

**NEW ERA OF WAREHOUSE IN THAILAND INDUSTRY 4.0
“WHAT ARE THE IMPACTS OF AUTOMATION WAREHOUSE
IN THAILAND?”**



**A THEMATIC PAPER SUBMITTED IN PARTIAL
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entitled
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“WHAT ARE THE IMPACTS OF AUTOMATION WAREHOUSE
IN THAILAND?”

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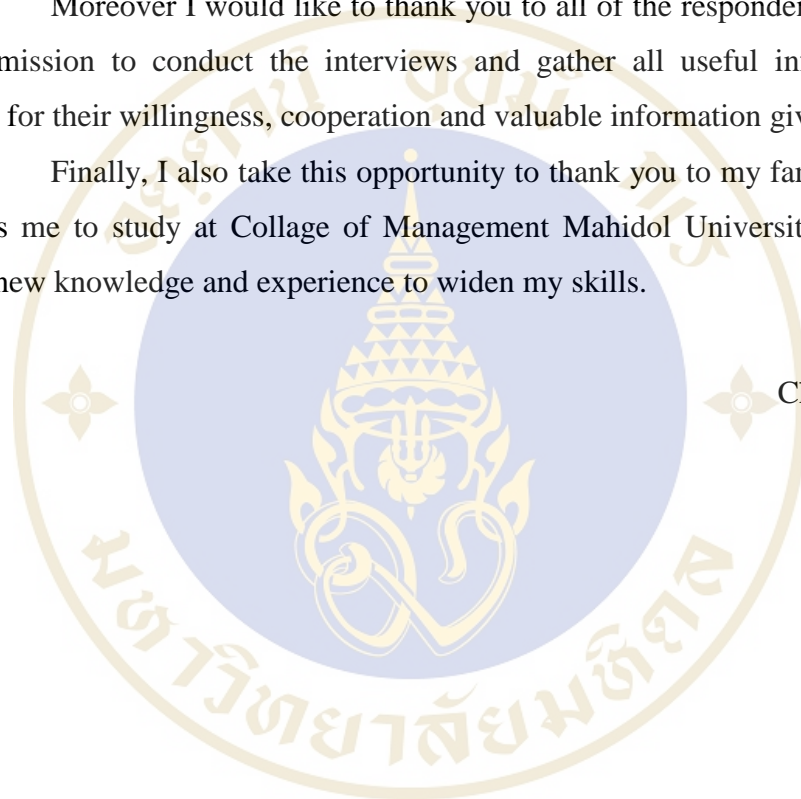
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Chonlada Anumas



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ABSTRACT

In order to enhance the efficiency of logistic system in the era of Thailand industry 4.0, many companies are interested in implementing automated systems into their warehouses. However, a careful exercise in balancing risks with rewards needs to be conducted in order to determine whether automation system would compliment their warehouse operation. This research therefore studies on the impacts of automation warehouse in Thailand to deeply understand its benefits and drawbacks. Moreover, this research also explores the possible challenges or issues that companies encountered during implementing automation warehouse.

The qualitative research method is used for collecting data from the selected samples. The interviews were conducted with seven respondents who work for different positions and come from different companies which already implemented automation system into their warehouses. Interviewed results were categorized into groups and compared with the findings from literature review. Research findings indicate that there are a variety of benefits from implementing automation warehouse such as higher space efficiency, increased speed, reduced energy consumption, reduced product damage, reduced labor cost, lowered injury risk, increased inventory accuracy, etc. Meanwhile, the drawbacks are high upfront cost, less flexibility, worker disengagement, high maintenance cost and costly breakdown, required new skills and expertise, etc.

KEY WORDS: Automation Warehouse / Warehouse Technology / Logistics Technology / Supply chain

38 Pages

CONTENTS

	Page
ACKNOWLEDGEMENTS	ii
ABSTRACT	iii
LIST OF TABLES	vi
LIST OF FIGURES	vii
CHAPTER I INTRODUCTION	1
1.1 Background and Problem Statement	1
1.2 Research Objectives	2
1.3 Research Scope	2
1.4 Expected Benefits	3
CHAPTER II LITERATURE REVIEW	4
2.1 Automation in manufacturing industries 4.0	4
2.2 Definition of Automation warehouse	6
2.3 Trend of Automation warehouse	7
2.4 Benefits and Drawbacks of Automation warehouse	9
2.5 Conclusions	12
CHAPTER III RESEARCH METHODOLOGY	13
3.1 Primary Data Collection Method	13
3.2 Sample selection	13
3.3 Develop opened-end questions	14
3.4 Conducting the interviews	15
3.5 Research Framework	16
CHAPTER IV RESEARCH FINDINGS	17
4.1 Benefits of automation warehouse	17
4.1.1 Space Efficiency	17
4.1.2 Increased speed	19
4.1.3 Reduced Energy Consumption	20

CONTENTS (cont.)

	Page
4.1.4 Reduced product damage	21
4.1.5 Reduced labor cost	21
4.1.6 Lowered injury risk	22
4.1.7 Increased inventory accuracy	23
4.1.8 Streamline manufacturing	23
4.1.9 Corporate Social Responsibility (CSR)	23
4.2 Drawbacks of automation warehouse	24
4.2.1 High Upfront cost	24
4.2.2 Less flexibility	25
4.2.3 Worker displacement creates demotivation	25
4.2.4 High maintenance cost and Costly breakdown	26
4.2.5 Required new skills and expertise	26
4.2.6 Dependence from technology owners	27
4.3 Problems when implementing automation warehouse	27
4.3.1 Misconception of automated system design	27
4.3.2 Misunderstanding on the use of technologies	28
4.3.3 Unclear assigned team in the early stage	28
4.3.4 Lack of workers with higher technical skill-sets	28
4.3.5 Cyber-attacks	29
CHAPTER V CONCLUSIONS AND RECOMMENDATIONS	30
5.1 Conclusions	30
5.2 Recommendations	31
5.3 Limitations and suggestions for future research	33
REFERENCES	35
BIOGRAPHY	38

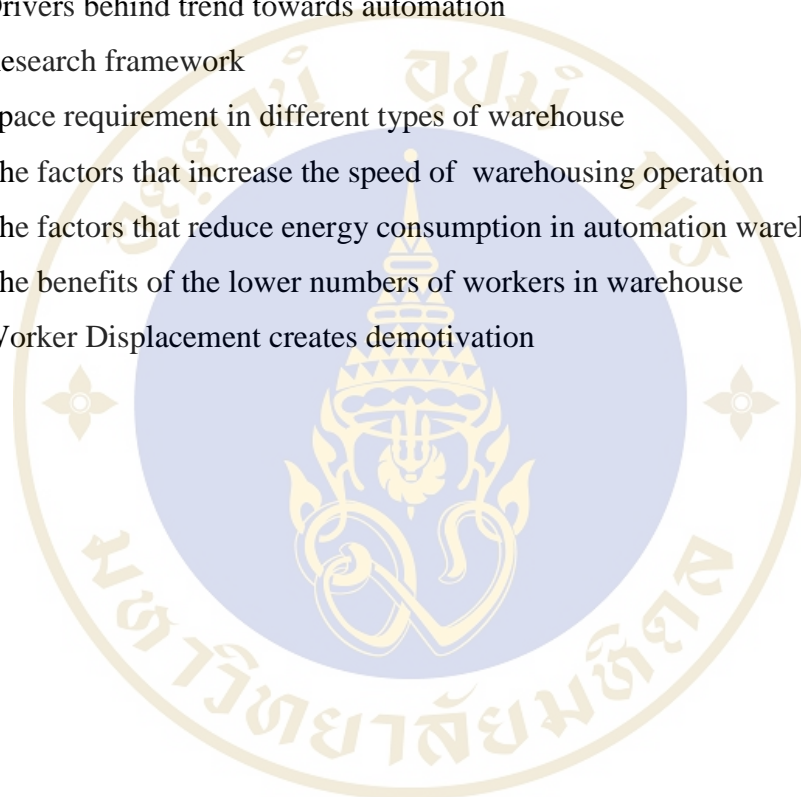
LIST OF TABLES

Table		Page
2.1	Estimated cost and payback period for different level of automation	7
2.2	Summary of impacts of automation warehouse	12
3.1	Interviewees list	14
3.2	Opened-end question list	15
5.1	Summary of benefits and Drawbacks of automation warehouse	30



LIST OF FIGURES

Figure	Page
2.1 The Nine Pillar of Technological Advancement	5
2.2 Four levels of automation warehouse	6
2.3 Drivers behind trend towards automation	8
3.1 Research framework	16
4.1 Space requirement in different types of warehouse	18
4.2 The factors that increase the speed of warehousing operation	19
4.3 The factors that reduce energy consumption in automation warehouse	20
4.4 The benefits of the lower numbers of workers in warehouse	22
4.5 Worker Displacement creates demotivation	25



CHAPTER I

INTRODUCTION

Since the dawn of the Industrial Revolution, automation in global industry has rapidly and significantly improved in order to serve the needs of human such as increasing efficiency, improving flexibility, eliminating human errors, and increasing safety. In the meantime, there are many factories in Thailand which are becoming increasingly automated in order to boost their production efficiency. For example, Robotic arms are used in car-body welding process in automotive factories in order to get higher efficiency and productivity. Automated cranes and telescopic forks are used in warehouse instead of using forklift trucks driven by human, in order to speed up the warehouse operation which is the critical activity in inbound and outbound logistics along the company's value chain.

1.1 Background and Problem Statement

Warehousing and warehouse management are essential to any logistics management system, which in itself is part of the supply chain. A warehouse is a spacious place, used for storing and accumulating goods. Even though it seems simple to store goods in storage facilities, warehousing plays a vital role in the supply chain process to ensure that the inbound functions accurately receive and store goods as well as outbound functions efficiently retrieve and ship orders, resulting in benefits for both the business and customers.

Due to the automation transformation and Thai industry 4.0 kick-off, many companies have decided to shift their warehouse from human-based to automation-based to gain competitiveness in their supply chain process. However, this warehouse transformation in Thai industry has created concern about the secure of human's jobs. Even though human is a mark of luxury in service industries, robot is destroying the

demand of human labors in manufacturing jobs. Some are afraid that they will be at risk of being replaced by machines or robots, and their job will be stolen.

On the other hand, there is a belief that automation warehouse offers a bright future to supply chain management and also makes warehouse staffs more valuable than ever. The warehouse staffs will be more specialized and innovative skilled workers because companies are concentrating on worker development to fit the required skills for operating automation system while robots are designed to collaborate effectively with human.

1.2 Research Objectives

The main objective of this research is to study the impacts of automation warehouse in Thailand. These impacts can be either the benefits that enhance the performance of warehouse and then increase the efficiency of supply chain in business, or drawbacks that can disrupt companies after transformation.

The second objective of this research is to discover the challenges or issues that companies encountering during and after implementing automation warehouse, especially human workforce issue.

1.3 Research Scope

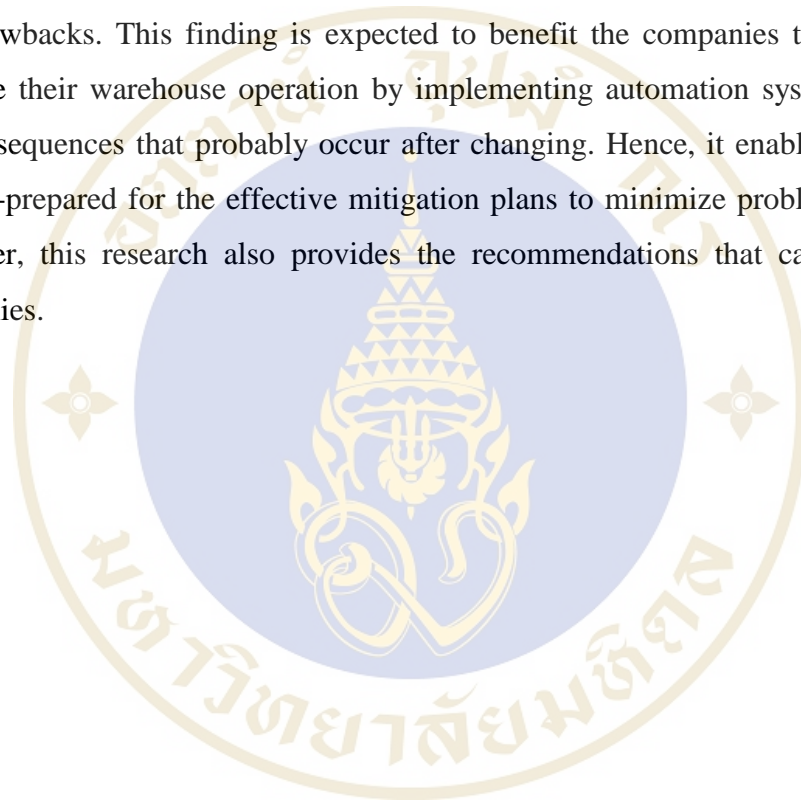
The scope of this research studies the impacts of automation warehouse in Thailand industry by analyzing information from two main sources which are the primary and secondary collected data. The primary collected data is collected by using qualitative research method to interview the judgement samples who have experience and work for companies which already implemented automation warehousing system to their warehouses in Thailand. The reason for choosing only the companies that already implemented the automation because the collected information will reflect the actual benefits and drawbacks that occurred in their companies, not just the expected benefit and drawbacks.

The secondary collected data is from reviewing the previous researches from a variety of sources such as journals and articles by focusing on automation

warehouse industry in global. In the final state, both primary collected data and secondary collected data are analyzed and compared to see the similarities and contrasts.

1.4 Expected Benefits

Findings from this research provide the insight information about the impacts of automation warehouse especially in Thailand for both factors of benefits and drawbacks. This finding is expected to benefit the companies that are going to improve their warehouse operation by implementing automation system to aware of the consequences that probably occur after changing. Hence, it enables companies to be well-prepared for the effective mitigation plans to minimize problems in advance. However, this research also provides the recommendations that can be useful for companies.



CHAPTER II

LITERATURE REVIEW

To understand more about the impacts of robot and automation in manufacturing industries in term of its benefits and drawbacks, the previous researches from a variety of sources such as journals and articles were reviewed focusing primarily on the automation warehouse industry. The information from literature review in this chapter is classified as secondary data which includes basic knowledge and concrete samples from U.S and Europe markets. However, in-depth interview from employers in Thailand industry is still needed as primary data for this research.

2.1 Automation in manufacturing industries 4.0

Rüßmann et al. (2015) discussed that Technological advance has affected significant increase in manufacturing productivity since the transformation of industrial revolution. Starting with, the steam engine was used to power factories in the nineteenth century, then electrification generated power to drive mass production in the early of the twentieth century, and Automation has been brought to industry since the thirds industrial revolution in the 1970s.

As the start of a new industrial revolution and the notion of Industry 4.0, Rüßmann et al. (2015) found that manufacturers in many industries have implemented automation system to their factories to increase productivity, enhance flexibility, integrate and optimize production flow, and modify the profile of workforce requirement. In this technological transformation, Rüßmann et al. (2015) described that machines, sensors, workpieces, and IT system are linked along the value chain in the whole single organization. These connected systems will help manufacturer to collect and analyze data across machines, creating more efficiency, more flexibility, and less cycle time in production process. In the finding of Rüßmann et al. (2015), they identified “The Nine Pillar of Technological Advancement” and considered it as

the foundation to form industry 4.0 (see Fig.2.1). Those nine pillars consist of Autonomous Robots, Simulation, Cloud Computing, Additive Manufacturing, Augmented reality, Big Data analytics, The Industrial Internet of Things, Cyber Security, and System Integration.

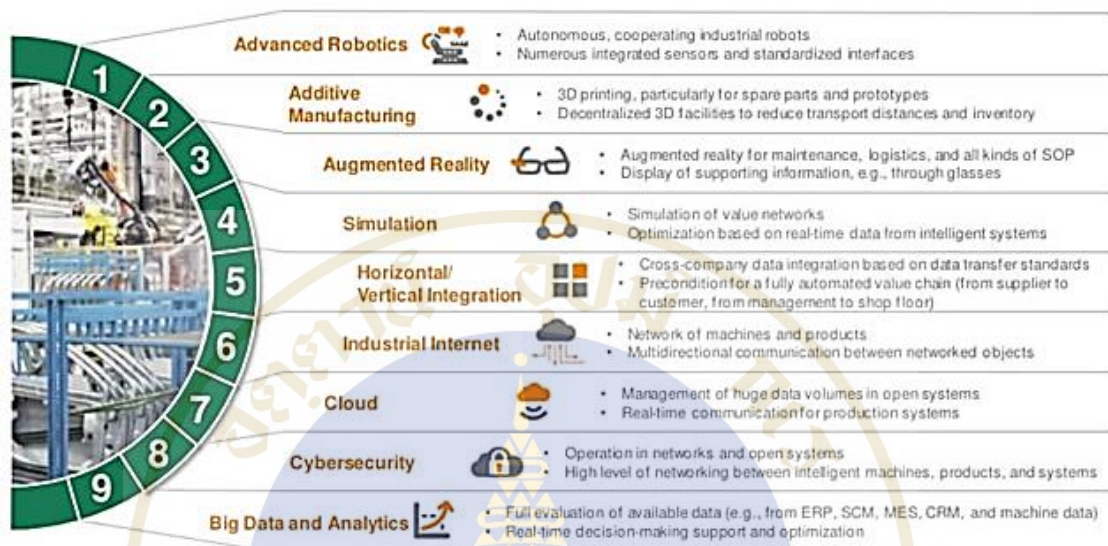


Figure 2.1 The Nine Pillar of Technological Advancement (Rüßmann et al., 2015)

Fawcett (2017) also stated in his article that “Industry 4.0 and the rapid rise of automation is spearheading the ever-changing landscape of manufacturing processes. Manufacturers are presented with the challenge of upgrading and digitizing their systems as a means of installing longevity in their businesses. Failure to do so risks them falling behind their customer’s growing demands.”

Rüßmann et al. (2015) mentioned that many companies have already implemented some technological advancement into their factories, especially Autonomous Robots to tackle the complex activities in their manufacturing process because human has inability to monitor and control every single small change during production process. Some factories are using collaborative robots which are designed to safely work alongside their human coworker. For example, KUKA, a German manufacturer of industrial robots, provides autonomous robots which can interact and work together with another robot as team to perform task automatically in manufacturing line. Same as ABB, which offered YuMi (signifies “you” and “me”). It is the first truly collaborative dual-arm industrial robot that used in electronic industry, and allows human to work side-by-side in the same task. Moreover, Daifuku who

introduced themselves as the technology owner for automation warehouse, has developed the automated storage and retrieval systems (AS/RS) that allowed warehouse to become three-dimensional and automated.

2.2 Definition of Automation warehouse

O'Byrne (2016) suggested that it is likely to think of automation warehouse in term of reducing time, improving space utilization, improving productivity and quality, and cutting manpower in order to improve supply chain management. Allais (2017) explained that the successful transformation of automation in warehouse and distribution center is partly because of its close integration with Warehouse Management System (WMS) to help track all going transactions in their warehouse. However, there are various types of automation warehouse and a variety of technologies can be used.

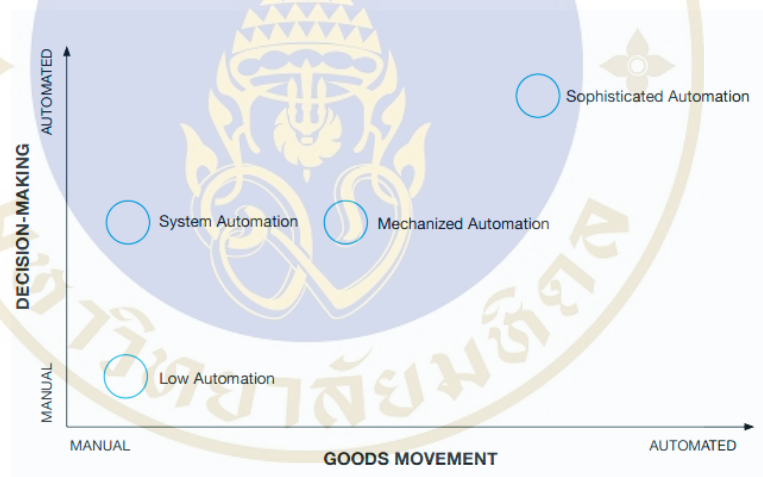


Figure 2.2 Four levels of automation warehouse (Trottmann and Zhang, 2017)

Trottmann and Zhang (2017) explained that there are two main things that can be automated in automation warehouse. First, the decision-making process which refers to how warehouse has better layout design, how to utilize space, and how to store automatically. Second, the goods-movement process refers to how various movements of goods from one point to another point can be done efficiently by machinery. These two main processes can be considered as brain and body of the automation warehouse.

Trottmann and Zhang (2017) classified the level of automation in warehouses into four levels according to Fig 2.2. First level is Low Automation which operates manually by using paper based to record inventory. Workers themselves need to make decision where to keep goods, and travel to put or pick up goods from shelves. Second level is System Automation which uses Warehouse Management System (WMS) to make decision where to put away and pick up items. Usually, Mobile RF (Radio Frequency) Technologies are involved in this System Automation to scan barcodes for tracking. In overall, Min (2015) found that companies gain 25% increase in productivity, 10-20% improvement in space utilization, and a 15-30% reduction in safety stock after changing from a paper-based system to this level of automation. Third level is Mechanized Automation which is not only have automatic logic, but goods movement is automated as well. There are many methods to bring inventory to order picker, or to move material to next appropriate operation such as carousels, automated storage and retrieval systems (AS/RS). Last level is Sophisticated Automation which is the ultimate automation in warehouse that eliminates manual movements and fully requires advance system to handle complex decision-making logic.

Table 2.1 Estimated cost and payback period for different level of automation (Trottmann and Zhang, 2017)

	TECHNOLOGIES	EST. COST IN USD	EST. PAYBACK PERIOD
System Automation	WMS with RF Device, Pick-to-light, or Voice-picking	0.5 – 2M	0.5 – 2 years
Mechanized Automation	+ Conveyors, AS/RS	5 – 15M	2 – 4 years
Sophisticated Automation	+ Sorter, AGV, Robotic picking, Palletizer, etc	>50M	> 5 years

2.3 Trend of Automation warehouse

PRG (2016) showed that, as of 2016, more than 10% of warehouse in U.S. used the autonomous warehousing robots that enable goods to person approach. And it

is forecasted that the number of robot in automation warehouses is probably to rocket by 15 times in the end of 2021 to 620,000 units of robot.

Trottmann and Zhang (2017) pointed out that automation warehouse is actually not a recent invention, because the first AS/RS was installed to warehouse in 1970s. Therefore the root cause of new trend of interest in automation warehouse besides the technology development is also from the higher consumer expectations mainly due to e-commerce. The higher demand and requirement from consumer create more frequent and complex orders which need more labor and land cost. This operational challenge has driven manufacturer moving toward automation warehouse as their solution.

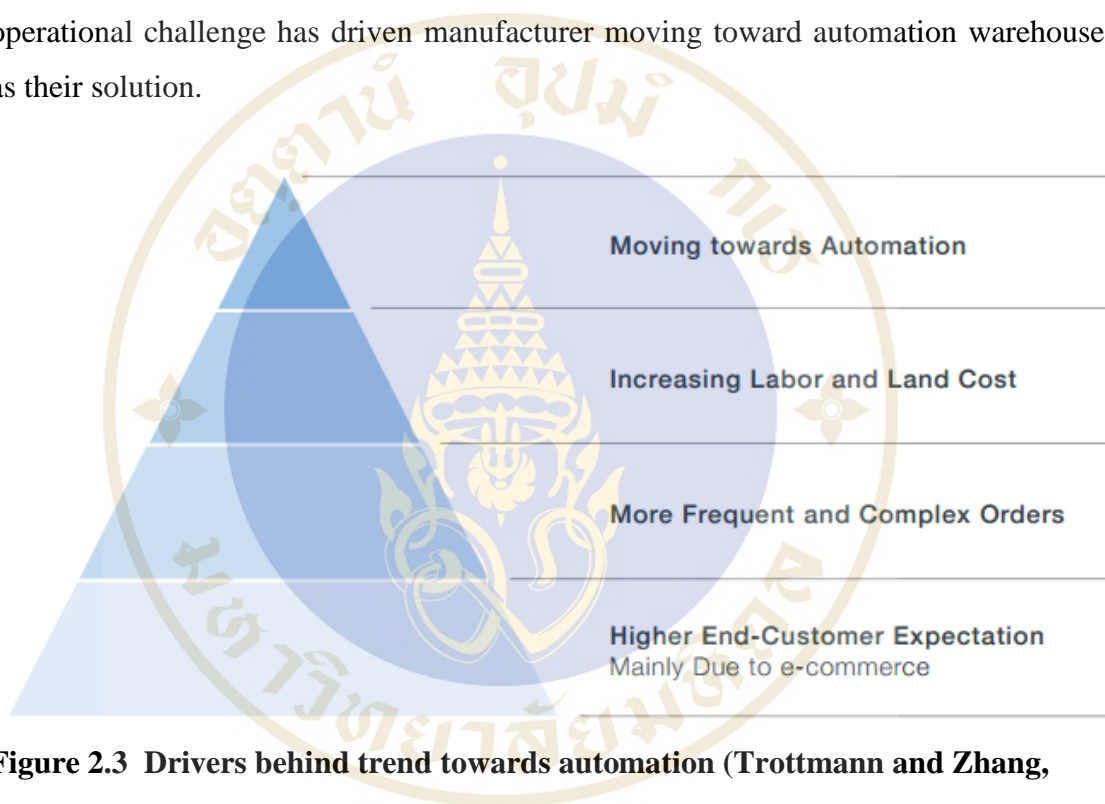


Figure 2.3 Drivers behind trend towards automation (Trottmann and Zhang, 2017)

From United States Census Bureau in 2016 presented that the sales growth from E-Commerce in U.S. was 25% which represented 8.2% of total retail sales. The E-commerce has influenced consumer expectation for faster delivery, especially when Amazon set new standard of free two-day delivery and consumers now get used to it as standard. Moreover, consumers also demand for customized and variety of goods. Manufacturers therefore need to expand their production and also warehouses. However, expanding in warehouse needs either more labors or more spaces (Trottmann and Zhang, 2017).

U.S. Bureau of Labor Statistics, Warehouse & Logistics Data in 2016 showed the statistic that the total employment for workers in warehouses and logistics rose up by 6% in 2016. With the higher demand on labors and tighter recruiting standard, the wages is pushed higher too. Furthermore, the higher standard needed for working in warehouses such as certified to drive forklift, makes warehouses harder to find the right skilled set of workers (Trottmann and Zhang, 2017).

Trottmann and Zhang (2017) emphasized that beside the rise of labor cost, warehousing space in U.S. is more expensive too. Comparing to 15 years ago, current warehouse is three times bigger than the former warehouse. The bigger size of warehouse may help to handle the higher volume of goods, but it is actually not the effective solution because of the rising space cost and longer distance to travel in warehouse. Therefore, many employers decided to shift to automation warehouse which can fully utilize the space in warehouse and can operate 24/7 without lunch break, fatigue or health insurance requirement same as human.

However, Allais (2017) argued that automation warehouse does not always provide what organization really needs. Employers themselves need to perform due diligence to see if automation makes economic sense or not.

2.4 Benefits and Drawbacks of Automation warehouse

Warehousing operations are very active and intense which is driven by the constant movement of people and equipment (Myerson 2012; Bohács et al. 2013; Kolarovszki et al. 2016; Mangan, Lalwani 2016; Nathanail et al. 2016; Apsalons, Gromov 2017; Dybskaya, Sverchkov 2017; Kłodawski et al. 2017; Palšaitis et al. 2017; Pyza et al. 2017). These operations are not just value-adding activities for the company's value chain, but there are many additional activities in the warehouse that cause extra costs and errors in the warehousing process. This reason influences employers to attempt to transform their existing technical equipment to the modern and advance technological system, in order to enhance the quality of work and increase productivity, which should help to minimize the errors in warehousing process (Rekik et al., 2008).

Škerlič et al. (2017) who studied on the dilemmas that accompany the introduction of modern automation warehouse and their impact on the work of operators in the Slovenian automotive industry concludes that the perception on the safety in companies that use automation warehouse is significantly greater than in companies that still use traditional system. From the research of Škerlič et al. (2017), 93% of warehouse managers in companies in Slovenia that use basic warehousing technology believe that the main reason of the occurrence of errors during execution of work activities in warehouse is from their existing basic technological equipment. Warehouse managers in general do not confident in basic warehouse technology, even though its reliability has been validated. This perception can create stress toward the warehouse staffs because they know the fact that their current basic equipment can potentially increase the errors to their assigned tasks. Škerlič et al. (2017) suggested that the management of companies that have not implemented the modern automation system to their warehouse yet, should add new technology to their warehousing system in order to modernize the processes. Because the finding from their research shows that the companies that currently have automated warehouse system gain a positive attitude toward its usefulness which is a clear sign that Slovenian suppliers of the international automotive industry need the implementation and use of modern warehouse technologies.

Moreover, the advantages of the use of automation warehouse also include a better space utilization, less energy consumption and labor cost, closer monitoring and control, fewer manual handling activities, better coordinating work flows to avoid bottlenecks, lower operational costs and fewer incidents in warehouse (Richards, 2014).

Warehouse Management System (WMS) is now very essential for every warehouse. Automated warehouse system requires less human effort and provides higher efficiency and consistency results, compared to a traditional warehouse that needs manual handling system. Moreover, the cost is also reduced through the effective warehouse processes, which is the result of WMS (Atieh et al., 2016). Furthermore, the use of WMS is considered as one of the proactive ways to accelerate goods turnaround time, increase inventory accuracy, provide real time order status information, manage warehouse space and boost labor productivity (Min, 2006).

One of the most advanced technologies for loading system in automation warehouse is an Automated Storage and Retrieval System (AS/RS), which have been implemented into many warehouses and distribution centers so far. There are various types of AS/RS which can be customized according to the required system design. AS/RS in automation warehouse will improve the material handling process by minimizing storage footprint, labor costs, and time required to store and retrieve goods from the storage location. Moreover, AS/RS helps warehouse to attain high inventory optimization and tracking level, and increase overall warehousing operation performance (Janilionis et al., 2016).

Meanwhile the warehousing process is transforming because the manual handling activities was replaced by automated robots, companies need to handle with the increase of data processing. Therefore, warehouse operations are now dealing with information system rather than with physical goods movement (Mangan, Lalwani 2016). Even though, these changes in warehouse leads to fewer human errors in terms of goods movement, automation still gives errors but in the different types due to an increased use of technology (Reason, 1997).

On the other hand, there is a different aspect from authors who studied human-automation interaction and application of modern technology to ensure the reliability of business operations. Their researches, which were conducted in the past, found that the adoption of modern technology does not reduce the occurrence of human errors, but solely leads to the potential of different kinds of errors (Bainbridge, 1983; Norman, 1990; Dekker, 2017; Reason, 2009).

Even though, McBride et al. (2014) accepted that automation has the potential to assist humans on various kinds of tasks and enhance overall system performance, he pointed out that automated systems are not constantly reliable. And this is the reason why humans need to be actively involved in the step of controlling, understanding and correcting errors.

Hancock (2014) pointed out that during the new wave of automation is going on, there is the essential concern on the excessive automated process. He suspects that the existence of automated system might actually constrain the growth of knowledge and skills of human operator. Therefore he suggests the interesting solution to achieve the optimum level of automation is to find a middle line. Škerlič et al.

(2017) also agree that finding a middle line allows companies to spend less on the automated warehouse equipment and system because companies implement modern warehouse technology only for those process that would gain the most benefit from it.

2.5 Conclusions

After analyzing the literature review on the impact of automation warehouse, it can be categorized into group of benefits and drawbacks as shown in table 2.2

Table 2.2 Summary of impacts of automation warehouse

Benefits	Drawbacks
<ol style="list-style-type: none"> 1. Better space utilization 2. Increase efficiency (speed & quality) 3. Decrease labor cost 4. Reduce energy consumption 5. Increase inventory accuracy 6. Minimize incidents in warehouse 7. Minimize the errors in warehousing process 8. Workers are more confident on their equipment. 9. Closer monitoring and control 10. Fewer manual handling activities 	<ol style="list-style-type: none"> 1. Potential risk of costly downtime from system shutdown. 2. High initial costs 3. High maintenance cost 4. The constraint in growth of operator's knowledge and skills due to the excessive automated process.

CHAPTER III

RESEARCH METHODOLOGY

3.1 Primary Data Collection Method

Even though the secondary data from the literature review pointed out various impacts of automation warehouse in the aspect of companies in global, there is still no any research studies the impacts of automation warehouse in Thailand market. Hence, this study aims to explore and understand what the insight benefits and drawbacks that companies in Thailand get after implementing the automation system in their warehouse are.

Therefore, qualitative research is developed and used for data collection in this research. Because the required information is complex and best described in comprehensive discussion, which is difficult to be retrieved by quantitative research method. The qualitative research also enables to understand the underlying opinions, experiences, and attitude of companies in Thailand toward automation warehouse.

For the adopted qualitative data collection methods, in-depth interview with open-ended questions and probing technique is used in this research, because the impact of automation warehouse in Thailand can be varied and diverse in different businesses. The opened-end questions will allow interviewees to response in their own words, rather than forcing them to choose from the fixed responses. Interviewees can be asked by more specific questions based on the response of them.

3.2 Sample selection

For this research, the interviewees include of seven selected samples who are responsible for automation warehouse projects in their companies. These seven selected samples have worked for different companies which have already implemented automation system into their warehouse in Thailand. Therefore, these selected samples have very well understanding and experience on automation

warehouse in both terms of operational and managerial level. This sampling is considered as convenient and judgement sampling method because the samples are selected from their direct expertise and availability.

Table 3.1 Interviewees list

No	Code	Position	Industry of company	Experience in warehousing operation
1	A	Project Development Manager	Chemical	5 years
2	B	Project Manager	Foods	6 years
3	C	Managing Director	Automation	16 years
4	D	Warehouse Manager	Beverages	10 years
5	E	Supply Chain Director	Beverages	15 years
6	F	Warehouse Manager	Foods Retailer	8 years
7	G	Project Engineer	Building Material and Construction	3 years

3.3 Develop opened-end questions

To understand the impacts of automation warehouse in Thailand in terms of its benefits and drawbacks, opened-end questions are utilized to collect deep information from interactive interview session. A list of opened-end questions is created to explore the benefits and drawbacks of automation warehouse from the view point of companies in Thailand.

To clarify the data, probing techniques from McDaniel & Gates (2013) is adopted by asking follow-up questions when the interviewer does not fully understand the responses, when the responses are ambiguous, and when more specific information or concrete example is needed.

Table 3.2 Opened-end question list

Finding factors	Interview Questions
General	(1) What is the automation system that your companies implemented into warehouse? (2) How long did your warehouse transform to be automated? (3) What does your company expect from changing to automation warehouse? Does your company achieve those expectations?
Benefits of automation warehouse in Thailand	(4) What are the benefits / advantages of implementing automation system to your warehouse, comparing to traditional warehouse? And how?
Drawbacks of automation warehouse in Thailand	(5) What are the problems/challenges that you encountered after changing to automation warehouse? (6) What are the difficulties or obstacles during transforming to automation warehouse? (7) Does automation affect human workforce? How?

3.4 Conducting the interviews

Interviewer starts the interview with brief description of the purpose of the interview and self-declaration as the student of College of Management Mahidol University (CMMU). The most effective way to interview is to have interactive conversation. Hence, Face-to-face interview is conducted so that non-verbal message such as emotion and behavior can be captured during interview. Each interview takes approximately 25-30 minutes including introduction, general questions, key questions, and probing questions. Interviewees have the right to ask for anonymity on their responses, if it makes them confident to open up more for deeper information. Next step is to conclude the information from all respondents together and analyze the data by grouping and categorizing into topics for further analysis in conclusion.

3.5 Research Framework

Collected data from both secondary data from literature review and primary data from interview are organized in topics and compared based on the categories and similarities as shown in the research framework in Fig 3.1.

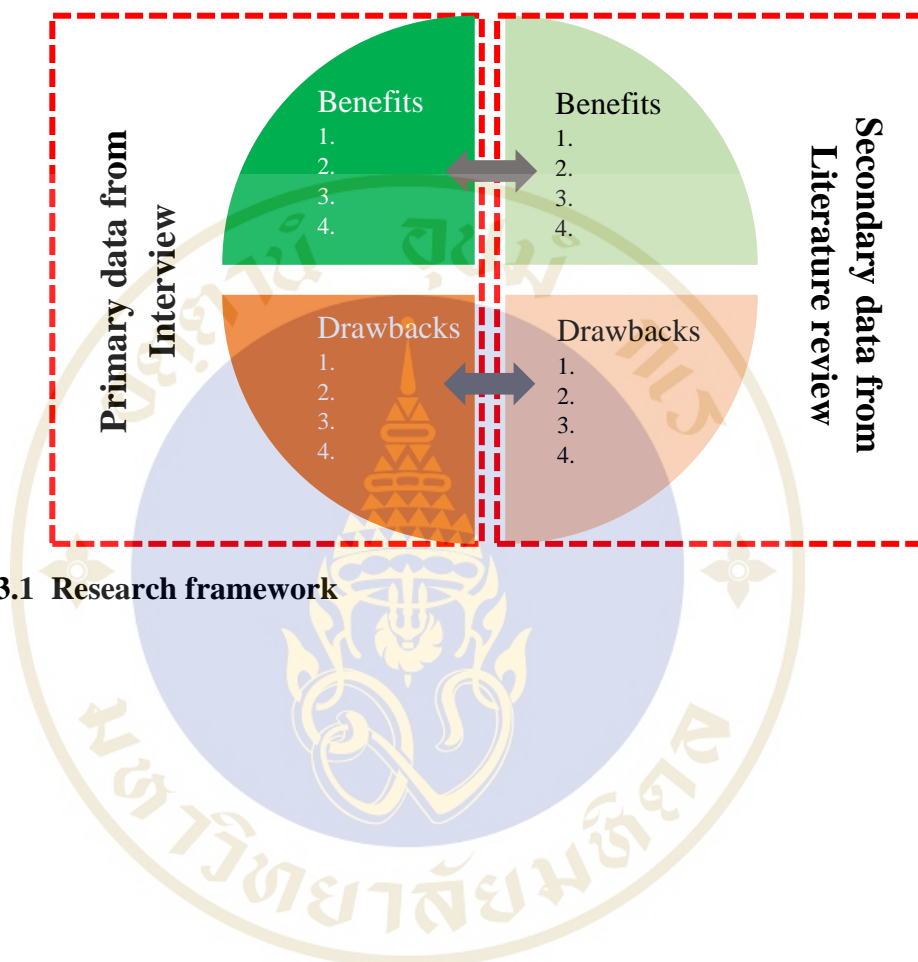


Figure 3.1 Research framework

CHAPTER IV

RESEARCH FINDINGS

According to the research methodology, in-depth interview with probing technique was conducted with seven selected interviewees who are from different companies and work in different positions such as Managing Director, Supply Chain Director, Project Development Manager, Project Manager, Warehouse Managers, and Project Engineer. The companies which interviewees work for are in different field of business such as Chemical, Foods, Beverages, Automation, Retailer, and Building Material and Construction. Since these companies already have automation warehouses, all collected information from the interview can reflect the actual consequences after implementing automation warehouse.

The summary of data findings from collected samples are analyzed and categorized into beneficial and detrimental factors of automation warehouse. Moreover, the problems those companies had after and during implementing automation warehouse is also discussed in this chapter.

4.1 Benefits of automation warehouse

Based on findings from the interviews, there are various beneficial factors that the companies of interviewees get after having automation warehouse. The summary of answers could be organized as follow:

4.1.1 Space Efficiency

All interviewees emphasized that space is the essential resources, especially for warehousing that are stored various kinds of goods. Therefore, minimizing storage space and maximizing the handling of inventory are the ultimate goals for warehousing. All companies of interviewees selected an automated storage and retrieval system (AS/RS) technology as their solution to achieve this goal because

it requires much smaller footprint than conventional warehouse by taking storage upward. Robots in automation warehouse need smaller space than manual forklift trucks when moving around. Furthermore, automation warehouse does not need human to walk inside, so it needs smaller aisles and create more space for storage.

Mr. G revealed that their company invested in the first phase of automation warehouse which situated in the area of 30,000 square meters. It can store 43,000 pallets in AS/RS, 5,000 tons of steel, and 5,000 pallets of ceramic. This automation warehouse can be considered as the best space utilizing distribution center of construction material in Thailand. Comparing to tradition warehouse in the same size, automation warehouse used up 40% less floor space.

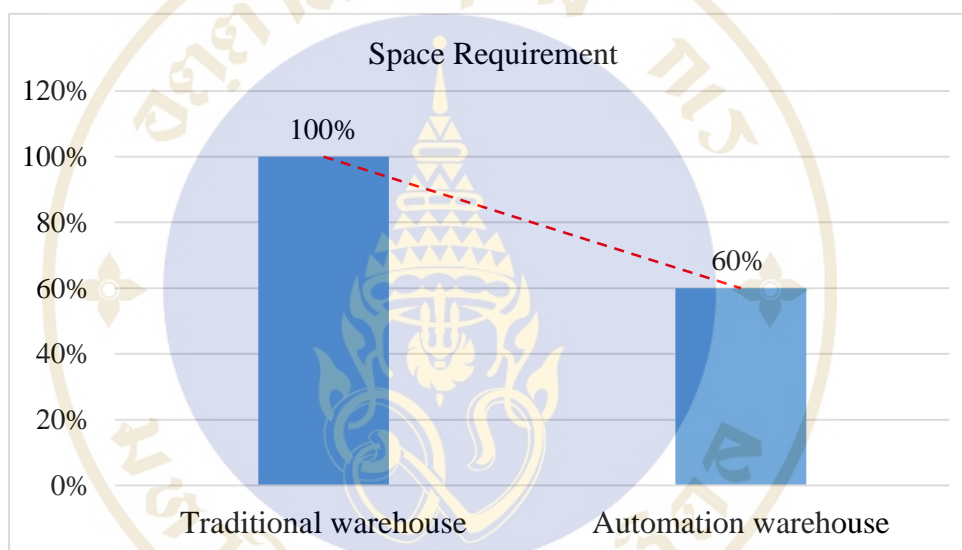


Figure 4.1 Space requirement in different types of warehouse

Mr. B accepted that their company faced the issue of insufficient warehouse space in the past. Space was not effectively utilized because there was the limit to store stack pallets in vertical, and forklift-truck drivers were the people who manage the space themselves without supporting from computerized system. This issue was solved after implementing automation warehouse with an automated storage and retrieval system (AS/RS). The space required by operations is reduced by 20-40 percent; therefore it requires only 60-80 percent of the size of area required by traditional warehouse to store the same amount of goods. Hence, it allows his company to relocate their warehouse to a smaller area with less expensive land cost, and able to store more inventories to support higher demand in market.

4.1.2 Increased speed

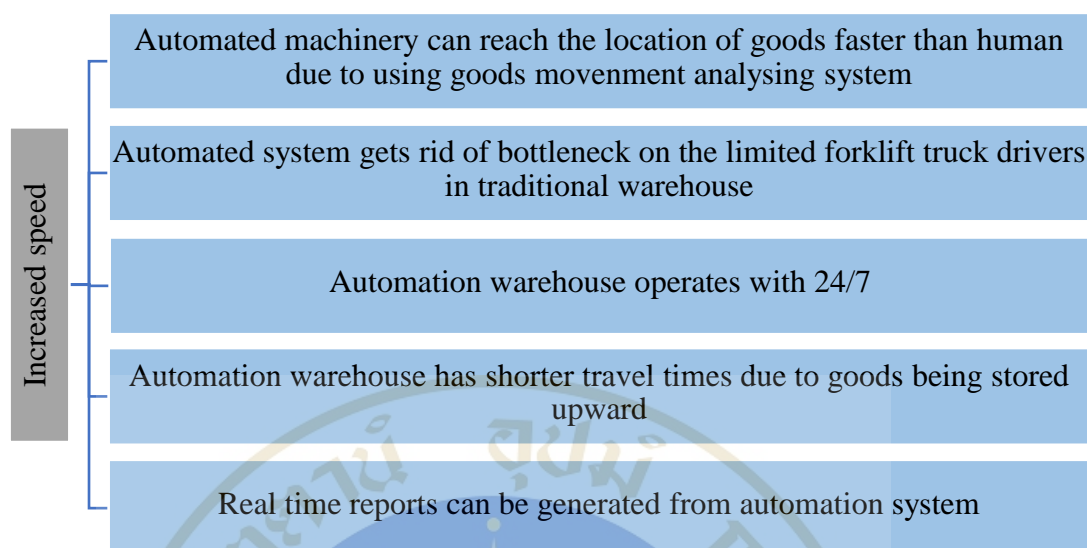


Figure 4.2 The factors that increase the speed of warehousing operation

Mr. C mentioned that “No matter how well forklift trucks drivers can memorize the location of goods and how fast they can reach the goods, human still cannot beat autonomous robot which has every single data embedded in its system”. This is because automated system can instantaneously identify the location of goods, and automatically design the optimum route to reach that location to collect or retrieve goods effectively.

Mr. F shared his experience that, the previous traditional warehouse was often full of products waiting to be shipped to customers. The process of retrieving goods is one of the bottlenecks in the warehousing operation because forklift trucks drivers do not work continuously. The drivers have to take breaks and stop for lunch.

Mr. D also gave more information that forklift truck drivers in his company have to manually check for the location of goods from their spreadsheet or clipboard before retrieving goods. These reasons can cause the delay to deliver goods to customers. On the other hand, automated system in automation warehouse spends less than a second to check the location of goods from their database in WMS, and AS/RS can run for 120 hours non-stop of storing and retrieving goods. Furthermore AS/RS in automation warehouse has goods pallets stored upward in the rack. This can reduce the unnecessary long travel times between locations.

Mr. F revealed his experience in the past that his warehouse staffs needed to do the daily inventory report on spreadsheet or clipboard themselves. This daily report is very time-consuming manual task and it also leaves room for human error. Moreover, the old-fashion method is difficult to monitor constantly in real time. After transforming to automation warehouse, he is satisfied with this new system because Warehouse Management System (WMS) in automation warehouse helps him to monitor and control inventory in real-time. Warehouse manager can easily generate the daily report from centralized computer system which keeps warehouse manager and warehouse personnel connected. The updated information on inventory with all details of input and output goods are recorded accurately. Therefore, this system in automation warehouse significantly reduces the processing time in warehousing operation.

4.1.3 Reduced Energy Consumption

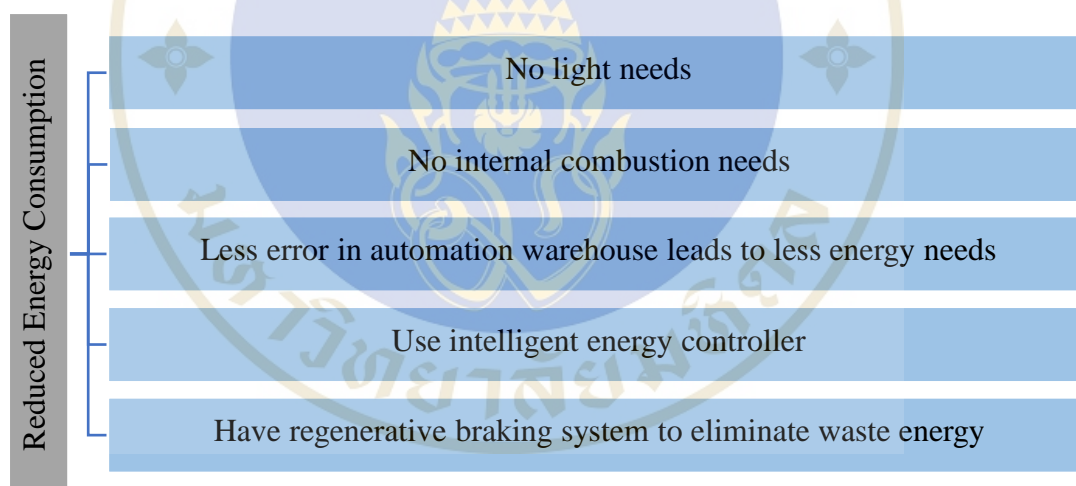


Figure 4.3 The factors that reduce energy consumption in automation warehouse

Due to automation warehouse can run in the dark, Mr. A confirmed that there is no need for the lights in warehouse. Although it needs electrical energy to operate AS/RS or AGV in automation warehouse, Mr. A revealed that there is an intelligent energy controller in his WMS platform to optimize workflow in order to reduce energy consumption, and there is regenerative braking system in automated cranes of AS/RS to further eliminate wasted energy. This regenerative braking system

converts the kinetic energy of a moving automated crane into potential or stored energy to slow the crane down.

Mr. G answered that automation warehouse does not need any internal combustion vehicle such as forklift truck, so carbon consumption in automation warehouse is less than tradition warehouse. In addition, less energy is utilized to facilitate the return of products stored and retrieved in error since automated product selection is more accurate than human selection in traditional warehouse.

4.1.4 Reduced product damage

A foremost concern for warehouse handling a high volume of goods is that products are not damaged in the warehousing process. Mr. D revealed that product damage is a significant problem that companies encountered before transforming their warehouse to be automated. In the traditional warehouse, all products are carried and lifted by manual forklift trucks, and the products often bump into the shelves or fall down to the floor via human error. Even though, plastic protections were used to wrap on every corners of shelves to minimize the damage from crashing, Mr. D confirmed that plenty of damaged pallets and products were still found every month in the past during using non-automated warehouse. Through the smooth, consistent, and controllable handling of products via an automated system, damaged products and waste of pallets can be dramatically reduced.

4.1.5 Reduced labor cost

Mr. C informed that even though, the initial cost of implementing automation warehouse is high, it is much cheaper than paying labor cost in long term. In non-automated warehouse, labor cost is a big part of warehouse operation cost and it can be increased by high employee turnover. The cost of employee turnover is much greater than just filling a vacant position. Not only lose time on recruit and hire new workers, but a company will also lost productivity and lost knowledge because the workers quit without passing information to new comers. Moreover, company will also waste more training expense for new workers, especially forklift truck drivers. All forklift truck drivers must have a valid forklift license and certification to ensure that they fully understand the correct material handling procedures and the importance of

safe operation. Therefore, companies need to be responsible for the cost of training which charge at a high price.

On the other hand, the companies which has automation warehouse will no longer confront high labor cost because the fewer workers are required. For example, forklift truck drivers are replaced by automated storage and retrieval machines which can keep business running all the time without extra charge needs.

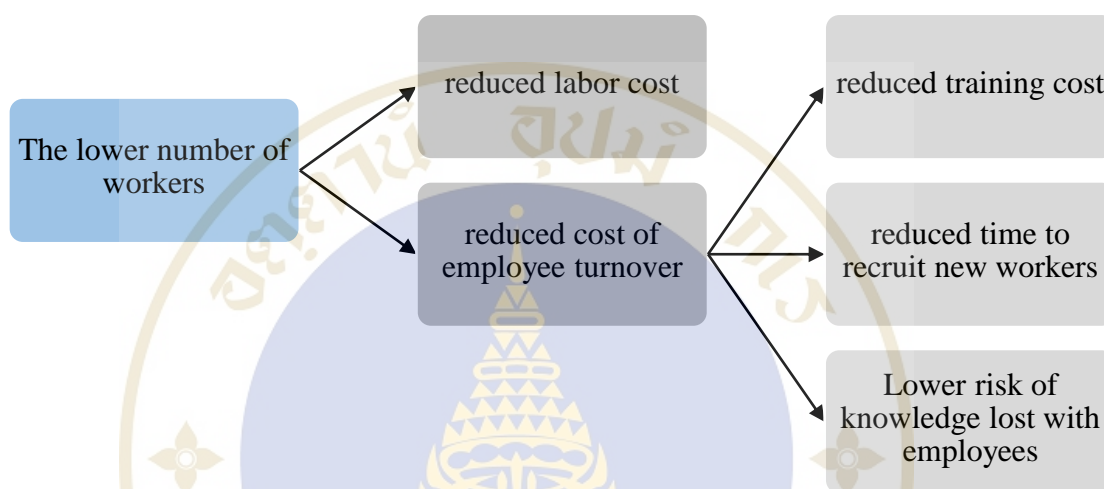


Figure 4.4 The benefits of the lower numbers of workers in warehouse

4.1.6 Lowered injury risk

Due to fewer workers being required in automation warehouse, Mr. F informed that the number of accidents in workplace is dramatically decreased since all repetitive and laborious tasks in automation warehouse are performed by automated system. The automated machines operate within fixed aisles protected by safety fences so workers are less likely to sustain a work related injury. Compared with conventional methods, warehouse heavily depends on manual labors which have potential risks of acute injury or repetitive strain injury because all heavy lifting and repetitive tasks are carried out manually by workers. Hence, automated system in warehouse can considerably eliminate the injury risk and create a much safer working environment.

4.1.7 Increased inventory accuracy

With the integration of automated storage and retrieval machines and inventory control software, Mr. D accepted that inventory counting error, recording error, and wrong storage location were eliminated. These inventory errors usually occur in traditional warehouse and lead to domino effect which creates costly mistake. Therefore switching from manual warehouse to automation warehouse decreases the space for errors significantly. Mr. A gave example of barcoding method in warehouse management system which helps ensure that every item is in its place. Inventory is accurately tracked in real time at all stage of movement to prevent inventory from being lost. Mr. B also gave examples of the intelligent location control which ensures goods are stored in the most appropriate location in automation warehouse, and the stock control system which enables goods to be automatically retrieved on a First In First Out method.

4.1.8 Streamline manufacturing

Mr. E answered that automation warehouse also enhances the efficient flow of materials by integrating the warehouse management system with production material planning system. Once job planning is completed, production planning system will automatically trigger the order for all needed resources such as raw materials, tools, and parts from the connected material ordering system. This integrated system can better streamline operations by removing many layer of processing between operation and supply chain.

4.1.9 Corporate Social Responsibility (CSR)

Mr. E answered that his company has used the benefits of having automation warehouse as a strategic approach to CSR. With the innovative technology, it allows company to operate warehousing production with low carbon footprint, safe workplace, high hygiene and healthy environments. His company calls this CSR initiative as “Greenovation” because innovation in automation warehouse allows them to have environment-friendly process, which both reduces pains and creates values to company’s stakeholders. For example, waste reduction and less carbon emission help reduce pollution in local community. Automation warehouse

also increase employee satisfaction because it improves safety and hygiene in workplace.

4.2 Drawbacks of automation warehouse

On the other hands, interviewees also shared their experiences that there are various essential drawbacks that all companies in Thailand should deeply consider before making investment decision on automation warehouse as follow:

4.2.1 High Upfront cost

Automation warehouse needs higher upfront cost than traditional warehouse, therefore it needs several years to achieve a financial payback or minimal ROI. This is the reason that prevents many companies from implementing automation warehouse and maintains the manual warehouse.

Mr. G revealed that his company invested for 600 million Thai baht on building their new automated distribution center. The size of this automation warehouse is 30,000 square meters with 43,000 pallets of AS/RS. The estimated payback period is around 5 years which was justified by basing the ROI on driving down the warehouse operating costs. Mr. C mentioned that “There can be market risks associated with automation. None of the companies wants to build 500 million Thai Baht automation warehouse, and then find out later that they have too much throughput capability than they actually need because of sales decrease. Hence, big automation warehouse project makes the most sense for companies that are growing”.

Mr. B accepted that ROI is the good factor to use in investment consideration. However his company also conducted an open and honest self-evaluation of readiness before making investment decision. Firstly, his company evaluated how big of the gap between the current IT in company and the implemented technology. Secondly, the in-house skill sets, familiarity with the technology, and aptitude of warehouse staffs were evaluated. Thirdly, He considered how the new automated warehouse technology can work in the same flow with the rest of the supply chain and logistic operations.

4.2.2 Less flexibility

Mr. G answered that the variety of products mix and the changing of consumer demands are the big challenges of automation warehouse designing because automation works perfectly with the stable sizes of carton or pallet. With an automated storage and retrieval system (AS/RS), the rack or the pallet storage space is critical. If the loads are too wide or too tall to store in the existing rack, there will be the flexibility issue. A layer of that stored pallet may have to be cut, which results in smaller storage density. Comparing to manual warehouse, AS/RS is more difficult and expensive to change warehouse workflows and move racking. Therefore, project engineering team must entirely consider all variable factors in order to effectively design an automation warehouse that efficiently handles the current and future inventory.

4.2.3 Worker displacement creates demotivation



Figure 4.5 Worker Displacement creates demotivation

Mr. B answered that a crucial disadvantage associated with automation is the worker displacement. Before implementing automation warehouse, there was a rumor saying that company was going to lay off workers because they will be replaced by automation. This rumor created emotional stress to workers because they were afraid to lose their jobs and have to relocate to other provinces to find new job. Consequently, the fear of losing their jobs demotivated employees from work.

Even though companies laid off some warehouse workers and reduced working hours as they automate a lot of lower-value repetitive tasks in warehouse, Mr.

C confirmed that the demand for creative skill significant increases. Warehouse staffs are assigned to higher-value tasks. The workers with high technical aptitude and up-to-date skill are needed to operate automation warehouse.

Mr. A mentioned that it is widely concerned that automation has driven Thailand to unemployment crisis, however it is important to note that many manual tasks that warehouse workers perform in traditional warehouse are implicit unsafe. In the meantime, automation technologies provide a growing social and economic environment in which workers can enjoy a higher living standard and a better way of working condition.

4.2.4 High maintenance cost and Costly breakdown

Mr. G admitted that there is always a chance of downtime due to equipment malfunction or software glitch while working with automation system, especially, if the issues cannot be solved by engineers on site, specialists from outside need to be called in and it spends long time for waiting because those specialists usually travel from abroad. This means warehouse system will be temporarily shut down and lead to lower customer satisfaction due to delayed delivery.

Mr. B shared his experience that in order to avoid equipment malfunction, daily maintenance is needed as routine by workers. Telescopic forks and cranes in AS/RS system, conveyor belts and other machines need to be monitored and maintained. Companies therefore need to hire maintenance technicians who usually command higher salaries than dockworkers because they have to be fully trained on specific automated system for warehouse. The preventive maintenance is also required from specialists outside which charge company at high price. Moreover, automation warehouse needs the long-term providers of spare parts of hardware and software to eliminate long downtime.

4.2.5 Required new skills and expertise

Due to a huge warehouse transformation to automated system, existing warehouse employees in all interviewed companies need to be adequately trained to safely operate the new automated system. However, it leads to some downtime while trainings take place. Company has high cost of training because it requires the experts

from outside to give trainings. This new skills requirement also leads to turnover of current workers who resist changing or stepping out of their comfort zone. Moreover, company needs to hire new warehouse staffs and new maintenance technicians who have higher skill-set and technical aptitude to operate and maintain the automation system.

4.2.6 Dependence from technology owners

Mr. B answered that implementing AS/RS technology in automation warehouse needs well cooperation between project engineering team in company and specialists from technology providers who are outsourcing vendors. Warehouse layout and technology selections must be precisely designed and chosen because automation warehouse has concrete limitations and cannot respond to unexpected dramatic increase in throughput. Therefore, the design phase is critical and Project Engineers need consultant from technology providers to set clear development plans to deal with the anticipated changes in the future such as stock reduction, stock growth or throughput increase.

Mr. A answered that his company takes more than two years to cooperate with automation technology providers both software and hardware to design layout, build warehouse, and install automated systems and machines such as AS/RS or AGV. Moreover, company requires a long-term dependency with technology providers on particular spare parts which have high switching cost if change to other technology providers.

4.3 Problems when implementing automation warehouse

Beside the mentioned drawbacks, this research also collected other problems that occurred when implementing automation warehouse from interviewees as follow:

4.3.1 Misconception of automated system design

Mr. C shared his experience that his company faced the problem that selected automation technologies did not associated with the goal of project during

implementing the first phase of project. This is because warehouse automation technology was very new for his project engineering team at that time. So they fully relied on their outside consultants from technology owners such as AS/RS technology. They became too wrapped up in technology selections without fully evaluating their needs and ensuring that the selected technologies have the functionality to achieve their goals and not to exaggerate their objective.

4.3.2 Misunderstanding on the use of technologies

Many interviewees revealed that there were misunderstandings from some employees that the implemented automation systems will do all the tasks and all the thinking instead of them. They also mistakenly believed that automation systems will solve all problems for them. The reality is that even the best automated technology still requires human to initiate through specific tasks such as making difficult decisions or solve problems. The automated system cannot work perfectly without being surrounded by well-defined processes and workers with technical skill-sets. This confusion and misunderstanding led to slow operating process in the beginning of the operation.

4.3.3 Unclear assigned team in the early stage

Mr. E revealed that his company failed to decide who will be in the responsible team for automation in the early stage. The person who planned the project, the person who selected automation systems, and the person who is going to use this system are from different divisions in company. But they did not have well communication and cooperation. When something went wrong in the project, all of them hesitated to take responsibility because they were not sure who the right person to take action was.

4.3.4 Lack of workers with higher technical skill-sets

Due to incomprehensive planning on human resource management, Mr. D revealed that training programs to develop skill sets for existing employees were not well prepared in advance. After automation warehouse was ready to be operated, the workers had not been trained to operate the system yet. Consequently, his company

wasted approximately a month without running operation in order to train their workers. Mr. E also revealed that his automation warehouse was not fully used in the first stage due to lacking of new employees with higher technical skills to operate. The exiting employees are not familiar with automation system and do not confident to operate it without supervisor. However, it took around 2 months to recruit and hire new employees, therefore his company waste running cost and lost opportunity in business.

4.3.5 Cyber-attacks

Mr. B shared his experience about one of the distribution company that his company usually deals with. This distribution company also uses automation system in their warehouse. The information in automated system such as inventory, customer information, or customer orders can be monitored via tablets by warehouse manager and employees because it is convenient and provide a quick access to vital information. In 2017, their system was attacked by hackers through the internet that tablet connected with, and the hacker immediately accessed to the confident information of company. This cyber-attack severely interrupted their business and reputation.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

By analyzing collected data from literature reviews and in-depth interviews, the impacts from implementing automation warehouse can be identified and categorized into benefits and drawbacks according to the summary in Table 5.1

Table 5.1 Summary of benefits and Drawbacks of automation warehouse

Benefits of automation warehouse	
Secondary data from Literature Review	Primary data from in-depth interview
<ul style="list-style-type: none"> - Better space utilization - Increase efficiency (speed & quality) - Decrease labor cost - Reduce energy consumption - Increase inventory accuracy - Minimize incidents in warehouse - Minimize the errors in warehousing process - Workers are more confident on their equipment. - Closer monitoring and control - Fewer manual handling activities 	<ul style="list-style-type: none"> - Space Efficiency - Increased speed - Reduced energy consumption - Reduced product damage - Reduced labor cost - Lowered injury risk - Increased inventory accuracy - Streamline manufacturing - Corporate Social Responsibility
Drawbacks of automation warehouse	
Secondary data from Literature Review	Primary data from in-depth interview
<ul style="list-style-type: none"> - Potential risk of costly downtime from system shutdown. - High initial costs - High maintenance cost - The constraint in growth of operator's knowledge and skills due to the excessive automated process. 	<ul style="list-style-type: none"> - High Upfront cost - Less flexibility - Worker displacement creates demotivation - High maintenance cost and Costly breakdown - Required new skills and expertise - Dependence from technology owners

5.2 Recommendations

Even though automation system is a powerful technology that can dramatically boost productivity, efficiency, and profitability in warehouse operation, it is not for every company. If your company decides to move to an automation warehouse, a careful exercise in balancing risks with rewards need to be conducted in order to determine whether automation system would compliment your warehouse operation.

Based on the finding in this research, there are various problems that interviewed companies encountered when implementing automation system such as misconception of automated system design, misunderstanding on the use of technologies, unclear assigned team in the early stage, lack of workers with higher technical skill-sets, and cyber-attacks. This research therefore provides the useful recommendations for company that considering implementing automation warehouse as follow:

5.2.1 Evaluate your company if it is ready for an automation warehouse

Before making investment on automation warehouse, company should conduct an honest self-assessment to evaluate the company's readiness. Company should evaluate how big the gap between the current IT team and the implemented system is, and how does the two align with each other. Employee's aptitude, technical skill sets and familiarity with the automated system should be considered. Company should be able to identify what and where the gaps are, and try to fill in those gaps by either internal improving or hiring third-party consultant to help. Once a company has completed this self-evaluation in both technical and cultural readiness, a company will have a clearer idea of how readiness a company is, and whether a company should implement automation warehouse.

5.2.2 Understand how automation warehouse support company's logistic goal

Since automation warehouse system cannot work independently, company should consider how it will work along with the rest of current logistical operations.

Company needs to be able to identify what company wants to attain from implementing automation warehouse and how it will support supply chain's goals. If the achievement from this project is not associated with the business's goal, it is a waste of time and money to invest in this project.

5.2.3 Assign the responsible person in the early stage

Once company decides to implement automation warehouse system, the project should be assigned to the right responsible team in the early stage. The assigned team needs to involve in every stage such as planning, designing, selecting, building and operating automation warehouse. This is because lacking of staffing plans and clear responsible team can significantly slow down the project and create issues such as non-alignment between designing and selecting technology stages.

5.2.4 Ensure the selected system meet the required performance

In the stage of selecting an automation warehouse technology, company should consider all factors such as trend of throughput, type of stored products, dimension of stored product, required storing environment condition and so on. Company must ensure that the selected technology meets all essential requirements. Project engineering team should run the simulation on that technology before deciding to purchase in order to confirm that the selected automation system can meet all requirements and not overestimate.

5.2.5 Set up the right support infrastructure in place

After conducting self-assessment and assigning the right team on the automation warehouse project, company should establish the strong base to support the implemented automation technology. This phase consists of many activities such as recruiting, training, vendor sourcing, and other activities that company needs to keep the project running smoothly and to be able to start the operation of automation warehouse immediately when the project is completed without any downtime. Moreover, the routine maintenance schedule should be clearly set in advance. Maintenance team should get the intensive training on this new technology to be able to address the issue and troubleshoot problem when the system is down.

5.2.6 Don't overlook the complexities of data migration

For any company that has been using manual or semi-automation warehouse system since the beginning, transforming to automation warehouse will require a data migration such as transferring data from paper or spread sheet to another storage format in computer system. The importance of data migration process should not be underestimated. Company should understand the data migration process, and develop a concrete migration plan with clearly defining the procedure and responsible person in advance.

5.3 Limitations and suggestions for future research

This research benefits a company which is considering implementing an automation warehouse, to deeply understand its benefits and drawbacks which are weighed to determine whether it would compliment the company's supply chain. This research also provides possible problems that company could encounter when transform warehouse to be automated. Company can use these case studies as scenario for setting up mitigation plans to avoid these issues occur.

However, this research has limitation on sampling selection. The findings are only explored from employees in management level of companies. Hence, in order to understand the impacts of automation warehouse in different point of view and more diverse insights, the suggestion for future research is to select staffs or workers who are in operational level in automation warehouse as samples to interview.

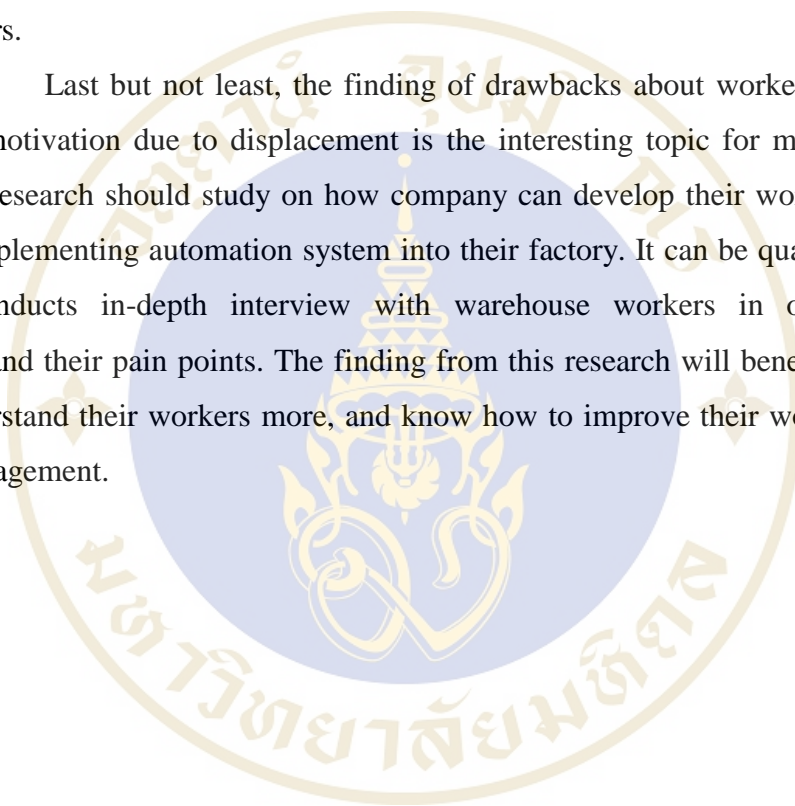
Another limitation of this research is that it purely focuses only companies with automation warehouse in Thailand. Therefore the findings in this research are based on the condition in Thailand such as cost of living, cultures, and knowledge. In order to develop more analysis toward the impacts of implementing automation warehouse, other companies outside Thailand are also needed to be explored regarding this issue as well.

Due to this research focusing only the impacts of automation warehouse and the problems after transformation, another suggestion for future research is to study on the factors using for evaluate the readiness of company before implementing

automation warehouse”, and also study on the criteria for selecting the level of automated system that is suitable for company’s condition.

Moreover, another suggestion for future research is to conduct a quantitative research to evaluate the key factors that influence company to implement automation warehouse. The finding from this research would benefit automation technology providers to know what the essential factors that make company decide to invest in automation warehouse are. These key factors are considered as the gain points from automation warehouse, and can be used as marketing tools for technology providers.

Last but not least, the finding of drawbacks about worker disengagement and demotivation due to displacement is the interesting topic for management area. Future research should study on how company can develop their workers motivation after implementing automation system into their factory. It can be qualitative research that conducts in-depth interview with warehouse workers in order to deeply understand their pain points. The finding from this research will benefit the employer to understand their workers more, and know how to improve their worker motivation and engagement.



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