

## An economic assessment on two investment options for bulk sugar dispensing methods in the warehouse of a seaport firm

Phatchara Sriphrabu<sup>1)</sup>, Chettha Chamnanlor<sup>2)</sup> and Rujapa Nanthapodej\*<sup>3)</sup>

<sup>1)</sup>Department of Nautical Science and Maritime Logistics, Faculty of International Maritime Studies, Kasetsart University, Sriracha Campus, Chonburi 20230, Thailand

<sup>2)</sup>Department of Industrial Engineering, Faculty of Engineering at Sriracha, Kasetsart University, Chonburi 20230, Thailand

<sup>3)</sup>Division of Industrial Engineering and Management, Faculty of Engineering, Nakhon Phanom University, Nakhon Phanom 48000, Thailand

Received 29 December 2022

Revised 28 February 2023

Accepted 3 March 2023

### Abstract

This study compares the economic pros and cons of two bulk sugar dispensing methods for a particular firm, which will be referred in the rest of the paper as “The company”. Bulk sugar dispensing is the process of transporting sugar from a warehouse at any port to berth for loading onto a cargo ship. Currently, the company has already implemented both methods in different warehouses. Type-1 starts with a backhoe scooping sugar into a rotainer, which will be loaded onto a flatbed truck (Toil). Next, the rotainer will be transported from warehouse to a buffer point, where all retainers will be lifted by a reach stacker, and be transferred to a trailer. Then the trailer will carry the rotainer to berth, and unload the sugar onto the cargo ship. With Type-2, sugar will be transferred by a conveyor system and stored in a hopper. Next, sugar will be dispensed from the hopper to a trailer carrying a rotainer, then got transported to berth, and then unloaded onto a cargo ship. We found that the Type-2 took 35.38 minutes less than the Type-1 on average, while the Type-2 has a higher investment about 72 million baht. In our economic study, we found that labor cost increases by 5 % per year, the net present value (NPV) will be 19,280,248.69 baht, the internal rate of return (IRR) 27.50 %, the benefit-cost ratio (B/C) 4.85, and the payback period (PB) 6 years 1 month. Our economic study results indicate that Type-2 is more beneficial for the firm to invest.

**Keywords:** Bulk sugar dispensing, Engineering economy, Rotainer, Warehouse

### 1. Introduction

Sugar is a plant-based sweetener, with 85% of total sugar produced from sugar cane. Sugar can be consumed directly or as a flavoring agent in various industries including beverages, confectionery, bakery products,...etc. Global sugar production is approximately 179.7 million tons (raw sugar), while the world sugar trade volume is remained at 56 million tons. Traded sugar volume accounts for 31.2% of global sugar production. Thailand is regarded as the world's major sugar producer and exporter with the second share of sugar exports in the world market after Brazil [1]. Annually, sugar industry generates a lot of national income from exports. In 2021, out of 66.7 million tons of sugarcane, Thailand was able to produce 7.6 million tons of sugar. 2.6 million tons of the production was allocated for domestic consumption while 5 million tons was exported [2].

The majority of raw sugar exports are transported by ship with bulk dispensing method. This dispensing method requires massive amounts of sugar to be transported to a warehouse since the sugar is transported with large cargo ships. In addition for transportation, sugar is poured into a barge without a cargo container. These requirements creates a financial trade-offs on the process steps in terms of capital investment and operational cash flow. In addition to CapEx, competition in port and shipping industries, especially services require us to consider demand dynamics as well. Therefore, to satisfy customers in this industry, the main goal is to reduce the time the merchant ships have to stay in port as well as the expenses incurred in the process of loading and unloading goods from the warehouse to the ship. If the company can reduce time and expenses, the company will have more profits given the cost of goods sold are same. One way to reduce the length of ship's docking period is to reduce time to unload the cargo to the ship [3].

The company in this case study operates as a port service provider for exports and imports operations as well as container, yard, and warehouse operations. The line of items that company operates are containers, chopped wood, steel coils and sugar, with 30, 15, 15 and 40 percent volume distribution, respectively. This can be seen that sugar products have the highest proportion of company services. The Company has an inbound volume of approximately 950,000 tons of sugar and an outbound volume of approximately 770,000 tons of sugar annually. Among the total outbound sugar volume, the bulk sugar dispensing is about 530,000 tons or 68.83%. The company owns 10 warehouses for storing bulk sugar dispensing. At each facility, the retainers are used as a sugar container for loading and unloading. The structure of the rotainer is similar to an open top container where a lifting device can directly grab and rotate the product from the container. In addition, the company is operating at one of the four major ports in Thailand that export sugar to foreign countries. Therefore, in this case study we focus on sugar as the main product of the company.

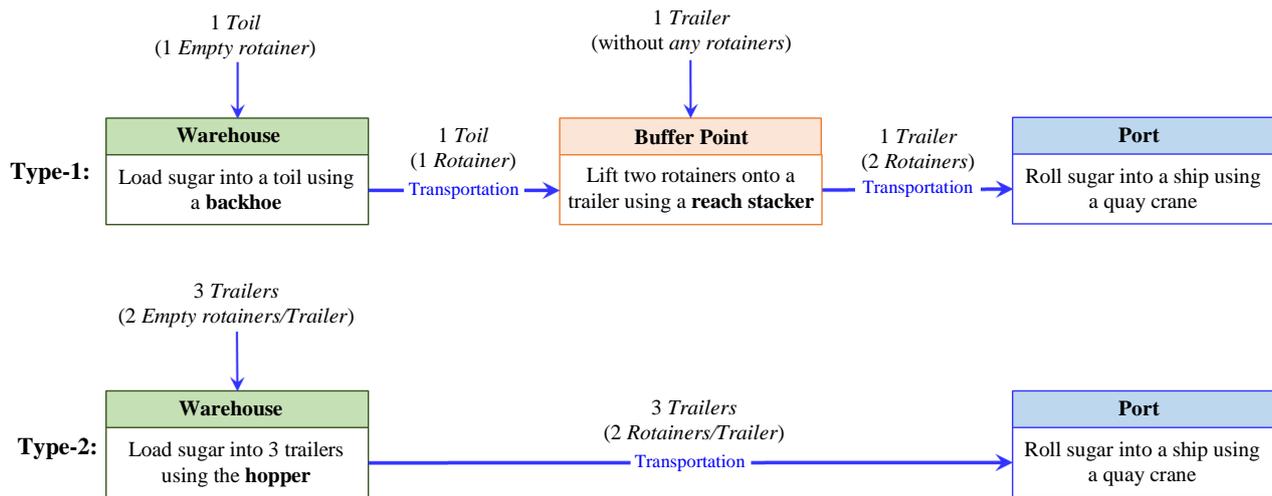
\*Corresponding author.

Email address: nanruja@npu.ac.th

doi: 10.14456/easr.2023.13

The transportation process of bulk sugar dispensing for exports by ship can be divided into 3 main parts: (1) Receiving sugar from manufacturers (2) Depositing sugar for storage in a warehouse (3) Dispatching sugar for loading and unloading into cargo ships. The process of distributing sugar must work within the specified time window by the shipping line. Since the operations time affects the length of time the merchant ships stay in the port, operations require coordination of many departments at warehouses, transport vehicles, ports and ships to sustain the processes are accurate and conducted within the specified time window.

There are two unique bulk sugar dispensing distribution methods analyzed in this case: Type 1 called Buffer and Type 2 called Hopper. Type 1, the distributing sugar process use a backhoe to scoop raw sugar that is piled up in the warehouse into a rotainer, which is loaded on a ten-wheeled truck (as a toil). The truck then takes the rotainer to a buffer point where the retainers are gathered and wait for being transferred to a trailer. In this method, a trailer is used instead of directly loading the rotainer on to a truck since the truck can transport only one rotainer from the warehouse, while the trailer can transport two retainers from the buffer point to the port. Type 2, sugar distributing process uses a conveyor system to transport the sugar to the hopper, which can distribute the sugar directly from the warehouse to the trailer without using trucks to transport retainers or trailers, hence no buffer points is needed. This type 2 method can distribute sugar up to 6 retainers at a time, but it requires additional investment in installing tools and equipment (as shown in Figure 1).



**Figure 1** Work Flow Diagram

From the above information, the two methods of bulk sugar dispensing have different procedures which affects the cost and time of operation. Therefore, this study aims to compare the advantages and disadvantages of both methods of bulk sugar dispensing and analyze investment feasibility using engineering economics principles to determine the worthiness of the decision to change the distribution model of bulk sugar dispensing.

## 2. Theoretical and literature review

The economic assessment on investment is part of a project feasibility study to ensure that the selected project is feasible and offers a return on investment within the available budget and time constraints. Therefore, a project feasibility study is necessary to analyze the project in different areas, including the market, technical, administrative, financial and economic analyses. However, in a particular study, feasibility of a project may focus on specific areas to analyze. Depending on the conditions of the companies, such as a business planning to expand by adding new machines or modifying tools and equipment to increase production capacity. Then the feasibility analysis can be done by only studying the specific technical and financial aspects. In this study, we focused on studying the feasibility of investing by using engineering economic principles to consider the worthiness of the decision to change the method of bulk sugar dispensing distribution for the company.

### 2.1 Financial and economic analysis

Feasibility analysis in project financial and economics in order to make appropriate and effective investment decision that requires financial tools to assist in the analysis includes:

Payback Period (PB) refers to the period of investment in which net cash inflows from the project are exactly same as net cash outflows. In other words, the investment has no profit and no loss. The payback period is a simple and straightforward tool for assessing the feasibility of an investment. However, the payback period calculation has a weakness that it does not take the time value of money into account and does not pay attention to the cash flow received after the payback period. This can cause the wrong investment project decision. Therefore, in some cases, the problem may be solved by discounting the cash flow at the market discount rate, which reflects the value of money over time period, and then calculate the payback period also known as Discounted Payback Period (DPB) [4].

Net Present Value (NPV) refers to the difference between the total present value of net cash inflows over the project life and the present value of investments. By using the market discount rate to adjust the value of future cash flows that occur in each future period to the present. The net present value method, or NPV, is a tool for assessing the feasibility of cash investment over the gain of an investment. Because the value of money over time is taken into consideration, NPV helps to understand the cash flow that occurs throughout the project life.

Internal Rate of Return (IRR) refers to a discounted return rate that makes the present value of net cash inflows over a project's life exactly equal to net investment cash. IRR is commonly used as a criterion for project evaluation widespread. Because this IRR method

is expressed as a percentage of return. This makes it easy to understand and easy to compare between different projects as an alternative to the existing investments at that time period [5].

Benefit-Cost Ratio (B/C ratio) refers to the ratio between the net present value of the cash flow received over the project life and the initial investment for that project. It is a comparison between the return in the form of a future income stream over the project life that has been adjusted to present value and the initial investment in the project that is currently incurred [6].

## 2.2 Literature review

The maritime industry is a business related to the transportation of goods by sea, which is moving through ports, warehouses, container yards, cargo ships, cargo trucks, ...etc. The expansion in these businesses requires a high capital expenditure investment. Therefore, it is necessary to study the feasibility of investment first to reduce the risk. Feasibility study of operating a container storage yard in the area Laem Chabang Port Chonburi found that the Pinthong industrial area was the most suitable. By using the Analytical Hierarchical Process (AHP) method found that this project needs 24 employees. In financial assessment, it was found that NPV 114,374,331 baht, IRR 66.5%, the benefit-investment ratio was 1.85, PB 2 years and 4 months. A 15% decrease will increase operating costs 15%. NPV will be 75,038,183 baht, IRR will be 51.87%, and returns can be reduced by 47%. Resulting NPV and IRR denote in favorable investment directions and denote that this project has a low risk [7] Including a feasibility study of the boat and towing business, the goods that are transported are export goods, that need to be loaded onto a cargo ship which is docked at sea. or, on the contrary, goods that are unloaded from a cargo ship for import into the country. Most of the products are in bulk, such as mineral fuels (coal) and cement. This study found that the investment required 19,553,549 baht, which yielded NPV 3,825,339 baht, IRR 24.33%, B/C Ratio 1.53 times and PB 7 years and 7 months, showing that the project was feasible to invest [8].

Besides, increasing the size and capacity of ICD (Inland Container Depot) was studied in one case study company in the Eastern Seaboard to accommodate the rapidly growing demand for port shipments following high expansion of this industry. This research presented a one-stop-service ICD with a feasibility study of 10-year project. The results showed IRR 28.56% (more than 18%), NPV 294,438,604 USD (greater than 0), PB 8 years (less than the project time), the minimum debt service coverage ratio (DSCR) 2.12 (at least 1 is acceptable). Therefore, it can be concluded that the one-stop-service ICD project is feasible and acceptable [9]. In addition, there is a feasibility study on the construction investment of a truck parking lot. Which can be considered a business related to marine transportation. This study was a project that the company wants to invest in building more truck parking lots in order to reduce wasted costs such as fuel costs, maintenance costs and overtime costs. The results showed that the project was worth the investment with NPV 2,091,589 baht, IRR 10.13%, the adjusted rate of return 9.15%, and the profitability index (PI) 1.17 [10].

However, not only the business related to the goods transportation by sea but also other businesses and industries have been studied in project feasibility, such as the Saen Saep Canal Maritime Project, an extension from Sribunruang temple to the Minburi district office. The financial study found that NPV 2,325,240,000 baht, the return on equity ratio (ROE) 5.46 and IRR 38.22%. The economic study found that NPV 7,754,550,000 baht, ROE 17.99 and IRR 149.75%. The sensitivity analysis found that regardless of the 20% increase in costs, the project still had a positive return. ROE and IRR on financial are less important than economics because the project was more socially cost-effective than financial viability where the focus was on increasing the social welfare [11]. Apart from that, the feasibility of infrastructure projects has been essentially studied, such as in a case study on a part of the Sumatran toll road network located on the island of Sumatra. Estimating construction costs and traffic volume was employed in financial analysis. Since the project was still under construction, the preliminary findings revealed an insatiability of NPV RP 3,091,208,000,000, IRR 12.50%, and BCR value less than 1 [12].

A feasibility study on an energy power plant was also conducted. In order to increase the potential of renewable energy resources at the Nam Pung hydropower plant, a very low head (VLH) hydro turbine downstream was installed and investigated. The selected hydro turbine in the project exhibited 84.61 kW of power output with 86.4% efficiency. The investment analysis of two cases, actual and general prices, found the benefit of the project with a payback period of 0.83 years for the actual price and 0.88 years for the general price, annual interest rates of 6.75% for the actual price and 12.625% for the general price, and an expected project lifespan of 25 years [13]. Regarding solar energy in Iraq, a solar photovoltaic microgrid system was investigated to serve the load during power outages and blackouts and to supply electricity to a household case study in Baghdad. The techno-economic and environmental feasibility study demonstrated that the most economical configuration was attained by allowing the grid to charge the batteries at all rates, with a net present cost (NPC) of \$29,713, the highest renewable fraction revealed at 64.9%, and the lowest CO<sub>2</sub> emissions at 4533 kg/year [14].

Moreover, the expansion decisions as modifying tools or equipment is evaluated more often though economic principles, such as an analysis of the economic viability of investing in replacing an air conditioner that has been used for more than 10 years in the center of the Rajamangala University of Technology Isan indicated advantages and disadvantages. Comparison of the energy efficiency and the payback rate between 2 new air conditioner brands, A and B, found that the replacement of a new air conditioner, brand B, has more energy saving rate than brand A, about 22.74 kW per year with PB 2.4 years [15]. There was a recent feasibility study on engineering economics for investing into car manufacturing with front grip assembly. By comparing first, purchasing cost from the Republic of India against the investment cost of producing in Thailand, and Second the cost of hiring manufacturer A and manufacturer B. The project duration was 5 years. The results of the study concluded that the investment in self producing in Thailand had the lowest total cost with NPV 40,250,451 baht. The economic sensitivity analyzing revealed that the amount of production order was more economically sensitive than the fixed cost factor given the cost of raw materials, electricity costs, labor costs, and shipping costs were within the range 50% increased or decreased [16]. In addition, there were some researchers using engineering economics principles to compare three alternatives for increasing tire storage space: option 1 was building more warehouses, option 2 was adding more racks, and option 3 was renting a warehouse. The analysis results showed that adding more racks was the most appropriate method, only 2,650,000 baht using in improvement cost with the highest NPV, IRR, B/C and net profit [17].

Moreover, a feasibility study of investment in a staple food business development in rural areas of the Bojonegoro regency was conducted and analyzed in four points includes trend analysis, aspect of investment, investment possibility, and sensitivity. The study found that economic growth increased by 26.50% per year during 2016-2019, 37.2% of IRR, positive NPV, payback period less than 5 years. The sensitivity analysis results revealed when costs increase. 2.0% and 4.0%, while income declined by 2.0% and 4.0%. In this research, both NPV and IRR illustrated the project feasibility. Besides, the research also had implications for the regional food chains development in terms of domestic food production security [18]. Studying a new merchandise store project feasibility for the PT Persib Bandung Bermartabat football team in Indonesia found that the project was financially feasible since the company will make

a profit and good return. The NPV was positive, and the profitability index (PI) was greater than 1, IRR exceeded the cost of capital, and the discounted payback period will be faster than the estimated time. However, the small change in COGS will greatly affect the profit of this project. Thus, the company should ensure that the Target Market Growth of this project must not be lower than 3.20%; otherwise, this project will not be profitable [19]. Additionally, feasibility study on a new production plant construction of PT. S Steel investigated on marketing, technical, law, environmental as well as financial aspects within the 5-year of the project. The results showed that the construction can be carried out with Rp 487,404,605,133 of NPV ( $NPV > 0$ ), 48.703% of IRR (11% greater than MARR), and 2.34 of PBP [20].

Increasing business competitiveness, Brown sugar supplier CV. DSG applied PRIME analysis to identify opportunities from business strategies, include short-term strategies. (distributor), medium term (factory construction), and long term (cane plantation). The feasibility study and fundraising found that the payback period was 6 years, NPV Rp 891.417.628, IRR 28.94%, ROI 18.35%, ROE 45.88%, BBP 22.60%. These indicated feasibility of DSG's business strategy and completed fundraising [21]. Maximizing business potential, distribution company in Sumatra island Indonesia focused on designing long-term strategies. One determined to meet the demand in Bengkulu area was warehouse location. Considering optimal location and financial feasibility, NPV, Payback Period, and IRR were taken into account as well as P-Median optimization with Mixed Integer Linear Programming. The results showed that the location with the lowest demand weighted distance was located in Kaur Regency. Thus, the company possibly reduce the total transportation cost by this investment [22]. Therefore, from the previous literatures show that feasibility study is one effective tool that helps executives and business owners in decision making before investing or committing to new business expansion. Table 1 summarizes the research background and literature review regarding the feasibility study and economic assessment topic.

**Table 1** summary of literature for feasibility study and economic assessment

Authors	Title	Methods	KPIs
Sriprabu P, Chamnanlor C, Kanoguraphan T [7]	Feasibility study for the container yard operations	- AHP - Feasibility Study - Sensitivity Analysis	NPV: THB 114,374,331 IRR: 66.5% B/C ratio: 1.85 PBP: 2 years 4 months
Sriprabu P, Sukkahwan C, Kuntapairoj P, Wiangkhamma K [8]	A feasibility study of barge and tugboat service in Phra Nakhon Si Ayutthaya Province	- Feasibility Study	NPV: THB 3,825,339 IRR: 24.33% B/C ratio: 1.53 BP: 7 years 7 months
Laptaned U [9]	A feasibility study of developing one-stop-service inland container depot: A case study of Kerry Siam Seaport, Co., Ltd.	- Feasibility Study	NPV: USD 294,438,604 IRR: 28.56% DSCR: 2.12 PBP: 8 years
Camhong S, Thaweewat K, Thaweewat B [10]	a feasibility study of investment on truck yard of AAA transport company limited in Changwat Rayong	- Feasibility Study	NPV: THB 2,091,589 IRR: 10.13% ARR: 9.15% PI: 1.17
Phaisarnthayangkul V [11]	Economic value of Khlong Saen Saeb navigation project from Wat Sriboonruang to Minburi District office	- Feasibility Study - Sensitivity Analysis	NPV: THB 7,754,550,000 IRR: 149.75% Return on equity ratio: 17.99
Wraharjo M, Susanti B, Kadarsa E [12]	Financial feasibility analysis of cost and traffic volume: Case study on toll road investment project	- Financial feasibility	NPV: IDR 3,091,208,000,000 IRR: 12.5% B/C ratio: < 1
Nuantong W, Taechajedcadarungsri S, Khamphool N [13]	Feasibility study of VLH hydro turbine installation at Nam Pung hydropower plant, Thailand	- Feasibility Study	Power output efficiency: 86.4% BP (actual): 0.83 years BP (general): 0.88 years AIR (actual): 6.75% AIR (general): 12.625% Project lifespan: 25 years
Aziz AS, Tajuddin MF, Adzman MR, Mohammed MF, Ramli MA [14]	Feasibility analysis of grid-connected and islanded operation of a solar PV microgrid system: A case study of Iraq	- Feasibility Study - Sustainability Assessment	NPC: USD 29,713 Renewable fraction: 64.9% CO2 emissions: 4533kg/year
Inrawong P, Apichatakul P, Kongnok R, Boon-Earb S [15]	A cost worthiness analysis of changing 10 years used air-conditioner	- Engineering Economic Study	Energy saving rate: 22.74 kW/year BP: 2.4 years
Ngampahuton P, Khemavuk P. [16]	The feasibility study in engineering economic for investment in handle assist part production	- Engineering Economic Study - Sensitivity Analysis	NPV: THB 40,250,451 S: Amount of orders was more sensitive than the fixed cost ( $\pm 50\%$ )
Rattanaboworn S, Phannikul T [17]	Use of engineering economics in increasing storage capability	- Engineering Economic Study	NPV: THB 2,650,000
Sutrisno [18]	The feasibility of staple food business and its implication on regional food supply chain development	- Feasibility Study - Sensitivity Analysis	NPV: IDR 35.554 million IRR: 37.30 B/C ratio: 3.77 S: Operational cost increase and revenue decrease 2-4%
Rahadi RA, Hasibuan MAH, Rahmawati D, Aziz RHA, Damayanti SM, and Witdarmono G [19]	Financial feasibility study for the second merchandise store of PT Persib Bandung Bermartabat	- Financial Feasibility Study - Sensitivity Analysis	Target market growth: > 3.20% IRR: 28% NPV: > 0 S (the smallest): the quantity of accessories S (the largest): cost of goods ( $\pm 20\%$ )
Rahardja AZ, Chumaidiyah E, Tripiawan W [20]	Feasibility analysis on the development of steel sheet zinc plated and galvalum production factory PT.S steel	- Feasibility Study	NPV: IDR 487,404,605,133 IRR: 48.703 PBP: 2.34 years
Ariyani LN, Siahaan UMMP [21]	Maintaining growth and sustainable strategy in brown sugar business, and the investment financing alternative decision (Case Study: CV. Delovry Sukses Gemilang)	- Feasibility Study	NPV: IDR 891.417.628 IRR: 28.94% ROI: 18.35% ROE: 45.88% BBP: 22.60%
Sbastian F, Ridwan AY, Novitasari N [22]	Feasibility analysis of financial aspect in determining optimal last mile warehouse location using P-Median method	- P-Median method - Mixed Integer Linear Programming - Feasibility Study	NPV: IDR 103,665,463.4 IRR: 33.8% PBP: 3.019years
Pornnatwutthikun N, Thaweewat K [23]	A feasibility study of investment on automatic robot arm in final assembly line of aa company limited	- Financial Feasibility Study - Sensitivity Analysis	NPV: THB 4,456,274 IRR: 24.66% MIRR: 16.16 PI: 1.85 PBP: 3.019years S: Operational cost increase $\leq 211.60$ , revenue decrease $\leq 37.84\%$ , investment increase $\leq 84.47\%$

### 3. Methodology

#### 3.1 Research data determination

The data used in this study defined into 2 parts: Part 1, data for advantages and disadvantages of each method in terms of processing times and cost incurred by the bulk sugar dispensing operation; and Part 2, the data for two bulk sugar dispensing methods containing data for the feasibility study of investment and suitability of bulk sugar dispensing methods at consideration.

#### 3.2 Data collection

Primary data is the information obtained directly from the data collection using a timetable to collect bulk sugar dispensing methods, Type 1 and Type 2, processing times. And then, we subtract the time vested on transportation from origin to destination at each stage, where the truck and trailer drives through, results in the difference in time intervals. This time period shows that the longest time taken in the sugar dispensing process. The operation time of trucks and trailers were measured for Type 1. While only trailers used in Type 2 are measured as the operation time. Furthermore, the data were collected through participant observations and in-depth interviews. Sugar warehouse staff and sugar warehouse administrators were interviewed to find the operation details in time limits and cost of bulk sugar dispensing methods, including previously observed problems, obstacles, and perceived qualitative advantages and disadvantages as well.

Secondary data contains a document collection from the company that includes operating procedures and equipment costs. Details on implementation tools for individual bulk sugar dispensing methods as well as additional information from books, websites, previous research papers and related prior studies (thesis).

#### 3.3 Feasibility study

Marketing study aims to perceive the trend of market demand for storage and handling of bulk sugar in the future. This ensures that investments in sugar dispensing will not affect future earnings.

Technical and administrative study aims to understand the operational procedures in terms of time, tools and equipment usage. An expedient information will be applied to estimate the required investment in the bulk sugar dispensing method modification.

Financial and Economics studies are to estimate income and expenses, and to analyze the return and assess whether the investment worth or not. In this study, the wage factor considered to increase by 5% per each year [24].

This study focused on investment feasibility study by applying engineering economic principle for the worthiness consideration of the bulk sugar dispensing method expansion. Moreover, it considered market demand trends as well as technical and administrative aspects in order to address the risks that may arise in the future. However, since Thailand has continuously been the world's major sugar exporter, the bulk sugar dispensing process regarded as an important service, which the case study company operates. As a result, market risk issues such as declining demand are unlikely to affect this project. In addition, the entrepreneur in this project has sufficient experience in this industry's management and operating Type-2 bulk sugar dispensing method. Therefore, the project was then considered a feasible operation in terms of technical and administrative aspects.

#### 3.4 Sensitivity analysis

A tool used to consider the factors, may occur in the project, that affect the risks and uncertainties, including increased costs and reduced revenues. This aims to discover which sensitive factors and which factors should consider reducing risk in the business.

## 4. Results and discussion

#### 4.1 Advantages and disadvantages comparison

The comparative analysis of advantages and disadvantages results of the bulk sugar dispensing methods, Type 1 and Type 2, are shown in Table 2.

**Table 2** The comparison of the bulk sugar dispensing methods, Type 1 and Type 2 results

Methods	Advantages	Disadvantages
Type 1	- Sugar can be dispensed in every warehouse. Since, there is no additional equipment installation requirement	- Redundant loading and unloading - Waiting - Requires both workers vehicles and tools in operation - Requires time to unload the sugar into the rotainer cabinet.
Type 2	- Fast loading sugar into the rotainer - Less operation steps than the buffer	- Requires skilled people to control - High investment

This study found that the average total time for sugar loading and unloading of Type 1 was 93.75 minutes/round and the total operating cost was 2,374.76 baht/hour, which was 11.87 baht/ton. Since, Type 1 can dispense sugar 200 tons/hour, then a trailer has to be used to transport the sugar in about 4 rounds. Type 2 spent an average of 58.37 minutes/round and the total operating cost was 5,866.76 baht/hour. Type 2 can dispense sugar 1,000 tons/hour by using a trailer to transport in 20 rounds, which was 5.87 baht/ton. Details are shown in Table 3 and Table 4 below.

**Table 3** The comparison of the bulk sugar dispensing cost, Type 1 and Type 2 results.

Details	Cost (baht/hr)	
	Type 1	Type 2
Reach Stacker	500.00	500.00
Toil	300.00	-
Trailer	800.00	4,000.00
Backhoe	300.00	-
Forklift	350.00	-
Quay Crane	124.76	124.76
Belt (Electricity Cost)	-	1,242.00

\*Note: Trailer cost was 200 baht per round for transportation, which can load 50 tons of sugar per round.

**Table 4** The economic comparison of the bulk sugar dispensing cost per unit, Type 1 and Type 2 results.

Details	Type 1	Type 2
Total cost (baht/hr)	2,374.76	5866.76
Amount of sugar transfer (ton/hr)	200	1,000
Cost per unit	11.87	5.87

Considering the above data, timing and cost difference occurred in the process of bulk sugar dispensing methods indicated that Type 2 took 35.37 minutes/round which was faster than Type 1, and it costed 6 baht/ton less. Therefore, it was worthwhile to consider the feasibility study for warehouse development investment in Type 1 and Type 2.

#### 4.2 Feasibility study results

The Thai sugar industry in 2022-2023 is expected to increase sugar production to 9-10 million tons, or an increase of about 10% due to weather forecast and the expansion of sugarcane planting areas [1]. Considering the company's existing customer base is actively using company's warehouse services, which is a major sugar exporting group in Thailand, then it is expected, the case study company will not face any marketing problems in the future.

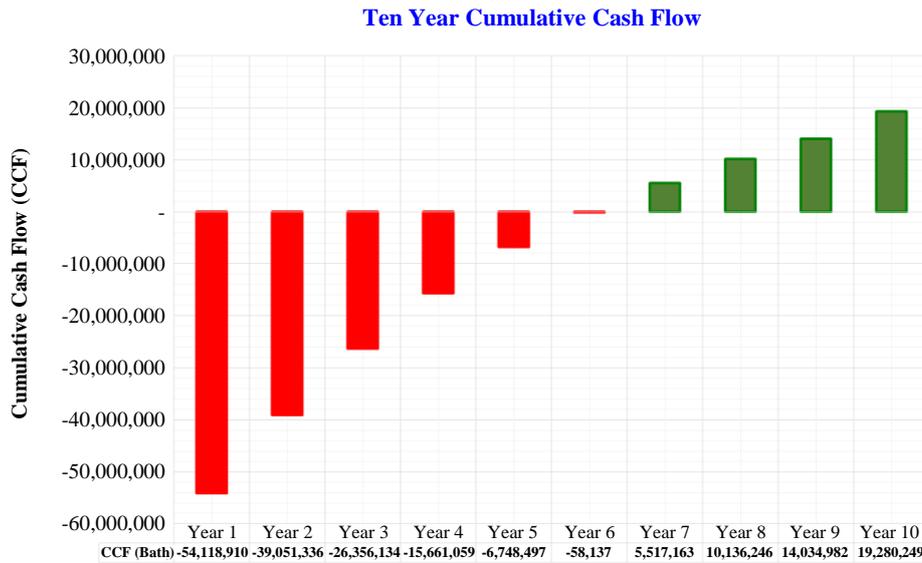
At present, the company has two methods of bulk sugar dispensing, Type 1 and Type 2. There are 1 out of 10 sugar warehouses that operating by Type 2, thus they have experience in doing so. It is expected that there is no obstruction in the technical and administrative aspect of implementation. Financial study with the investment estimation value of 72,000,000 baht is consisting of permanent investment 55,000,000 baht, pre-operating expenses 15,500,000 baht, and net working capital 1,500,000 baht. Our results showed that the net present value (NPV) of the project was 19,280,248.69 baht. Internal rate of return (IRR) was 27.50%, the benefit cost ratio (B/C) was 4.85 times, and the payback period was approximately 6 years and 1 month. Table 5 shows the payback period calculation that the accumulated net present value was equal to the investment value. The following showed payback period calculation result after applying rule of three during the 6-7th year.

$$\begin{aligned} \text{Payback period} &= 6 \text{ years} \left[ \frac{(72,000,000 - 71,941,863)}{(77,517,163 - 71,941,863)} \right] \times 12 \\ &= 6 \text{ years and } 0.13 \text{ months} \end{aligned}$$

**Table 5** The payback period calculation.

Year	Investment (baht)	Net Cash Flow (baht)	Net Present Value (baht)	Accumulated net present value (baht)
0	72,000,000			
1		21,457,308	17,881,090	17,881,090
2		21,697,308	15,067,575	32,948,664
3		21,937,308	12,695,201	45,643,866
4		22,177,308	10,695,075	56,338,941
5		22,177,308	8,912,563	65,251,503
6		19,977,308	6,690,360	71,941,863
7		19,977,308	5,575,300	77,517,163

Figure 2 shows that the cumulative cash flow of the project was negative from the 1<sup>st</sup> to the 6<sup>th</sup> year due to the initial investment burden. However, the positive cash flow appeared at the year 7<sup>th</sup> onwards which corresponds to payback period. Denoting that the project starts to have retained earnings before the project end for 4 years with around 19 million baht accumulated cash flow at the last year of the project.



**Figure 2** Ten Year Cumulative Cash Flow

In addition, applying the sensitivity analysis (cost and revenue) with fluctuated data by changing one factor at a time as shown in Tables 6 and 7. The cost changing over the entire study period still made NPV positive and IRR greater than 20% (MARR). Signifying that the project was feasible for investment. Likewise, the change in income (revenue) reduced by at least 20% (or -20%), it still results in the NPV and IRR values being possible to invest as well. Apparently that the income factor was more sensitive than the cost factor as shown in Figure 3. If the cost remains unchanged but the income decreases, the feasible income decreased should not be over 20.97%.

After performing a sensitivity analysis with simultaneously change in both factors, by given costs increase and income decrease equally, ranging from 5% to 20% as shown in Table 8. The results implied that the project will remains feasible to invest if the cost increase and income decreases up to 18.33% as shown in Figure 4.

**Table 6** Sensitivity analysis on cost fluctuation.

Cost Change in Percent	NPV (Baht)	IRR (%)
-25	22,588,428	28.77
-20	21,926,792	28.51
-15	21,265,156	28.26
-10	20,603,520	28.01
-5	19,941,885	27.75
0	19,280,249	27.50
5	18,618,613	27.24
10	17,956,977	26.99
15	17,295,341	26.74
20	16,633,705	26.48
25	15,972,070	26.23

**Table 7** Sensitivity analysis on revenue fluctuation.

Revenue Change in Percent	NPV (Baht)	IRR (%)
-25	-3,711,899	18.50
-20	886,531	20.36
-15	5,484,960	22.18
-10	10,083,390	23.98
-5	14,681,819	25.75
0	19,280,249	27.50
5	23,878,678	29.23
10	28,477,108	30.94
15	33,075,537	32.63
20	37,673,967	34.31
25	42,272,396	35.97

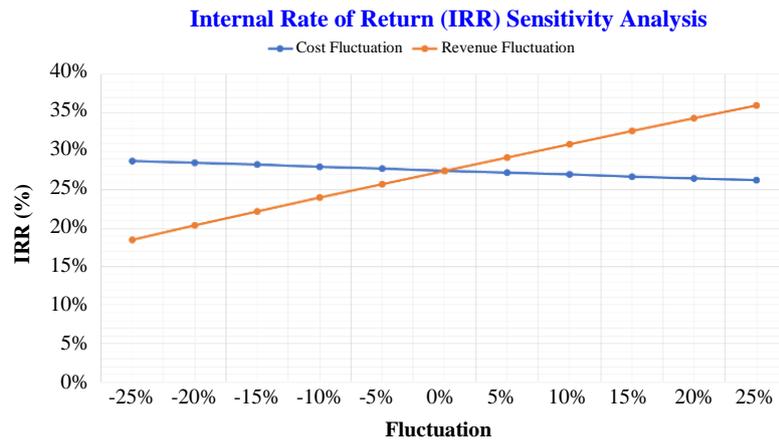


Figure 3 IRR Sensitivity Analysis with Single Factor

Table 8 Sensitivity analysis with two-factor simultaneous.

Cost Increase	Revenue Decrease	NPV	IRR
5%	5%	14,020,183.39	25.49
10%	10%	8,760,118.10	23.46
15%	15%	3,500,052.81	21.40
20%	20%	- 1,760,012.48	19.29

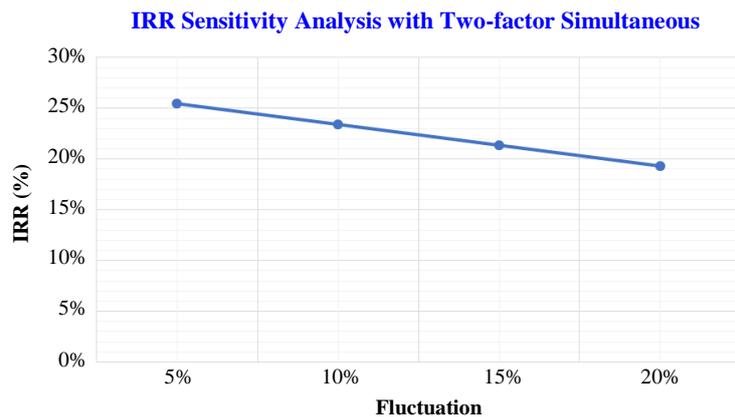


Figure 4 IRR Sensitivity Analysis with Two-factor Simultaneous

5. Summary

The bulk sugar dispensing methods analysis results indicate that the cycle time of Type 2 was approximately 35.376 minutes faster and operating cost was approximately 6 baht/ton lower than Type 1. Since Type 2 can supply sugar directly to the trailer and Type 2 also can dispense more sugar 5 times than Type 1. The income factor is more sensitive than the cost factor.

Table 9 Summary of project feasibility study

KPIs	Value	Criteria	Decision
NPV	19,280,249	> 0	Worth investment
IRR	27.50	> 20	Worth investment
PB	6.03	< 10	Worth investment

The economic cost-effectiveness analysis utilizing net present value, rate of return, and return-to-cost ratio metrics, points out that it is worthwhile to continue with the warehouse investment project of Type 2 as summarized in Table 9. Comparative analysis illustrated corresponding results of our research and Pornnatwutthikun and Thaweewat [23]. The specific feasibility study on technical and financial aspects proceeded by modifying tools and equipment to reduce operating costs. In this research, net present value (NPV), internal rate of return (IRR), and sensitivity analysis factor-by-factor demonstrated changes in revenue were more sensitive than changes in expenses as well. However, in our research we analyzed changes in both factors simultaneously, assuming that there were more than one uncertainty situations occurred concurrently. This is one of the important knowledge areas for dynamic feasibility studies due to the various situations, which are undergoing rapid change in many dimensions nowadays. We also found that with current economic dynamics, the investment will payback approximately within 6 years and 1 month.

The preceding research studies demonstrated that economic decisions are important to the worth of investment analysis and even suitable machinery and equipment modifications for the project. Both new investment projects, a partial investment to improve project efficiency, an expanding production capacity project, etc. Even though there were some difficulties due to the study's limitations, such as some data that could not be disclosed or accessed and some data change due to the study duration, it is still necessary to investigate the physical structure of the warehouse before implementing the hopper dispensing method to other warehouses and goods for investment suitability.

## 6. Acknowledgements

We would like to thank the manager and staff in the sugar warehouse case study company, Ms. Kamonwan Kaewklom, Mr. Thanathon Khiecha-um, and Ms. Namthip Timreuk for cooperating and providing useful information in this study.

## 7. References

- [1] Sowcharoensuk C. Industry outlook 2021-2023: sugar industry [Internet]. Bangkok: Krungsri Research Online Resources; 2021 [cited 2022 Mar 1]. Available from: <https://www.krungsri.com/th/research/industry/industry-outlook/agriculture/sugar/IO/io-sugar-21>. (In Thai)
- [2] Manager Online. Sugar cane industry hits the year '65, productivity - high price [Internet]. 2022 [cited 2022 Mar 1]. Available from: <https://mgronline.com/business/detail/965000002689>. (In Thai)
- [3] Mahpour A, Nazifi A, Mohammadian Amiri A. Development of optimization model to reduce unloading and loading time at berth in container ports. *Iran J Sci Technol Trans Civ Eng*. 2021;45:2831-40.
- [4] Gafli GFM, Daryanto WM. Decision making on project feasibility using capital budgeting model and sensitivity analysis. case study: development solar PV power plant project. *Int J Bus Econ Law*. 2019;19(1):50-8.
- [5] Galli BJ. Effective decision-making in project based environments: a reflection of best practices. *Int J Appl Ind Eng*. 2018;5(1):50-62.
- [6] Ramos DG, Arezes PM, Afonso P. Analysis of the return on preventive measures in musculoskeletal disorders through the benefit–cost ratio: a case study in a hospital. *Int J Ind Ergon*. 2017;60:14-25.
- [7] Sriphrabu P, Chamnanlor C, Kanoguraphan T. Feasibility study for the container yard operations. *RMUTT Glob Bus Econ Rev*. 2016;11(1):17-30. (In Thai)
- [8] Sriphrabu P, Sukkawan C, Kuntapairoj P, Wiangkhamma K. A feasibility study of barge and tugboat service in Phra Nakhon Si Ayutthaya Province. *UBU Eng J*. 2020;13(1):101-13. (In Thai)
- [9] Laptaned U. A feasibility study of developing one-stop-service inland container deport: a case study of Kerry Siam Seaport, Co., Ltd. Proceedings of the Eurasia Business Economics Society; 2010 May 26-28; Istanbul, Turkey. p. 291-301.
- [10] Camhong S, Thaweewat K, Thaweewat B. A feasibility study of investment on truck yard of AAA Transport Company Limited in Changwat Rayong. *Journal of Business Administration Association of Private Higher Education Institutions of Thailand*. 2018;7(2):94-107. (In Thai)
- [11] Phaisarnthayangkul V. Economic value of Khlong Saen Saeb navigation project from Wat Sriboonruang to Minburi District Office. Bangkok: National Institute of Development Administration (NIDA); 2014. (In Thai)
- [12] Wraharjo M, Susanti B, Kadarso E. Financial feasibility analysis of cost and traffic volume: case study on toll road investment project. *Eng Appl Sci Res*. 2022;49(3):308-15.
- [13] Nuantong W, Taechajedcadarungsri S, Khampool N. Feasibility study of VLH hydro turbine installation at Nam Pung hydropower plant, Thailand. *KKU Eng J*. 2016;43(4):210-4.
- [14] Aziz AS, Tajuddin MF, Adzman MR, Mohammed MF, Ramli MA. Feasibility analysis of grid-connected and islanded operation of a solar PV microgrid system: a case study of Iraq. *Energy*. 2020;191:116591.
- [15] Inrawong P, Apichatakul P, Kongnok R, Boon-Earb S. A cost worthiness analysis of changing 10 years used air-conditioner. 7<sup>st</sup> Thailand Renewable Energy for Community Conference; 2014 Nov 12-14; Prachuap Khiri Khan, Thailand. p. 391-6.
- [16] Ngampahuton P, Khemavuk P. The feasibility study in engineering economic for investment in handle assist part production [Internet]. 2022 [cited 2022 Mar 1]. Available from: [https://07540795831794215969.googlegroups.com/attach/66b553b36576aaa5/Paper%20KMUTNB%20Journal,%20Phaisan.pdf?part=4&vt=ANaJVrFMjxdDLFO4PGkox3GY3\\_YqzYndGVgA99jzW8FksxTDDMMVDiT0mQrZkHTt\\_Xf3HobI9eCtrbQNrrB2AIIYR5rIynjZ-N60890Ugv52uEUohaRC1eM](https://07540795831794215969.googlegroups.com/attach/66b553b36576aaa5/Paper%20KMUTNB%20Journal,%20Phaisan.pdf?part=4&vt=ANaJVrFMjxdDLFO4PGkox3GY3_YqzYndGVgA99jzW8FksxTDDMMVDiT0mQrZkHTt_Xf3HobI9eCtrbQNrrB2AIIYR5rIynjZ-N60890Ugv52uEUohaRC1eM). (In Thai)
- [17] Rattanaboworn S, Phannikul T. Use of engineering economics in increasing storage capability. *UBU Eng J*. 2015;8(2):48-61. (In Thai)
- [18] Sutrisno. The feasibility of staple food business and its implication on regional food supply chain development. *J Socioecon Dev*. 2019;2(1):54-60.
- [19] Rahadi RA, Hasibuan MAH, Rahmawati D, Aziz RHA, Damayanti SM, Witdarmono G. Financial feasibility study for the second merchandise store of PT Persib Bandung Bermartabat. *Int J Criminol Sociol*. 2020;9:2031-42.
- [20] Rahardja AZ, Chumaidiyah E, Tripiawan W. Feasibility analysis on the development of steel sheet zinc plated and galvalum production factory PT.S steel. *IOP Conf Ser: Mater Sci Eng*. 2019;528:012031.
- [21] Ariyani LN, Siahaan UMMP. Maintaining growth and sustainable strategy in brown sugar business, and the investment financing alternative decision (case study: CV. Delovry Sukses Gemilang). *Indonesian J Bus Adm*. 2013;2(19):2266-74.
- [22] Sbastian F, Ridwan AY, Novitasari N. Feasibility analysis of financial aspect in determining optimal last mile warehouse location using P-median method. *Adv Eng Res*. 2022;210:332-44.
- [23] Pornnatwutthikun N, Thaweewat K. A feasibility study of investment on automatic robot arm in final assembly line of AA company limited. *GNRU Conference 21; 2021 Jun 9; Kamphaeng Phet, Thailand*. p. 66-76. (In Thai)
- [24] Reuters. Thailand plans to raise minimum wage by 5-8% [Internet]. 2022 [cited 2023 Jan 5]. Available from: <https://www.reuters.com/markets/asia/thailand-plans-raise-minimum-wage-by-5-8-2022-08-08/>.