrances or ground-level shelves, for easy access.

3. Upgrading the Racking System

Rationale: A well-organized racking system is crucial for maximizing space utilization and ensuring easy access to items. For HV Power, a racking system tailored to their specific product dimensions and weight can significantly enhance operational efficiency.

Implementation: A comprehensive assessment of the existing racking system, with an emphasis on reconfiguring the layout to accommodate the specific dimensions of unassembled products, is recommended. Currently, these products are stored alongside finished goods, which may not be spatially efficient. The introduction of dedicated racks for unassembled products is likely to enhance space utilization within the warehouse.
Furthermore, the team's observations indicate that while the racking of components is generally effective, there is an issue with the storage of pallets of varying sizes. These pallets are presently stored both outside and inside the warehouse. Establishing a designated area adjacent to the racking zone specifically for pallet storage could significantly improve operational efficiency. This change would not only streamline storage practices but also contribute to a more organized and cohesive warehouse environment. Such a strategic reorganization would facilitate smoother operations, potentially reducing the time and effort required for pallet handling and access (Erinosho et al., 2021).

4. Block Stacking for Smaller Items

Rationale: For HV Power's smaller items, an optimized block stacking approach can be more space-efficient. This method is particularly useful for storing bulk items or products that do not require frequent access.

Implementation: Analysing the smaller inventory items be it products or components, to develop a block stacking strategy. This should prioritize safety, ease of access, and efficient use of vertical space. Having these fundamentals in mind would ensure that the goods are safe, easy to pick and utilising the space.

6.2 Long-term Recommendations:

5. Space Utilization Optimization

Rationale: Optimizing space utilization is crucial for enhancing long-term warehouse efficiency. The calculations performed provide valuable insights into the current use of space and potential areas for improvement.

Implementation: Revisiting the warehouse layout with the goal of optimizing space would be helpful. This might involve repositioning racks, redesigning the floor plan, and introducing multi-tiered storage systems both for the products and components. Regularly reviewing space utilization metrics and adjusting the layout accordingly to accommodate changing inventory needs would provide a lean warehouse setting.

6. RFID Technology Integration

Rationale: Integrating RFID technology, as outlined by Chetouane (2015), can significantly improve inventory accuracy and operational efficiency. RFID systems allow for real-time tracking and quicker inventory processing.

Implementation: Initiating a partnership with established RFID providers like Zentag or HID Global is crucial for HV Power's shift towards lean warehousing. Implementing RFID tags on high-value and frequently circulated items, along with installing RFID readers at key warehouse points, will significantly advance HV Power's warehousing efficiency. Integrating this technology with the warehouse management system will also enhance real-time inventory visibility, streamlining operations.

7. Transition from Handwritten SAP Codes to RFID Barcodes

Rationale: Moving to an automated barcode system will enhance inventory management efficiency, reduce errors, and streamline warehouse processes.

Implementation: Transitioning to an integrated system of barcodes and RFID technology is a beneficial step for HV Power. It involves adopting appropriate barcode labels and scanners, integrated with the current inventory system (GreenTree). This shift will replace manual coding with efficient barcode scanning, streamlining inventory management and information retrieval.

Figure 10- Transition from barcodes to RFID tags

7.0 Conclusion:

This report concludes by presenting a comprehensive strategic framework for HV Power, developed through thorough research and analysis of their warehouse operations. Anchored in the principles of lean warehousing and the application of advanced technological solutions, this framework outlines a path toward transformative operational improvements. Central to this change is the implementation of bespoke picking strategies, namely cluster and wave picking, which are specifically designed to meet the unique, project-centric requirements of HV Power. This is complemented by the proposed integration of MYOB software with RFID technology to enhance inventory management practices. The adoption of RFID technology stands as a critical breakthrough, with the potential to significantly overhaul inventory tracking and management processes, thereby reducing errors and enhancing the accuracy of data. The report also recommends refined storage methods, such as sophisticated block stacking and bin location tactics, aimed at optimizing space utilization. Furthermore, the application of a mathematical model for space utilization provides HV Power with valuable insights, enabling them to enhance their warehouse layout to meet both current and future operational demands. Ultimately, this report not only addresses the pressing operational challenges faced by HV Power but also lays a strategic foundation for sustained growth and innovation in warehouse management, thus marking a notable advancement in achieving operational efficiency.

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