

The Future of Warehouse Automation and Robotics

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Overview

Warehouse automation refers to the utilization of technology to enhance efficiency and productivity within warehouse operations. In real estate, the growing demand for online marketplaces has made warehouse automation a key consideration in facility selection. To stay competitive and maintain efficient operations, adopting automation technology is becoming essential for warehouses.

Warehouse automation consists of two main types: digital and physical. **Digital automation** involves the use of data and software tools, such as barcode readers, and automatic identification and data capture systems. **Physical automation** refers to the use of robotics, conveyors, and other automated equipment. The main objective of these automation systems is to reduce manual labour and eliminate labour-intensive processes, as it allows workers to focus on more complex aspects of the operations, increasing productivity and minimizing the risk of human errors.

In the real estate industry, the incorporation of automation in warehouses highlights the progression of property use and management, illustrating a shift towards more technologically advanced and efficient facilities.

Historical Overview

The history of warehouse automation has been characterized by notable milestones, beginning with simpler machinery that has grown into the multifaceted systems that benefit all aspects of warehouse operations today. This evolution has been driven by the need for efficiency, accuracy, and cost-effectiveness when increasing the volume of goods.

The Introduction of Automated Equipment (1901-1940s)

Warehouse automation began in 1901 with the creation of steel conveyor belts, a significant innovation that allowed for efficient movement of goods within warehouses. This early automation paved the way for future advancements, creating the opportunity for more productive operations.

The Industrial Revolution (1950s-1960s)

This era is marked by rapid industrialization and mass production. The introduction of forklifts and the advancement of conveyor systems are some examples of how this upcoming technology was implemented into warehouse operations. These innovations became essential in managing the growing scale of production and distribution globally.

In the 1960s, the first Automated Storage and Retrieval Systems (ASRS) were developed, utilizing cranes and shuttles to store and retrieve items. In 1962, a Bertelsmann book-club warehouse located in Germany was one of the first to implement a complex storage and retrieval machine, changing the way warehouses had previously been operating (Ruehrdanz, 2024). Although their system was manually controlled, the punch-card control mechanism was fundamental to the evolution of modern automation. This high-density storage solution helped businesses manage increasing global consumption and provided financial relief from rising labour costs.

Technological Advancement and Barcoding (1970s)

The 1970s introduced barcoding, transforming inventory tracking by allowing for more accurate and efficient data collection (Ruehrdanz, 2024). During this period, advancements in ASRS enabled systems to switch between aisles and reach impressive heights. This innovation spurred the widespread development of high-bay warehouses.

The Rise of Robotics and Industry 4.0 (1980s-1990s)

The 1980s and 1990s were transformative decades for warehouse automation. The use of sensors, magnets, and lasers became crucial to enhancing operational precision.

The creation of technologies including Automated Guided Vehicles (AGVs), robotic palletizers, and conveyor systems with integrated sorting capabilities significantly reduced labour costs while improving operational efficiency (Sodiya, 2024). These technologies paved the way for higher levels of automation.

It was at this time that the concept of Industry 4.0 began to take shape, marked by the integration of technologies, such as the Internet of Things (IoT), cloud computing, analytics, AI, and machine learning (Ruehrdanz, 2024). These innovations enabled new levels of automation, predictive maintenance, and operational efficiency, significantly impacting how warehouses and manufacturing facilities operated.

The Expansion of Robotics and AI (2000s-Present)

In the 21st century, the market for ASRS and related technologies has continued to grow. In 2019, the ASRS market was valued at approximately US\$7.6 billion and is projected to reach US\$12.7 billion by 2028 (MarketsandMerkets, 2023). This expansion has been driven by the adoption of robotics and AI across various sectors, including healthcare, food & beverage, and automotive.

AI technologies have become an essential component of modern warehouses, particularly through computer vision systems that automate visual inspection tasks, identify products, and accurately track inventory movements. The COVID-19 pandemic emphasized the importance of automated systems, as safety protocols heightened and labour shortages raised, the need for reliable, efficient automation was crucial to maintain operational stability.

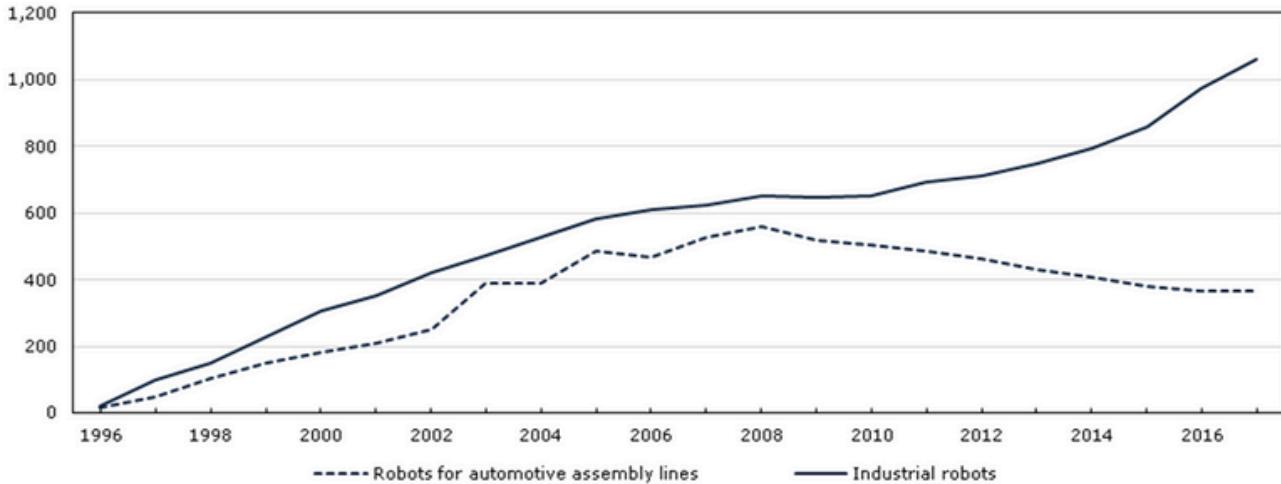
Robotic Investment Trends (1996-2016)

The graph at the end of this section illustrates the significant growth in spending on industrial robots and robots for automotive assembly lines from 1996 to 2016. In 1998, both sectors were below \$200 million in spending. However, the investment in assembly line robots peaked at \$600 million in 2008, before declining to \$400 million by 2016. On the other hand, industrial robot spending showed continuous growth, surpassing \$1 billion in 2016.

This data highlights the increasing reliance on robotics within the industrial sector, particularly for general industrial applications, which indicates strong future opportunities for further investment and innovation. The steady rise in industrial robot spending suggests a growing recognition of their value in enhancing efficiency, while the fluctuation in assembly line robot investment reflect the evolving needs and economic conditions within the automotive industry.

Chart 1
Robot stock, industrial robots and robots for automotive assembly lines

CAN\$ millions



Note: Robot stocks calculated based on 12-year useful life suggested by the International Federation of Robotics.
Source: Statistics Canada, import data.

Current Trends and Technology

The rapid expansion of e-commerce and the growing need for efficient supply chain management have accelerated advancements in warehouse automation and robotics. As businesses seek to improve operational efficiency, reduce labor costs, and enhance accuracy, they are increasingly adopting these technologies.

Automated Mobile Robots (AMRs)

Additionally, the current labor shortage has prompted many industries to embrace automation and artificial intelligence (AI) to take over repetitive and undesirable tasks previously handled by humans. Technologies, such as Automated Mobile Robots (AMRs), are gaining popularity as they efficiently handle tasks. Without pre-set paths or directions, these devices are capable of travelling across spaces and carrying out activities using sensors and machine vision (PrimeRobotics, 2024). This shift towards automation is not only a response to the labour shortage, but also a way to increase operation efficiency and return on investment (ROI). Governments at federal, provincial, and regional levels are providing incentives to encourage companies to upgrade and adopt automation systems, which further accelerates the transition to fully automated warehouse facilities. These incentives cover up to 25% of system costs and provide additional funding for research and development (Canada Department of Finance, 2024). The goal is to strengthen domestic production in Canada and combat foreign providers.

Vertical Expansion

The introduction of advanced technologies is reshaping how warehouse facilities are designed and built. A notable trend is the vertical expansion of storage and racking space. This approach reduces the floor area needed for storage, as modern facilities are increasingly built with higher clear heights – often up to 40 feet, compared to the previous standard of 30 feet. Automated Storage and Retrieval Systems are commonly used in these facilities, utilizing scanners, conveyors, and software to efficiently manage the storage and retrieval of products. This trend maximizes the use of vertical space, resulting in significant cost savings and more efficient use of the warehouse space.

Eco-Friendly Solutions

As the demand for eco-friendly and sustainable practices grows, companies are increasingly adopting green automation solutions in their facilities. One popular approach is the use of motion-sensor lighting systems, which ensure that lights are only on when needed, thus conserving energy. These systems automatically turn off lights when areas are not in use, preventing unnecessary energy consumption.

Green incentives, such as subsidies and tax breaks, are also encouraging businesses to invest in energy-efficient equipment and technologies. Additionally, emerging trends are pushing the industry towards more sustainable building practices, including the shift from traditional steel structures to timber frames, which have a lower carbon footprint. This transition is consistent with the increasingly common zero-carbon incentive programs.

The installation of solar panels on facility rooftops is another impactful trend, reducing reliance on non-renewable energy sources. In line with these efforts, the Canada Green Building Council has set an ambitious goal to decarbonize all of Canada's existing large buildings by 2050, aiming to reduce energy use by 70% (CAGBC, 2023). This long-term vision is driving significant changes in the design and operation of modern warehouses.

Generative and Advanced AI

Generative AI and advanced AI technologies are transforming modern warehouse automation. AI-powered systems excel at analyzing and generating data to optimize various aspects of logistics, such as risk management, demand forecasting, customer service automation, warehouse layout design, inventory management, and route optimization (Sodiya, 2024). The increasing complexity of warehouse operations and the demand for faster delivery times have accelerated the integration of AI. Technologies like machine learning, computer vision, and robotics are streamlining processes, enhancing supply chain visibility, and boosting overall efficiency. By identifying patterns, trends, and anomalies, AI algorithms enable warehouses to make data-driven decisions and proactively address operational challenges (Sodiya, 2024). These systems help improve order accuracy, reduce fulfillment times, and minimize inventory holding costs by optimizing warehouse layouts, picking paths, and storage locations.

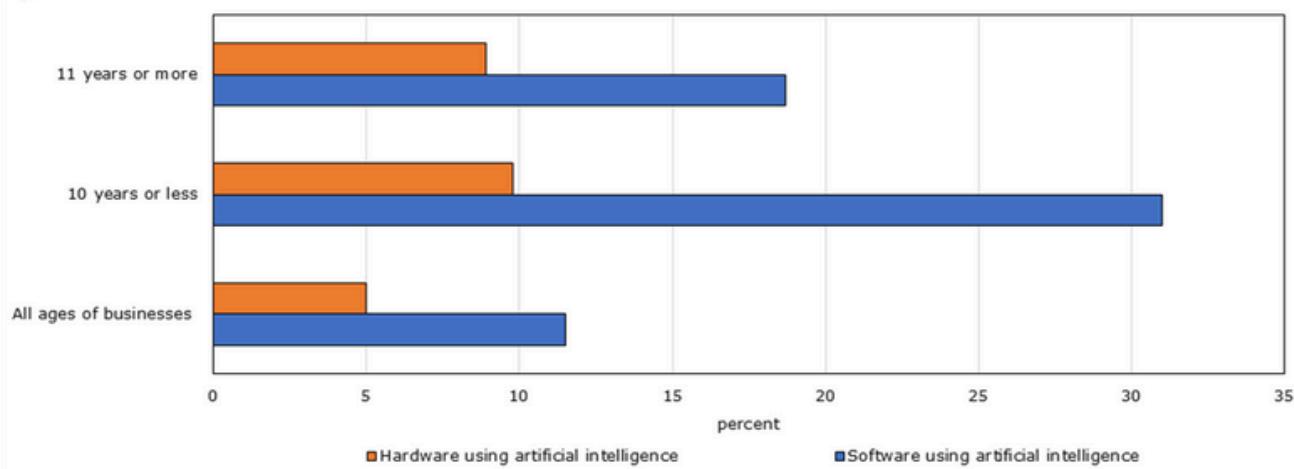
Despite these advancements, a recent chart on AI adoption shows that a relatively small percentage of businesses have plans to incorporate AI hardware or software within the next 12 months. For businesses over 11 years old, under 10% plan to incorporate AI hardware, while 17% plan to implement AI software. In contrast, for businesses under 10 years old, 10% plan on incorporating AI hardware, and over 30% plan to implement AI software. These small

percentages underscore a substantial market opportunity for businesses to adopt AI technologies. Companies that leverage AI can gain a competitive advantage by boosting productivity and efficiency, particularly through the automation of repetitive and undesirable tasks. As AI technology advances, early adopters are positioned to lead in an increasingly automated landscape.

Chart 2

Businesses with plans to adopt or incorporate artificial intelligence software and hardware over the next 12 months by age of business, second quarter of 2024

Age of business



Notes: The results in this table are based on the survey that was in collection from April 2 to May 6, 2024, and respondents were asked what the business or organization experienced in the last 12-month period. As a result, those 12 months could range from April 2, 2023 to May 6, 2024, depending on when the business responded.

Source: Canadian Survey on Business Conditions, second quarter of 2024 (Table 33-10-0822-01).

The Future of Warehouse Automation

The advancement of artificial intelligence technologies indicates a more comprehensive future for warehouse automation. The potential to automate nearly every aspect of warehouse operations is becoming a reality, with robotics playing a crucial role. This shift suggests that, aside from the necessary maintenance and repairs of equipment, human labour could eventually be minimized or even eliminated in many warehouse environments.

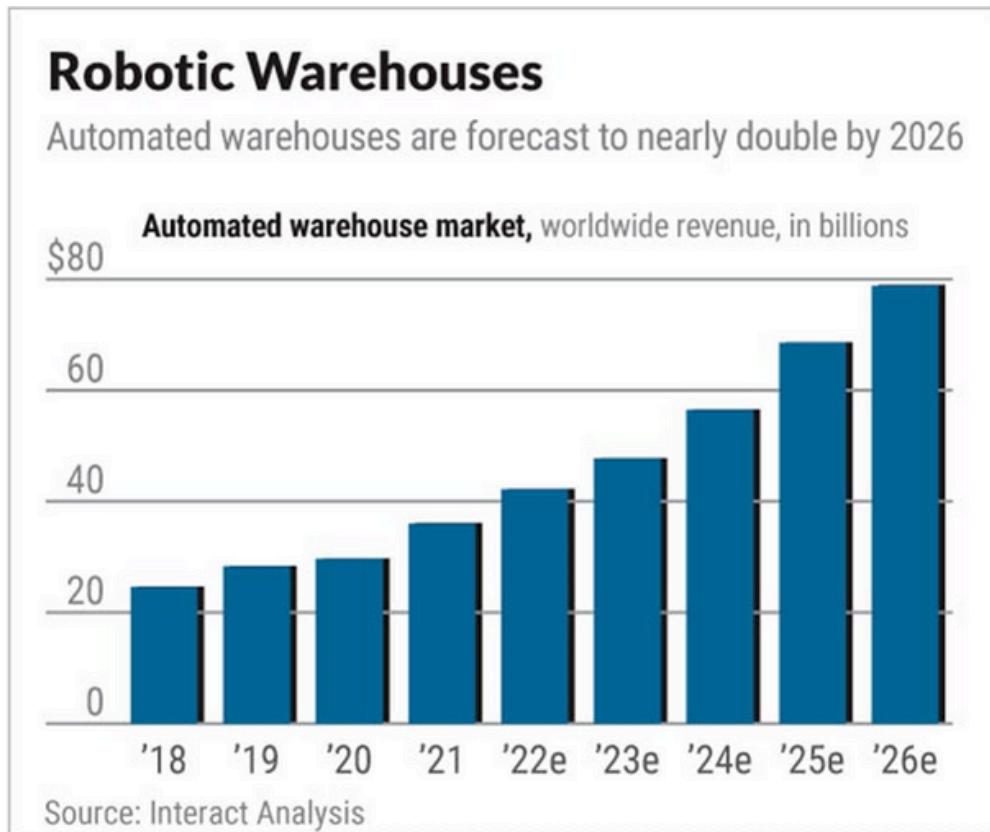
However, the goal to achieve full automation is still out of reach due to significant challenges we currently face. One of the main problems is the limitation of automation systems when handling larger or uniquely shaped products and packages. While standard-sized items can be efficiently managed by automated systems, irregular items often require human intervention. Overcoming this barrier will be crucial for the next generation of automated warehouses.

The future workforce in warehousing and logistics is expected to see drastic changes in warehouse operations. According to Bloomberg, the generative AI market is expected to grow from \$40 billion in 2022 to \$1.3 trillion over the next decade. This surge in demand for AI-driven solutions could generate an additional \$280 billion in new software revenue. This creates significant opportunities for efficiency and innovation, but it also raises concerns about job security. As more tasks become automated, the need for traditional warehouse jobs may decline, leading to job displacement. However, this will also open opportunities for new roles focused on managing and maintaining these advanced systems.

The future of warehouse automation is guaranteed for significant expansion. The chart below (Chart 3) indicates that the number of automated warehouses is forecasted to nearly double by 2026. In 2022, the global automated warehouse market was valued around \$40 billion, and it is expected to reach \$80 billion by 2026. This growth underscores the accelerating adoption of automation technologies across the industry. As more companies recognize the efficiency gains and cost reduction associated with automation the market is set to expand rapidly, paving the way for a future where fully automated warehouses become the norm.

The future of warehouse automation guarantees increased efficiency and reduced operational costs, but it will also require careful consideration of the evolving role of labour and the ethical implications of automation. As technology continues to advance, the industry will need to navigate these challenges to ensure a balanced and sustainable approach to automation.

Chart 3



Industry Research and Application

This section will present insights from visits to various warehouse facilities, highlighting how different types of automation have been successfully implemented across industries. Each facility has tailored its automation systems to meet their specific needs, optimizing operations and enhancing efficiency.

Custom Automation Systems

Facilities today have the option to design custom automation systems tailored to their specific operational needs. These solutions can be seen in many warehouses across sectors, from 3PL to food and storage facilities. The type of items handled and the unique requirements of their industry are taken into consideration while designing these systems. This customization allows facilities to maximize efficiency, reduce costs, and improve overall workflow.

3PL Facilities

A notable example is a beauty retailer's logistics setup, which involved partnering with a leading third-party logistics (3PL) provider based in Denmark. This facility utilizes advanced automation, including automatic inventory replenishment systems. When inventory levels at a store drop below a certain threshold, the system automatically triggers the shipment of necessary products to maintain optimal stock levels. Powered by generative AI, this system analyzes data from each store's product receipts to forecast replenishment needs. This approach ensures timely restocking, reduces the risk of stock-outs, and enhances both customer satisfaction and operational efficiency.

Direct-to-Consumer Warehouses

In direct-to-consumer (DTC) operations, many facilities have adopted automation systems to streamline the order fulfillment process. For example, Amazon employs advanced robotics and software systems to manage online orders, automating each step from picking to packing and shipping. Complex Automated Storage and Retrieval Systems (ASRS), equipped with scanners, scales, and elevators, enhance item storage accuracy and ensure that products are easily accessible and identifiable. This approach not only accelerates the delivery process but also reduces reliance on manual labor, enabling more efficient handling of high order volumes.

Food and Cold Storage

Automation is essential in the food and cold storage industries, where product quality and safety are paramount. Advanced software helps optimize storage layouts by analyzing seasonal demand and product popularity, ensuring efficient use of space. Custom automation solutions, including sophisticated camera systems and laser technology, are employed for quality control, detecting and removing defective or contaminated products. By minimizing the need for manual inspections, these systems not only boost efficiency but also uphold stringent food safety standards.

During these facility tours, several emerging trends and future directions in warehouse automation were apparent. Key developments include the growing adoption of artificial intelligence for predictive maintenance, the integration of IoT devices for real-time monitoring and data analysis, and a continued shift toward sustainable, eco-friendly automation solutions. These innovations are shaping the future of the industry, driving both operational efficiency and environmental responsibility.

Benefit and Key Considerations

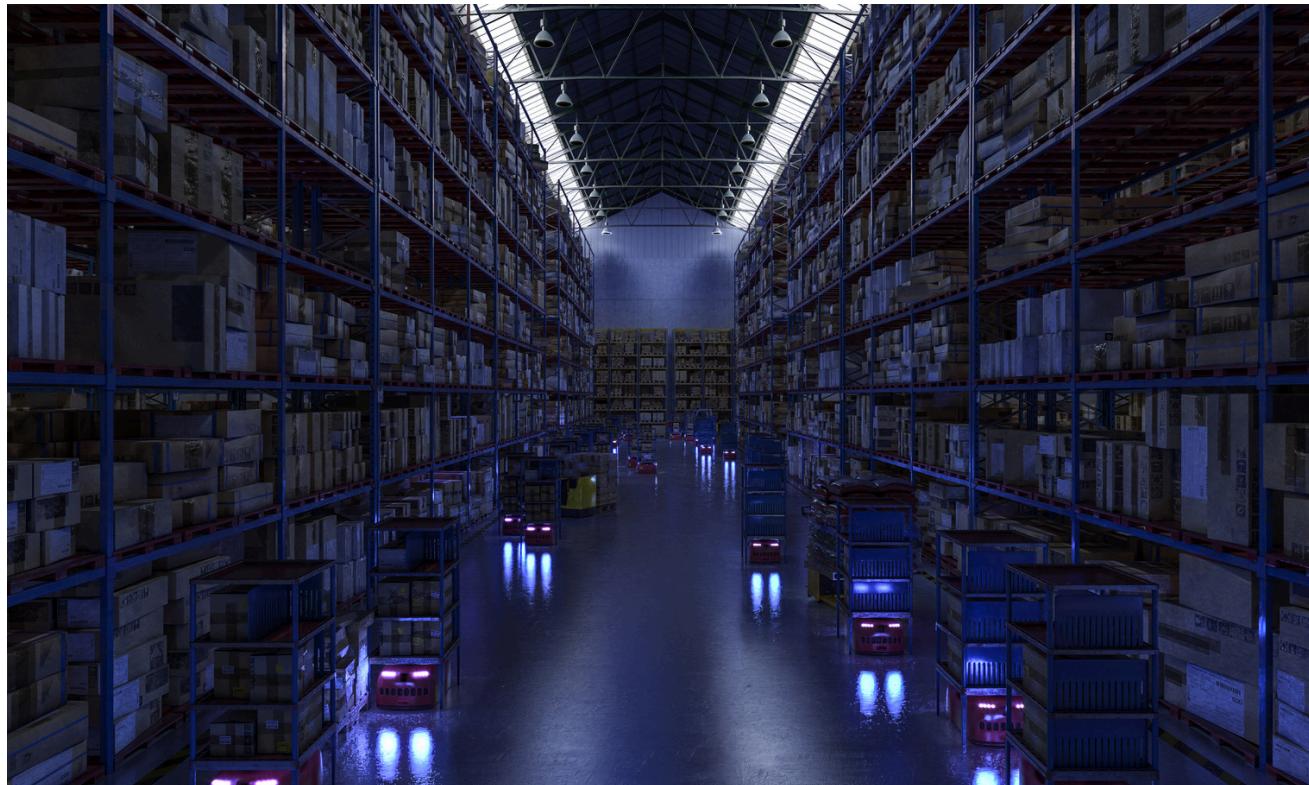
Efficient warehouse automation provides numerous benefits, significantly boosting productivity, lowering costs, and enhancing employee satisfaction. By incorporating advanced technologies like AI, robotics, and cloud-based systems, warehouses can streamline operations, increase output, and foster a more positive work environment. These innovations not only optimize processes but also contribute to a more sustainable and agile business model.

Benefits and Considerations of Automation:

- **Increased Productivity:** Fully automated facilities can operate 24/7, processing products and fulfilling orders continuously. This eliminates the limitations of a traditional work week and allows for higher inventory turnover and faster order fulfillment. For example, many of the facilities visited during our research process explained that their productivity has increased by at least 10x since implementing automation into their warehouses.
- **Cost Savings:** Automation leads to substantial cost savings by reducing reliance of human labour and cutting overhead expenses like wages and benefits. Cloud-based solutions further reduce costs by eliminating the need for on-site servers. Systems like Automated Storage and Retrieval Systems (ASRS) and Automated Mobile Robots (AMRs) provide a quick return on investment, making them a financially sound choice for long-term efficiency.
- **Management of Repetitive Tasks:** Automation can improve employee satisfaction by alleviating the physical and mental strain of repetitive tasks. With robots handling monotonous duties, workers can engage in more complex and fulfilling roles, enhancing both safety and job satisfaction.
- **Manage Fluctuating Demand:** Automation enables facilities to efficiently manage fluctuating demand, particularly during peak seasons in industries like retail. Automated systems swiftly adjust to changes, maintaining accurate inventory levels and ensuring timely order fulfillment.

- **Environmental Sustainability:** Automation boosts energy efficiency by integrating technologies like sensor-controlled lighting, as seen in Canada Post's automated warehouses, which only activate lights when necessary. Similarly, automated systems like ASRS elevators operate at full capacity to minimize energy waste. In the food industry, automation enhances hygiene by reducing human contact with products, lowering the risk of contamination and ensuring higher safety standards.

In summary, warehouse automation enhances productivity, reduces costs, improves employee satisfaction, and promotes environmental sustainability. By embracing these technologies, companies can improve operational efficiency while positively impacting their workforce and environment.



The Next Generation of Warehouse Automation and Robotics

Warehouse automation is revolutionizing a variety of industries, bringing unmatched efficiency, accuracy, and scalability to operations. From the historical evolution of simple conveyor belts to the current integration of AI and robotics, the journey of warehouse automation has been marked by continuous innovation and adaption to changing market demands. This white paper has explored the key trends, technologies, and benefits associated with modern warehouse automation, highlighting its critical role in enhancing productivity, reducing costs, and improving employee satisfaction.

The implementation of advanced automation systems, such as Automated Storage and Retrieval Systems (ASRS) and Automated Mobile Robots (AMRs), has enabled facilities to operate around the clock, handle higher volumes of goods, and streamline complex processes. These technologies are not only increasing operational efficiency but also providing fast return on investment (ROI), making them a financially sound choice for business.

Moreover, automation's impact on the workforce is multifaceted. While it reduces the need for manual labour in repetitive and physically demanding tasks, it also creates opportunities for workers to engage in more strategic and value-added activities. This shift increases job satisfaction and workplace safety, contributing to a healthier work environment.

In conclusion, as warehouse automation continues to evolve, it holds the potential to transform the logistics landscape in ways we are only beginning to imagine. What new capabilities might emerge in future technologies? How will businesses adapt to an increasingly automated world? Those who stay ahead of these advancements may not only achieve cost savings, increased productivity, and environmental sustainability but also redefine the very nature of work and competition in their industries. The next generation of warehouse automation and robotics is yet to be written, and it promises to be ads groundbreaking as the innovations that have come before.

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Chart 2 <https://www150.statcan.gc.ca/n1/pub/11-621-m/11-621-m2024008-eng.htm>
Chart 3 <https://www.investors.com/news/technology/warehouse-automation-drive-spurred-by-labor-shortage/>

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