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Optimization for Main Distribution Materials of Low-Voltage Switching Devices (MDU PHBTR) Allocation for Transportation Cost Efficiency in PT PLN (Persero) using Goal Programming

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Abstrak. Logistics costs for Main Distribution Material (MDU) of Low Voltage Switchgear Devices (PHBTR) increased from IDR 12.5 billion in 2023 to IDR 13.9 billion in 2024, alongside persistent delivery delays beyond the Service Level Agreement (SLA) standards (30 days for Sumatera and Jamali; 45 days for Kalimantan and Sulmapana). In 2023, 172 Detailed Contracts (8.35%) experienced delays, affecting 2,223 units (12.18%), while in 2024, 149 contracts (6.34%) were delayed, impacting 1,448 units (7.17%). The key challenge is developing a distribution allocation model that considers supplier cost differences and Unit Induk demand to improve transportation efficiency and reduce delays. This study applies a quantitative approach using internal secondary data from PT PLN Quarter III 2025, involving 17 suppliers and 22 Unit Induk. The Weighted Goal Programming method is employed to address multi-objective trade-offs between minimizing transportation costs and fulfilling regional demand. Modeling using LINGO software produced an optimal transportation cost of IDR 2,129,998,480 with zero deviation, indicating full demand satisfaction. Compared to the initial allocation cost of IDR 2,704,828,480, the optimized model generated savings of IDR 574,830,000 (approximately 21.25%), particularly for the PL-250-2-LBS, PL-400-2-LBS, and PL-400-4-LBS variants. The proposed model offers a practical decision-making framework to control logistics costs and enhance service reliability..
Keywords: Optimization; Allocation; Supply Chain; Weighted Goal Programming.

INTRODUCTION

Supply Chain Management (SCM) is one of the most crucial aspects of a company's operations, especially in the electrical energy sector, which relies heavily on the timely availability of equipment and materials. PT PLN (Persero), Indonesia's state-owned electricity provider, manages this function through its Supply Chain Management Division. The organizational structure of the SCM Division at PLN Headquarters was established in 2013 through the Decree of the Board of Directors of PT PLN (Persero) Number 527.K/DIR/2013 dated August 20, 2013, concerning amendments to Decree Number 254.K/DIR/2012 regarding the Organizational Structure, Responsibilities, and Main Duties of the Directorate of Strategic Procurement of PT PLN (Persero). The most recent regulatory update was issued through Regulation of the Board of Directors of PT PLN (Persero) Number 0168.P/DIR/2024 dated December 31, 2024, concerning amendments to Regulation Number 0029.P/DIR/2024 on the Organization and Work Procedures of the Directorate of Project Management and New Renewable Energy. This regulation governs organizational alignment, work procedures, and position formations within DIT MPRO, including the structure, duties, and responsibilities of the Supply Chain Management Division (Karunarathna et al. n.d.; Pathan 2023; Setino 2018; Toivola 2025).

The Supply Chain Management Division consists of several sub-divisions, one of which is the Transmission and Distribution Supply Chain Management Division, headed by a Vice President (VP) (Regulation of the Board of Directors of PT PLN Number 0168.P/DIR/2024 concerning Amendments to Regulation Number 0029.P/DIR/2024 on Organizational and Work

Procedures of the Directorate of Project Management and New Renewable Energy, 2024). The main tasks and functions of the VP include evaluating and approving allocation and delivery schedules of transmission and distribution materials to the Main Unit, as well as identifying, evaluating, and optimizing transportation and logistics management using appropriate criteria and parameters, considering company finances and consumer service levels (Brooker et al. 2015; Huang et al. 2025; Laghrissi et al. 2018; Ullah et al. 2019; Zhang et al. 2019). Distribution Materials are categorized into centralized and decentralized procurement processes. One of the centrally procured Distribution Materials is the Low Voltage Connection Device (PHBTR) (Regulation of the Board of Directors of PT PLN Number 0178.P/DIR/2015 concerning Supply Chain Management Policy for Distribution Materials within PT PLN, 2015). This is regulated in Article 3 on Process Segmentation.

A Low Voltage Connection Device (PHBTR) is a system consisting of protective switches (circuit breakers or fuses), conductors, and terminals assembled to distribute low-voltage electrical power from the source to various loads or installations (Aliyari 2017; Manda n.d.; Sunaya et al. 2025; Wahyudi et al. 2024; Wardhany et al. 2025). The Main Distribution Materials for PHBTR (MDU PHBTR) supplied by providers must comply with PT PLN (Persero) Standard (SPLN) No. SPLN D3.016-1:2018 for External Pair Low Voltage Connection Devices, comprising six types ranging from PL-250-2 to PL-1000-6, and with SPLN No. SPLN D3.016-2:2018 for Internal Pair Low Voltage Connection Devices, comprising five types from PD-630-4 to PD2-1600-8. Of the variants specified in these standards, six PHBTR variants are centrally procured, each with different dimensions for each unit (Cappiello et al. 2023; Hiller et al. 2024; Majerczak et al. 2024). The procurement of PHBTR required by PLN Units is conducted centrally, and for the 2025 KHS contract period, multiple suppliers and their respective origins are involved.

Previous research has addressed logistics optimization using linear programming and multi-objective models. Mansour et al. (2021, IEEE Access) demonstrated that optimization algorithms can significantly reduce distribution costs in multi-supplier networks. Similarly, Khan et al. (2022, Computers & Industrial Engineering) applied goal programming to balance cost minimization and service targets in supply chain systems. In the Indonesian context, several Scopus-indexed studies have explored transportation optimization in energy logistics; however, most focus on single-product or single-objective cost-minimization models (Alegoz et al. 2019; Ghayebloo et al. 2015; Utama et al. 2025).

Despite these contributions, limited studies integrate multi-product, multi-supplier allocation with explicit service-level constraints and deviation measurement in state-owned energy distribution systems. Many optimization models prioritize cost reduction without explicitly incorporating SLA compliance as a weighted objective. Consequently, a research gap remains in developing a decision model that simultaneously minimizes transportation costs and ensures fulfillment targets across multiple regional distribution units.

Addressing this gap is urgent because persistent delays in MDU distribution directly affect infrastructure readiness and electricity service reliability. In a highly regulated utility environment, failure to meet SLA commitments may generate financial penalties, reputational risk, and operational bottlenecks. Therefore, a comprehensive allocation framework that balances efficiency and service reliability is essential to enhance organizational performance.

This study introduces a Weighted Goal Programming (WGP) approach to model the

distribution of PHBTR materials across 17 suppliers and 22 Unit Induk Distribusi/Wilayah. Unlike traditional cost-minimization models, WGP allows the assignment of priority weights to multiple objectives and measures deviations from predetermined targets. The novelty of this research lies in integrating multi-product allocation, supplier cost heterogeneity, and zero-deviation service fulfillment constraints within a single optimization framework supported by LINGO software modeling.

The purpose of this research is to develop an optimal allocation model that reduces transportation costs while ensuring complete demand satisfaction without deviation. By incorporating weighted objectives, the model aims to provide a balanced and operationally realistic solution rather than a purely theoretical minimum-cost scenario.

The contribution of this study is both theoretical and practical. Theoretically, it extends the multi-objective optimization literature in energy logistics by operationalizing deviation-based evaluation within a multi-supplier, multi-region distribution network. Practically, it offers PT PLN a structured decision-support tool to evaluate allocation strategies, control logistics expenditures, and mitigate delivery delays.

Ultimately, this research seeks to provide measurable benefits in terms of cost efficiency, service reliability, and strategic logistics planning. By demonstrating potential savings of over 20% compared to existing allocation practices while achieving zero deviation in demand fulfillment, the study provides empirical evidence that optimization-based allocation can significantly enhance performance. The findings are expected to inform policy decisions, improve SLA compliance, and support long-term logistics sustainability in the electricity distribution sector.

METHODS
Types of Research

This study employs a quantitative research method. Quantitative research methods can be interpreted as approaches grounded in the philosophy of positivism. Positivism assumes that reality, phenomena, and observable symptoms can be classified, are relatively fixed, concrete, observable, measurable, and exhibit causal relationships. Quantitative research is conducted on specific populations or representative samples (Sugiyono, 2019). This method analyzes numerical data and applies statistical techniques to test previously formulated hypotheses. Through quantitative data processing, researchers seek to identify patterns, examine relationships between variables, and generalize findings to a broader population based on the sample studied. The use of this method ensures objectivity and precision in measuring and understanding the phenomenon under investigation, while providing a solid foundation for drawing valid and reliable conclusions.

The selection of weights in the Weighted Goal Programming (WGP) model was determined based on managerial priorities and operational risk considerations. The primary objective—minimizing transportation costs—was assigned a high priority weight due to the significant increase in logistics expenditures over the past two years. However, fulfillment of Unit Induk demand was treated as a mandatory constraint with equal or higher priority, since failure to meet regional supply requirements directly affects service reliability and SLA compliance. The assignment of weights was discussed with logistics management to reflect strategic importance, ensuring that cost efficiency does not compromise service-level

performance. This structured weighting approach enables the model to align with both financial efficiency targets and operational continuity requirements.

A brief sensitivity analysis was conducted by varying the relative weights between cost minimization and demand fulfillment objectives within a reasonable managerial range. The results indicate that moderate changes in weight composition did not significantly alter the optimal supplier allocation pattern, although total transportation cost savings varied marginally. When greater emphasis was placed on service reliability, the model slightly increased allocations from geographically closer suppliers to reduce potential delay risks. These findings demonstrate that the solution is relatively stable and robust, confirming the reliability of the WGP model under different managerial priority scenarios.

Identification

Start

Problem Identification
- PHB TR distribution transportation costs are increasing.
- There is still potential for distribution delays (exceeding SLA).
- Allocation decisions are not yet structured based on multi-objective optimization.

Problem Formulation and Objectives
Determine the optimal allocation of PHBTR per Parent Unit for transportation cost efficiency and to reduce potential delays.

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Literature Review
- Supply Chain and Distribution: the relationship between logistics costs and demand fulfillment
- *Linear Programming* (LP): variables, objectives, and constraints
- *Goal Programming* (GP): multi-objectives and deviations (d_n^+ and d_n^-)
- *Weight Goal Programming*: trade-offs through weights (ω_n)

Formulation

Implementation in LINGO and Optimization
- Input sets, parameters, and variables
- Weighted Goal Programming Objectives
- Optimization process and results analysis

Target and Weight Setting
- Cost target: C (initial baseline plan)
- Demand target: K(i,k) must be met (focus on minimizing shortage d_n^-)
- Weight: ω_1 for cost and ω_2 for demand fulfillment

Weighted Goal Programming (WGP) Model Formulation
- Index: i (product), j (supplier), k (unit)
- Decision variable: X(i,j,k) = allocation amount
- Deviation variables: d_n^+ and d_n^- for each target
- Constraint formulation development

Data Collection and Preparation
- Demand: K(i,k) per product-unit
- Supplier capacity: S(i,j) per product-supplier
- Transportation cost: C(i,j,k) per product-supplier-unit

Research Design and Scope
- Internal secondary data
- Entities: 17 suppliers, 22 parent units, 6 PHBTR variants
- Limitations: according to the data period and suppliers/products studied

Interpretation of Results & Discussion

Analysis and Interpretation of Results
- Recap of optimal allocation per supplier–unit–product
- Total costs and efficiency
- Implications: demand is met and potential delays are reduced

Conclusion and Recommendations
Summarize achievements and provide implementation recommendations for the allocation process and delivery schedule evaluation.
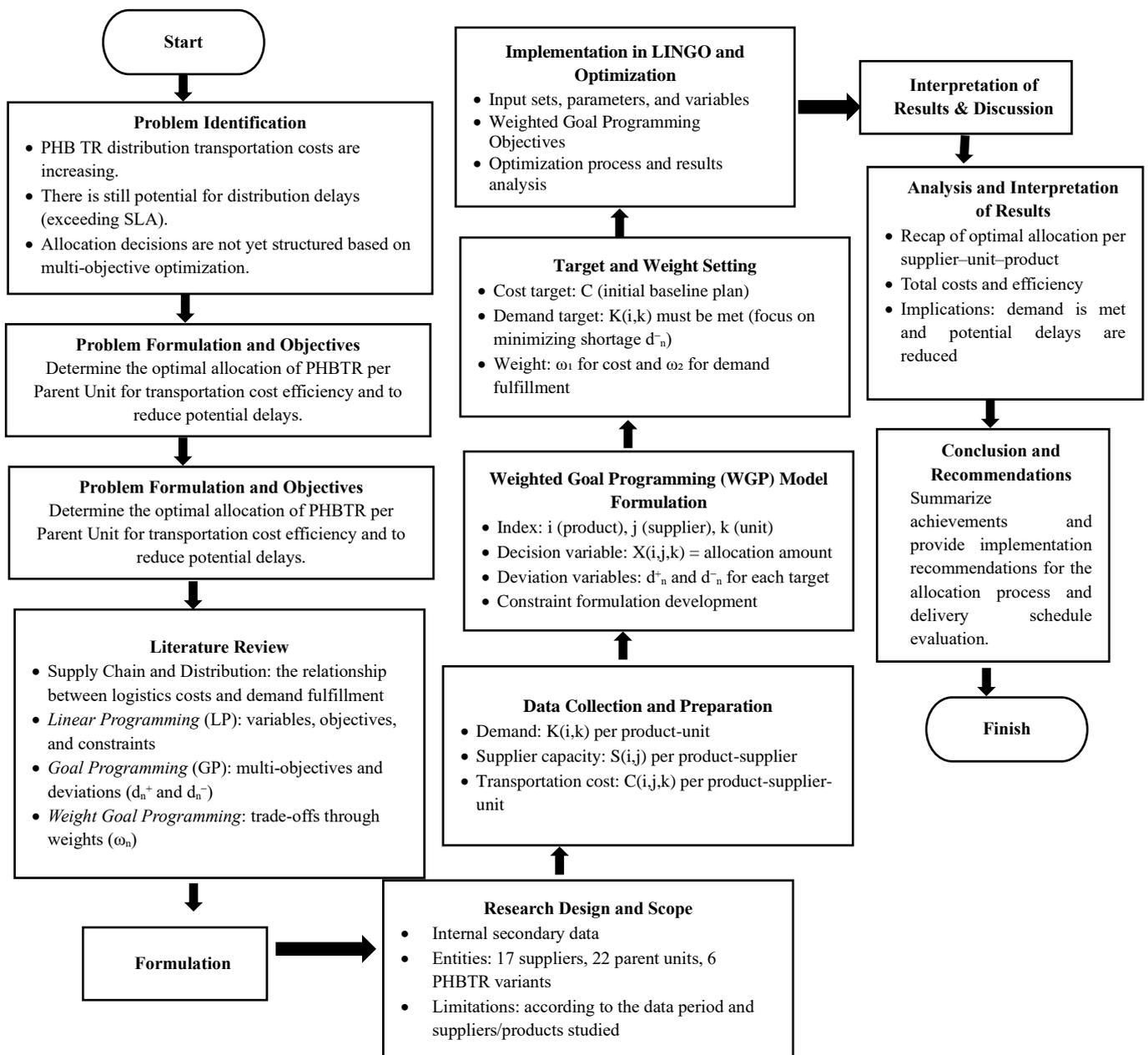
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Figure 2.1 Research Framework
Source: Researcher

This study uses secondary data as the main source of information. Secondary data is data obtained not directly from respondents, but through other parties or documents, such as archives, papers, scientific journals, the internet, and books relevant to research problems (Sugiyono, 2019). The data collected includes transportation costs per unit of PHBTR from the supplier's area to the destination, the allocation of supplier shipments to the Distribution Main Unit/Region, as well as the PHBTR needs of each Distribution Main Unit/Region. The researcher took data on transportation costs per PHBTR unit, delivery allocation, and PHBTR needs for each Distribution Main Unit/Region. The sampling technique uses *purposive sampling*, which is a specific sample selection method that is relevant to the research objectives (Sugiyono, 2019), so that the data obtained is in accordance with the focus of the analysis. The research location is at PT PLN (Persero) with coverage of all PT PLN Main Distribution Units/Regions throughout Indonesia. This approach allows for a comprehensive and representative analysis of PHBTR distribution for the entire company's distribution network.

RESULTS AND DISCUSSION

In this study, the problem that wants to be solved is to minimize transportation costs as the top priority, as well as meet all PHBTR needs in each Distribution/Region Main Unit (UID/UIW) as the second priority. This study uses the Weighted Goal Programming approach to achieve the goals that have been set. This approach is carried out to obtain optimal product allocation while still considering the target of transportation cost efficiency. The material that is the object of this study is one of the Low Voltage Connection Device (PHBTR) products which is widely used by every UID/UIW PT PLN (Persero). The PHBTR used consists of six types, ranging from PL-250-2 to PD-1000-6, each of which has different technical specifications and distribution needs.

The procurement of PHBTR is carried out centrally by PLN, so the distribution process to the Distribution/Regional unit is highly dependent on allocation planning and transportation cost efficiency. This research is limited to the use of data for the third quarter of 2025. Each PHBTR unit has different dimensions. Shipping can be made for multiple units at once, but transportation costs are not determined based on the frequency of delivery, but rather based on the allocation volume and location of the supplier; The more units allocated the higher the cost, and the cost varies for each supplier depending on the location where the supplier is located. The capacity of the means of transportation was not a consideration in this study, while the scope of the study included all PHBTR suppliers.

Problem Identification and Formulation

Problem identification is carried out through *the mapping of the demand-supply* process and evaluation of *baseline* cost performance and meeting needs. The *PHBTR material demand-supply* process is carried out through the S'Mar SCM Marketplace portal as shown in Appendix C, starting from the submission of needs by the PLN Unit, the process of allocating materials by the Central PLN, the issuance of Detailed Contracts/POs, to the delivery and receipt of materials. The increase in the cost of sending PHBTR materials from 2023 to 2024 shows the need to improve the allocation process so that transportation cost efficiency can be increased. Despite the decrease in the percentage of delays, this still has a negative impact on operations and the quality of customer service, and can increase operational costs and affect stakeholder confidence. As such, allocation decisions require a structured, multi-target optimization-based

approach to balance transportation costs and meeting regional needs (as well as supporting the reduction of the risk of delays).

Research Data

In this study, data was used on the needs of each Distribution Main Unit/Region for PHBTR products, production capacity of each supplier, and transportation costs from suppliers to the Main Unit. Requirements data shows the number of product units needed by each Distribution/Region. Production capacity data describes the maximum limit of products that can be provided by each supplier. Meanwhile, transportation cost data contains the amount of shipping costs per unit from each supplier to each region. The three data are compiled in the form of a table and used as a basis for the preparation of a distribution optimization model using LINGO software.

Table 3.1 Each Region's Needs for Every Product

Region	PL-250-2-LBS	PL-250-2-MCCB	PL-400-2-LBS	PL-400-4-LBS	PL-630-4-LBS	PD-1000-6-LBS
Aceh	173	-	121	3	-	-
North Sumatra	160	-	120	50	-	-
Riau and Riau Islands	-	40	130	30	-	-
West Sumatra	18	40	-	-	5	-
Bangka and Belitung	27	-	-	60	20	-
S2JB	113	-	196	176	-	-
Lampung	-	-	35	24	-	-
DKI Jaya	-	-	-	-	6	-
Banten	-	-	12	6	15	-
West Java	105	-	-	-	170	27
Central Java and DIY	-	-	-	-	-	-
East Java	124	-	-	-	-	-
Bali	-	-	135	-	211	-
West Kalimantan	-	-	241	86	-	-
South Kalimantan	73	-	163	-	-	-
Kaltimra	79	-	53	63	-	-
Suluttenggo	78	-	3	9	-	-
Sulselrabar	241	-	206	-	-	-
Nusa Tenggara Barat	-	-	-	-	-	-
Nusa Tenggara Timur	-	-	-	20	20	-
Maluku and North Maluku	-	-	-	1	-	-
PLN Batam	-	-	-	27	6	33
Papua and West Papua	-	-	-	-	-	-
Total	**1.191**	**80**	**1.415**	**555**	**453**	**60**

Source: Researcher

In Table 3.1 above, the distribution of PHBTR needs in the third quarter of 2025 can be seen, it can be seen that the PL-400-2-LBS type has the largest number of demands, namely 1,415 units, followed by PL-250-2-LBS as many as 1,191 units, PL-400-4-LBS as many as 555 units, PL-630-4-LBS as many as 453 units, PL-250-2-MCCB as many as 80 units, and PD-

1000-6-LBS as many as 60 units. The largest demand for the PL-250-2-LBS type is found in the S2JB (113 units), Aceh (173 units), North Sumatra (160 units), and South Sulawesi (241 units) regions. For PL-400-2-LBS, the highest demand came from the West Kalimantan (241 units) and South Sulawesi (206 units) regions. Meanwhile, the PL-400-4-LBS is in high demand in S2JB (176 units) and West Kalimantan (86 units), while the PL-630-4-LBS is highest in Bali (211 units) and West Java (170 units). PD-1000-6-LBS has the largest demand in Batam (33 units). This data shows the variation in the needs of each type of PHBTR in various regions, which is the basis for allocation and transportation planning in the study.

Table 3.2 Production capacity Suppliers

No	Providers	Asal	PL-250-2-LBS	PL-250-2-MCCB	PL-400-2-LBS	PL-400-4-LBS	PL-630-4-LBS	PD-1000-6-LBS
1	AHA	Pekanbaru	193	-	-	-	-	-
2	TS	Jabodetabek	361	-	-	-	-	18
3	RKA	Field	-	8	495	-	-	-
4	CHAPTER	Padang	-	-	-	111	-	-
5	ONLY	Jabodetabek	-	45	-	-	-	30
6	BD	Surabaya	301	-	142	-	-	-
7	PPP	Jabodetabek	72	27	-	55	-	-
8	MUMS	Surabaya	-	-	-	167	-	-
9	SE	Jabodetabek	-	-	283	-	91	-
10	PM	Jabodetabek	-	-	354	-	-	-
11	TME	Padang	-	-	-	-	136	-
12	EIP	Jabodetabek	-	-	-	-	226	-
13	PMT	Jabodetabek	-	-	-	222	-	12
14	PGEI	Field	119	-	142	-	-	-
15	TEA	Jabodetabek	84	-	-	-	-	-
16	GI	Jabodetabek	60	-	-	-	-	-
17	PUSHARLIS	Jabodetabek	119	-	142	-	-	-

Source: Researcher

Based on Table 3.2, data from PHBTR providers shows that the largest material supply for the PL-250-2-LBS type comes from TS with 361 units, followed by BD with 301 units, and AHA with 193 units. These findings indicate the specialization of each provider on a specific type of product, which is an important aspect of allocation and distribution planning. Based on the data on the needs of each region for each type of PHBTR product and the amount of supply from each provider, the problem that needs to be optimized is how to allocate products from suppliers appropriately so that all the needs of each region can be met. This allocation process must also consider transportation costs from providers to regional units, so another goal of this study is to minimize transportation costs in the distribution process, in addition to ensuring that all needs are met. The following is presented data on transportation costs in the allocation of products from each provider to each region from the source of suppliers in Greater Jakarta and its surroundings.

Table 3.3 Transportation Costs for suppliers from Greater Jakarta and surrounding areas

Manufacturer's Origin Location	: Jabodetabek and its surroundings					
Shipping Destination	Transportation and Insurance Costs					
	(Rp/Unit)					
PLN Parent Unit/Sub Holding/Subsidiary	PL-250-2-LBS	PL-250-2-MCCB	PL-400-2-LBS	PL-400-4-LBS	PL-630-4-LBS	PD-1000-6-LBS
Aceh Region	928,800	993,810	998,460	1,300,320	1,500,020	1,569,670
North Sumatra Region	720,160	756,160	757,400	984,630	1,112,630	1,230,330
West Sumatra Region	674,330	721,530	724,900	944,070	1,089,050	1,139,630
Riau Region and Riau Islands	661,610	707,910	711,230	926,250	1,068,500	1,118,110
South Sumatra, Jambi, and Bengkulu Regions	330,800	353,960	355,610	463,120	534,250	559,050
Bangka Belitung Region	725,230	775,990	779,620	1,015,320	1,171,250	1,225,640
Lampung Distribution	432,590	462,860	465,040	605,620	698,620	731,080
DKI Jakarta Distribution	95,420	102,100	102,560	133,580	154,100	161,260
Banten Distribution	152,670	163,350	164,120	213,750	246,560	258,020
West Java Distribution	152,670	163,350	164,120	213,750	246,560	258,020
Distribution in Central Java and DI Yogyakarta	127,220	136,130	136,770	178,120	205,480	215,010
East Java Distribution	330,800	353,960	355,610	463,120	534,250	559,050
Bali Distribution	610,710	653,460	656,520	855,000	986,320	1,032,110
West Kalimantan Region	699,780	748,760	752,270	979,690	1,130,150	1,182,630
South Kalimantan and Central Kalimantan Region	636,160	680,690	683,880	890,630	1,027,410	1,075,120
East Kalimantan and North Kalimantan Regions	954,250	1,021,040	1,025,820	1,335,940	1,541,110	1,612,690
North Sulawesi, Gorontalo, and Central Sulawesi Regions	1,208,710	1,293,330	1,299,370	1,692,200	1,952,080	2,042,740
South Sulawesi, Southeast Sulawesi, and West Sulawesi Regions	763,400	816,830	820,650	1,068,750	1,232,880	1,290,150
West Nusa Tenggara Region	922,430	987,000	991,620	1,291,410	1,489,740	1,558,920
East Nusa Tenggara Region	890,630	952,970	957,440	1,246,890	1,438,380	1,505,170
Maluku and North Maluku Regions	1,526,800	1,633,670	1,641,310	2,137,520	2,465,780	2,580,300
Papua and West Papua Region	1,717,650	1,837,890	1,846,470	2,404,710	2,774,010	2,902,840
PLN Batam	661,610	707,910	711,230	926,250	1,068,500	1,118,110

Source: Researcher

As for transportation costs and insurance for various variants of PHBTR from Suppliers from Surabaya and its surroundings, as follows:

Table 3.4 Transportation Costs for suppliers from Surabaya

Manufacturer's Origin Location	: Surabaya and its surroundings					
Shipping Destination	**Transportation and Insurance Costs**					
	(Rp/Unit)					
PLN Parent Unit/Sub Holding/Subsidiary	**PL-250-2-LBS**	**PL-250-2-MCCB**	**PL-400-2-LBS**	**PL-400-4-LBS**	**PL-630-4-LBS**	**PD-1000-6-LBS**
Aceh Region	1,173,510	1,255,650	1,261,520	1,642,910	1,895,220	1,983,240
North Sumatra Region	731,280	767,840	769,080	999,800	1,129,780	1,248,860
West Sumatra Region	856,040	920,280	920,280	1,210,560	1,396,480	1,461,330
Riau Region and Riau Islands	741,160	793,040	796,750	1,037,620	1,196,980	1,252,570
South Sumatra, Jambi, and Bengkulu Regions	617,630	660,860	663,960	864,690	997,480	1,043,800
Bangka Belitung Region	1,235,280	1,321,740	1,327,920	1,729,380	1,994,970	2,087,610
Lampung Distribution	419,990	449,390	451,480	587,980	678,290	709,780
DKI Jakarta Distribution	330,800	353,960	355,610	463,120	534,250	559,050
Banten Distribution	333,510	356,870	358,530	466,930	538,630	563,650
West Java Distribution	391,080	418,450	420,420	547,510	631,600	660,920
Distribution in Central Java and DI Yogyakarta	333,510	356,870	358,530	466,930	538,630	563,650
East Java Distribution	123,510	132,160	132,780	172,930	199,490	208,750
Bali Distribution	345,870	370,080	371,810	484,220	558,580	584,530
West Kalimantan Region	741,160	793,040	796,750	1,037,620	1,196,980	1,252,570
South Kalimantan and Central Kalimantan Region	494,100	528,690	531,160	691,750	797,980	835,040
East Kalimantan and North Kalimantan Regions	494,100	528,690	531,160	691,750	797,980	835,040
North Sulawesi, Gorontalo, and Central Sulawesi Regions	988,220	1,057,390	1,062,330	1,383,510	1,595,970	1,670,090
South Sulawesi, Southeast Sulawesi, and West Sulawesi Regions	432,340	462,600	464,760	605,270	698,240	730,660
West Nusa Tenggara Region	432,340	462,600	464,760	605,270	698,240	730,660
East Nusa Tenggara Region	679,390	726,950	730,350	951,160	1,097,220	1,148,180
Maluku and North Maluku Regions	1,235,280	1,321,740	1,327,920	1,729,380	1,994,970	2,087,610
Papua and West Papua Region	1,482,320	1,586,090	1,593,510	2,075,260	2,393,970	2,505,140
PLN Batam	926,450	991,300	995,930	1,297,040	1,496,220	1,565,710

Source: Researcher

For Supplier sources from Padang and its surroundings, there are transportation costs and insurance for various variants of PHBTR to all Main Units, as follows:

Table 3.5 Transportation Costs for suppliers from Padang and surrounding areas

Manufacturer's Origin Location	: Padang and its surroundings					
Shipping Destination	**Transportation and Insurance Costs**					
	(Rp/Unit)					
PLN Parent Unit/Sub Holding/Subsidiary	**PL-250-2-LBS**	**PL-250-2-MCCB**	**PL-400-2-LBS**	**PL-400-4-LBS**	**PL-630-4-LBS**	**PD-1000-6-LBS**
Aceh Region	439,750	471,860	471,860	704,100	762,160	856,040
North Sumatra Region	265,570	284,620	284,620	387,720	404,530	452,720
West Sumatra Region	43,230	45,700	45,700	67,930	80,280	90,170
Riau Region and Riau Islands	140,820	150,700	150,700	245,810	258,160	289,050
South Sumatra, Jambi, and Bengkulu Regions	234,700	251,990	251,990	398,980	410,100	460,750
Bangka Belitung Region	604,040	648,520	648,520	844,920	973,390	1,093,220
Lampung Distribution	292,750	313,750	313,750	492,860	503,980	565,750
DKI Jakarta Distribution	674,330	721,530	724,900	944,070	1,089,050	1,139,630
Banten Distribution	469,400	503,980	503,980	791,810	938,800	1,053,690
West Java Distribution	673,220	723,870	723,870	1,078,390	1,255,030	1,409,450
Distribution in Central Java and DI Yogyakarta	674,450	725,100	725,100	1,082,100	1,250,100	1,404,510
East Java Distribution	856,040	920,280	920,280	1,210,560	1,396,480	1,461,330
Bali Distribution	1,079,630	1,079,630	1,079,630	1,079,630	1,079,630	1,079,630
West Kalimantan Region	1,163,620	1,250,100	1,250,100	1,752,860	2,032,030	2,282,790
South Kalimantan and Central Kalimantan Region	1,103,100	1,184,630	1,184,630	1,666,390	1,935,670	2,174,090
East Kalimantan and North Kalimantan Regions	1,405,740	1,510,740	1,510,740	2,090,090	2,422,380	2,722,550
North Sulawesi, Gorontalo, and Central Sulawesi Regions	1,646,620	1,770,150	1,770,150	2,428,550	2,813,960	3,161,070
South Sulawesi, Southeast Sulawesi, and West Sulawesi Regions	1,222,920	1,314,330	1,314,330	1,836,860	2,129,620	2,392,730
West Nusa Tenggara Region	1,374,860	1,478,620	1,478,620	2,006,090	2,324,790	2,611,380
East Nusa Tenggara Region	1,343,980	1,445,270	1,445,270	2,006,090	2,324,790	2,611,380
Maluku and North Maluku Regions	1,948,030	2,095,020	2,095,020	2,852,250	3,301,890	3,708,300
Papua and West Papua Region	2,130,850	2,290,210	2,290,210	3,105,490	3,593,430	4,036,880
PLN Batam	228,510	244,580	244,580	416,280	422,460	473,100

Source: Researcher

As for transportation costs and insurance for various variants of PHBTR from Suppliers from Pekanbaru and its surroundings to all Main Units, as follows:

Table 3.6 Transportation Costs for suppliers from Pekanbaru and surrounding areas

Manufacturer's Origin Location	: Pekanbaru and its surroundings					
Shipping Destination	**Transportation and Insurance Costs**					
	(Rp/Unit)					
PLN Parent Unit/Sub Holding/Subsidiary	**PL-250-2-LBS**	**PL-250-2-MCCB**	**PL-400-2-LBS**	**PL-400-4-LBS**	**PL-630-4-LBS**	**PD-1000-6-LBS**
Aceh Region	439,750	471,860	471,860	704,100	762,160	856,040
North Sumatra Region	265,570	284,620	284,620	387,720	404,530	452,720
West Sumatra Region	140,820	150,700	150,700	245,810	258,160	289,050
Riau Region and Riau Islands	43,230	45,700	45,700	67,930	80,280	90,170
South Sumatra, Jambi, and Bengkulu Regions	128,470	156,880	154,400	201,350	233,460	258,170
Bangka Belitung Region	604,040	648,520	648,520	844,920	973,390	1,093,220
Lampung Distribution	292,750	313,750	313,750	492,860	503,980	565,750
DKI Jakarta Distribution	674,330	721,530	724,900	944,070	1,089,050	1,139,630
Banten Distribution	469,400	503,980	503,980	791,810	938,800	1,053,690
West Java Distribution	673,220	723,870	723,870	1,078,390	1,255,030	1,409,450
Distribution in Central Java and DI Yogyakarta	674,450	725,100	725,100	1,082,100	1,250,100	1,404,510
East Java Distribution	856,040	920,280	920,280	1,210,560	1,396,480	1,461,330
Bali Distribution	1,079,630	1,079,630	1,079,630	1,079,630	1,079,630	1,079,630
West Kalimantan Region	1,163,620	1,250,100	1,250,100	1,752,860	2,032,030	2,282,790
South Kalimantan and Central Kalimantan Region	1,103,100	1,184,630	1,184,630	1,666,390	1,935,670	2,174,090
East Kalimantan and North Kalimantan Regions	1,405,740	1,510,740	1,510,740	2,090,090	2,422,380	2,722,550
North Sulawesi, Gorontalo, and Central Sulawesi Regions	1,646,620	1,770,150	1,770,150	2,428,550	2,813,960	3,161,070
South Sulawesi, Southeast Sulawesi, and West Sulawesi Regions	1,222,920	1,314,330	1,314,330	1,836,860	2,129,620	2,392,730
West Nusa Tenggara Region	1,374,860	1,478,620	1,478,620	2,006,090	2,324,790	2,611,380
East Nusa Tenggara Region	1,343,980	1,445,270	1,445,270	2,006,090	2,324,790	2,611,380
Maluku and North Maluku Regions	1,948,030	2,095,020	2,095,020	2,852,250	3,301,890	3,708,300
Papua and West Papua Region	2,130,850	2,290,210	2,290,210	3,105,490	3,593,430	4,036,880
PLN Batam	144,520	155,640	154,410	226,050	238,410	266,810

Source: Researcher

For Supplier sources from Medan and its surroundings, there are transportation costs and insurance for various variants of PHBTR to all Main Units, as follows:

Table 3.7 Transportation Costs for suppliers from Medan and surrounding areas

Manufacturer's Origin Location	: Medan and its surroundings					
Shipping Destination	**Transportation and Insurance Costs**					
	(Rp/Unit)					
PLN Parent Unit/Sub Holding/Subsidiary	**PL-250-2-LBS**	**PL-250-2-MCCB**	**PL-400-2-LBS**	**PL-400-4-LBS**	**PL-630-4-LBS**	**PD-1000-6-LBS**
Aceh Region	263,110	281,640	286,570	373,050	427,400	471,860
North Sumatra Region	92,640	98,810	104,990	135,870	155,640	171,690
West Sumatra Region	265,570	284,620	284,620	387,720	404,530	447,160
Riau Region and Riau Islands	275,450	293,980	300,170	389,100	445,920	492,860
South Sumatra, Jambi, and Bengkulu Regions	403,930	450,870	454,570	590,460	679,390	751,040
Bangka Belitung Region	688,050	736,210	739,920	962,270	1,105,560	1,222,920
Lampung Distribution	439,750	469,400	473,100	615,160	706,580	780,690
DKI Jakarta Distribution	720,160	756,160	757,400	984,630	1,112,630	1,230,330
Banten Distribution	727,570	763,400	764,620	994,390	1,122,860	1,241,450
West Java Distribution	727,570	763,400	764,620	994,390	1,122,860	1,241,450
Distribution in Central Java and DI Yogyakarta	701,630	736,210	737,450	958,570	1,083,340	1,198,210
East Java Distribution	731,280	767,840	769,080	999,800	1,129,780	1,248,860
Bali Distribution	728,800	765,250	766,480	996,430	1,125,960	1,245,150
West Kalimantan Region	663,330	710,270	711,510	930,160	1,072,220	1,185,860
South Kalimantan and Central Kalimantan Region	604,040	646,040	647,280	844,920	974,630	1,077,150
East Kalimantan and North Kalimantan Regions	905,450	968,450	969,690	1,267,390	1,462,560	1,616,970
North Sulawesi, Gorontalo, and Central Sulawesi Regions	1,147,570	1,227,860	1,229,090	1,605,850	1,854,150	2,050,560
South Sulawesi, Southeast Sulawesi, and West Sulawesi Regions	725,100	774,510	775,740	1,014,160	1,171,030	1,294,560
West Nusa Tenggara Region	874,570	937,570	938,800	1,225,390	1,414,390	1,563,860
East Nusa Tenggara Region	844,920	904,220	905,450	1,183,390	1,364,980	1,509,500
Maluku and North Maluku Regions	1,450,210	1,550,270	1,551,500	2,040,670	2,342,080	2,590,380
Papua and West Papua Region	1,630,570	1,744,210	1,745,440	2,282,790	2,633,610	2,912,790
PLN Batam	302,630	323,630	328,580	427,400	491,630	543,520

Model Formulation Development

The complexity of *the many-to-many* and multi-product concepts makes allocation decisions ineffective when done manually. Therefore, this study formulates decision variables (supplier allocation-Main Unit-product variants) and applies *Weighted Goal Programming* to balance transportation cost efficiency goals and meeting the needs of the Main Unit with supplier capacity constraints and network *feasibility*.

Based on the results of observations, it was obtained that the goal of minimizing transportation costs was more important than meeting all the needs of the Distribution Main Unit/Region. Therefore, the weights given are as follows:

a. Minimizing transportation costs has a weight of 0.55.
b. Meeting the needs of the Distribution Main Unit/Region has a weight of 0.45.

The formulation of the goal function with the model of the *Weighted Goal Programming* method is as follows:

$$\sum_{i=1}^{m}\sum_{j=1}^{n} c_{ijk}\, x_{ijk} - d_1^+ + d_1^- = B$$

$$\text{Minimizing } Z = 0.55\,(\,d_1^+ + d_1^-) + \sum_{j=1}^{m} 0{,}45\,(d_n^+ + d_n^-), \text{ n} = \text{n} + 1$$

Limitation Function

a. Destination limitations minimize transportation costs

$$\sum_{j=1,i=1,k=1}^{n} C_{ijk} * \text{Xsipkwj} + d_1^+ + d_1^- = B$$

Si = Supplier 1, Supplier 2, Supplier 3,........................,Supplier N, PK = Product 1, Product 2,......................... product n, wj = region 1, region 2, region 3,................,region n, B = target transportation cost.

b. Objective constraints to meet all the needs of the Distribution/Regional Main Unit

Product 1

$$\text{Xs1p1w1} + d_1^+ + d_1^- = K$$

.
.
.
.

$$\text{Xsnpnwn} + \text{Description :} d_n^+ + d_n^- = K$$

Si : Supplier to I

pk : product to k

WJ : Region to J

C_{ijk} : Transportation Cost from supplier i to region j of product k

d_1^+ : deviation from the transportation cost target

d_1^- : deviation below the transportation cost target

d_n^+ = deviation above the target unit requirement

d_n^- = deviation below the unit requirement target

B = Target transportation costs

K = target unit needs

c. Producer Capacity Constraints

$$\text{Xs1p1w1} \leq C$$

....

$$\text{Xsnpnwn} \leq C$$

d. Non-Negative Constraints

$$\text{Xs1p1w1} >= 0$$

.

...
    Xsnpnwn >= 0
e. Non Negative Deviation Constraints
    $d_1^+, , , \ d_1^- d_n^+ d_n^- >= 0$

Product Allocation Research Results

The results of LINGO optimization as shown in Appendix B formulate the pattern of product allocation from each Provider to the Distribution Main Unit/Region in such a way that the main goal, which is to minimize transportation costs, can be achieved, while ensuring that all the needs of each Main Unit in the third quarter of 2025 are met. This optimization process takes into account the transportation costs per unit for each combination of regional product suppliers, so that the route with the lowest cost will be prioritized. Instead, high-cost combinations are automatically eliminated from the solution.

This pattern makes up only a small fraction of all possible routes used in the final solution, which means that distribution is focused on the most efficient route in terms of both cost and supply availability. This shows that the model is able to filter and select the optimal combination without having to take advantage of all the available options, making the use of the distribution budget more effective.

The following table presents in detail the optimal allocation amount for each combination of regional product suppliers selected in the solution. This information is the basis for actual distribution recommendations, because it contains routes that must be carried out so that the needs of all Distribution Main Units/Regions can be met according to the target, while maintaining transportation cost efficiency at an optimal level.

Table 3.8 Product allocation PL-250-2-LBS

	Aceh	North Sumatra	RKR	West Sumatra	Babel	S2JB	Lpg	Jaya	Banten	West Java	DJTY	East Java	Bali	West Kalimantan	KSKT	Kaltimra	SUTG	SSTB	NTB	NTT	MMU	Batam	P2B	Total
TS	0	67	0	0	0	113	0	0	0	0	0	25	0	0	0	0	78	45	0	0	0	0	0	328
BD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	79	0	196	0	0	0	0	0	275
AHA	65	93	0	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	176
PGEI	108	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	108
TEA	0	0	0	0	0	0	0	0	0	0	0	71	0	0	6	0	0	0	0	0	0	0	0	77
PPP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	67	0	0	0	0	0	0	0	0	67
GI	0	0	0	0	27	0	0	0	0	0	0	28	0	0	0	0	0	0	0	0	0	0	0	55
PUS	0	0	0	0	0	0	0	0	0	105	0	0	0	0	0	0	0	0	0	0	0	0	0	105
TOTAL	173	160	0	18	27	113	0	0	0	105	0	124	0	0	73	79	78	241	0	0	0	0	0	1.191

(PL-250-2-LBS Products (3 Quarter Total))

Source: Researcher

Table 3.8 shows the distribution of PL-250-2-LBS product requirements in Q3 in various regions in Indonesia supplied by a number of suppliers. The number "0" that dominates the table indicates that most regions do not take or do not have a need for such products from a particular supplier. This condition indicates that there is an imbalance in distribution or market concentration in certain regions that have higher demand for these products. The large number of "0s" can also reflect the specialization of distribution between suppliers, where each supplier

has a different area of responsibility so that not all areas are the target of their distribution. Thus, the number "0" does not merely indicate the absence of sales, but rather describes distribution patterns that are segmented based on geographical areas, logistics capacity, and market needs that vary in each region.

Table 3.9 Product allocation PL-250-2-MCCB

	Aceh	North Sumatra	RKR	West Sumatra	Babel	S2JB	Lpg	Jaya	Banten	West Java	DJTY	East Java	Bali	West Kalimantan	KSKT	Kaltimra	SUTG	SSTB	NTB	NTT	MMU	Batam	P2B	Total
												PL-250-2-MCCB Products (3rd Quarter Total)												
PPP	0	0	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	27
ONLY	0	0	13	32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	45
RKA	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8
TOTAL	0	0	40	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	80

Source: Researcher

The pattern in Table 3.9 shows that the distribution of PL-250-2-MCCB products is still uneven across Indonesia, and is likely to be concentrated only in areas with high levels of demand or more accessible distribution ranges by major suppliers.

Table 3.10 Product allocation PL-400-2-LBS

	Aceh	North Sumatra	RKR	West Sumatra	Babel	S2JB	Lpg	Jaya	Banten	West Java	DJTY	East Java	Bali	West Kalimantan	KSKT	Kaltimra	SUTG	SSTB	NTB	NTT	MMU	Batam	P2B	Total
												PL-400-2-LBS Products (3rd Quarter Total)												
BD	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	53	0	72	0	0	0	0	0	137
PGEI	0	120	14	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	137
RKA	121	0	116	0	0	0	0	0	0	0	0	0	0	108	0	0	0	134	0	0	0	0	0	479
PM	0	0	0	0	0	0	0	0	0	0	0	0	123	55	163	0	0	0	0	0	0	0	0	341
SE	0	0	0	0	0	196	0	0	0	0	0	0	0	78	0	0	0	0	0	0	0	0	0	274
PUS	0	0	0	0	0	0	35	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	47
TOTAL	121	120	130	0	0	196	35	0	12	0	0	0	135	241	163	53	3	206	0	0	0	0	0	1.415

Source: Researcher

Table 3.11 Product allocation PL-400-4-LBS

	Aceh	North Sumatra	RKR	West Sumatra	Babel	S2JB	Lpg	Jaya	Banten	West Java	DJTY	East Java	Bali	West Kalimantan	KSKT	Kaltimra	SUTG	SSTB	NTB	NTT	MMU	Batam	P2B	Total
												PL-400-4-LBS Products (3 Quarter Total)												
PPP	0	0	0	0	0	55	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	55
PMT	0	0	0	0	59	121	24	0	6	0	0	0	0	12	0	0	0	0	0	0	0	0	0	222
MUMS	0	0	0	0	0	0	0	0	0	0	0	0	0	74	0	63	9	0	0	20	1	0	0	167
CHAPTER	3	50	30	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	27	0	111
TOTAL	3	50	30	0	60	176	24	0	6	0	0	0	0	86	0	63	9	0	0	20	1	27	0	555

Source: Researcher

Table 3.12 Product allocation PL-630-4-LBS

	Aceh	North Sumatra	RKR	West Sumatra	Babel	S2JB	Lpg	Jaya	Banten	West Java	DJTY	East Java	Bali	West Kalimantan	KSKT	Kaltimra	SUTG	SSTB	NTB	NTT	MMU	Batam	P2B	Total
PL-630-2-LBS Products (3rd Quarter Total)																								
SE	0	0	0	0	0	0	0	0	0	86	0	0	0	0	0	0	0	0	0	5	0	0	0	91
EIP	0	0	0	0	59	121	24	0	6	0	0	0	0	12	0	0	0	0	0	0	0	0	0	222
TME	0	0	0	0	0	0	0	0	0	0	0	0	0	74	0	63	9	0	0	20	1	0	0	167
TOTAL	3	50	30	0	60	176	24	0	6	0	0	0	0	86	0	63	9	0	0	20	1	27	0	555

Source: Researcher

Table 3.13 Product allocation PD-1000-6-LBS

	Aceh	North Sumatra	RKR	West Sumatra	Babel	S2JB	Lpg	Jaya	Banten	West Java	DJTY	East Java	Bali	West Kalimantan	KSKT	Kaltimra	SUTG	SSTB	NTB	NTT	MMU	Batam	P2B	Total
PL-1000-6-LBS Products (3 Quarter Total)																								
TS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18	0	18
ONLY	0	0	0	0	0	0	0	0	0	27	0	0	0	0	0	0	0	0	0	0	0	3	0	30
PMT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0	12
TOTAL	0	0	0	0	0	0	0	0	0	27	0	0	0	0	0	0	0	0	0	0	0	33	0	60

Source: Researcher

From the results of the study, it can be seen that there is a significant difference between the initial allocation transportation cost and the transportation cost resulting *from Goal Programming*. The initial allocation transportation cost is the result of calculation when the product is allocated based on actual conditions before optimization, i.e. when the product is shipped from the supplier to the parent unit without considering distance efficiency or minimum cost. In other words, the cost in the initial allocation column reflects the real conditions in the field when distribution is made based on product availability, not based on the calculation of the lowest transportation cost. This causes the total transportation cost to reach Rp 2,704,828,480.00 because some product allocations still come from suppliers who are quite far from the destination unit, thus increasing the overall shipping cost as calculated in Appendix D.

Meanwhile, the transportation cost column from *Goal Programming* describes the results of the calculation after the optimization process is carried out using a mathematical model. The *Goal Programming approach* is used to determine the most efficient combination of product allocation with the aim of minimizing total transportation costs without compromising the ability of supply to meet the demands of each parent unit. The optimization results showed a decrease in transportation costs to Rp 2,129,998,480.00, which means that there was an efficiency of Rp 574,830,000.00 compared to the initial condition. This value indicates that the optimization model successfully steers product distribution to a more cost-effective path, for example by prioritizing shipments from nearby suppliers or rearranging shipment combinations to be more efficient. Thus, the application of *the Goal Programming method* has proven to be effective in reducing transportation operational costs while increasing the efficiency of product distribution throughout the region.

Based on the table of research results, the minimum transportation cost as calculated in Appendix E for the allocation of products from suppliers to the Main Unit to meet needs is IDR

2,129,998,480.00, the transportation cost of LINGO results is lower than the initial transportation cost plan of IDR 2,704,828,480.00. The following is a detailed table of comparative transportation costs for each product:

Table 3.14 Cost Comparison Table

Products	Initial Allocation Transportation Costs	Transportation Costs Goal *Programming Results*
PL-250-2-LBS	IDR 779.011.900.00	IDR 545,338,880,00
PL-250-2-MCCB	IDR 53,774,240,00	IDR 53.682.320.00
PL-400-2-LBS	IDR 898.998.510,00	IDR 717.073.010,00
PL-400-4-LBS	IDR 510.505.260.00	IDR 363.512.040.00
PL-630-4-LBS	IDR 418.674.400.00	IDR 406.528.060.00
PD-1000-6-LBS	IDR 43,864,170,00	IDR 43,864,170,00
Total	**IDR 2,704,828,480,00**	**IDR 2,129,998,480,00**

Source: Researcher

In addition to being able to minimize transportation costs, Weighted *Goal Programming* is able to meet the needs of PHBTR products for each Main Unit. *Weighted Goal Programming* can optimize in providing the number of allocations and suppliers from the nearest one at minimal cost.

For example, that in accordance with Table 3.15 and Table 3.16, one of the PL-400-4-LBS products has been optimally allocated to all the Main Units without any shortcomings and with *Weighted Goal Programming* can map the source of the nearest supplier so that transportation costs become more efficient.

Table 3.15 Product Allocation Comparison PL-400-4-LBS

Region	Initial Allocation	Programming Goal *Allocation*
Aceh	3	3
North Sumatra	50	50
Riau and Riau Islands	30	30
Bangka and Belitung	60	60
S2JB	176	176
Lampung	24	24
Banten	6	6
West Kalimantan	86	86
Kaltimra	63	63
Suluttenggo	9	9
Nusa Tenggara Timur	20	20
Maluku and North Maluku	1	1
PLN Batam	27	27

Source: Researcher

From the comparison table of the initial allocation and the results of *the Weighted Goal Programming optimization* for the PL-400-4-LBS external pair PHBTR product, it can be seen that all regions obtained the same allocation between the two schemes. This indicates that the

initial distribution has been optimal, taking into account the needs of each region, distribution capacity, distance, transportation costs, and geographical accessibility. The absence of allocation changes shows that the initial planning is efficient, able to maintain a balance between supply and demand, and to manage distribution costs well. In other words, *the Weighted Goal Programming* model only confirms that the initial allocation decision has reflected proper and efficient distribution, without the need for additional adjustments, so that each region receives the optimal amount of product as needed and capacity.

Table 3.16 Comparison of PL-400-4-LBS Product Allocation by Supplier

Suppliers	Origin /Asal	Initial Allocation	Early Territory	Programming Goal *Allocation*	Final Region
CHAPTER	Padang	111	Aceh, North Sumatra, Riau & Riau Islands, Babel, S2JB, Lampung, Banten, West Kalimantan, East Kalimantan, Suluttenggo, NTT and PLN Batam	111	Aceh, North Sumatra, Riau & Riau Islands, Babel and PLN Batam
MUMS	Surabaya	167	Aceh, North Sumatra, Riau & Riau Islands, Babel, S2JB, Lampung, Banten, West Kalimantan, East Kalimantan, Suluttenggo, NTT and PLN Batam	167	West Kalimantan, East Kalimantan, NTT, MMU
PMT	Jabodetabek	221	Aceh, North Sumatra, Riau & Riau Islands, Babel, S2JB, Lampung, Banten, West Kalimantan, East Kalimantan, Suluttenggo, NTT, MMU and PLN Batam	222	Babel, S2JB, Lampung, Banten and West Kalimantan
PPP	Jabodetabek	56	North Sumatra, Riau & Riau Islands, Babel, S2JB, Lampung, Banten, West Kalimantan, East Kalimantan, Suluttenggo, NTT and PLN Batam	55	S2JB

Source: Researcher

The additional allocation illustrates that Greater Jakarta has a strong and efficient production and distribution capacity to serve high demand, especially outside the island. Good land and sea transportation infrastructure also supports the role of Greater Jakarta as a national logistics hub. The reduction in allocation means that the distribution system of the PPP is quite efficient, but there are few adjustments to optimize total costs or capacity between suppliers. Since Greater Jakarta has several large suppliers, such as PMT and PPP, this small redistribution is natural to maintain a balance between supply capacity and the needs of a large area.

CONCLUSIONS

The multi-product distribution optimization model from various suppliers to the Main Unit successfully minimized the total transportation cost to Rp 2,129,998,480.00. Based on the calculation results using LINGO software, all deviation values (D) in the objective function are zero (0), indicating that all regional demand targets were fully satisfied without deviation. This demonstrates that the formulation and solution of the distribution model operate optimally. The allocation of product distribution from each supplier to the destination regions complies with existing supplier capacity and regional demand, thereby reflecting logistics efficiency. Each product variant (PL-250-2-LBS, PL-250-2-MCCB, PL-400-2-LBS, PL-400-4-LBS, PL-630-4-LBS, and PD-1000-6-LBS) was successfully allocated across all demand areas through a diversified combination of suppliers, without exceeding the production capacity of any supplier.

Future research is recommended to extend the model by incorporating additional real-world uncertainties, such as demand fluctuations, supplier reliability variability, lead time uncertainty, and transportation disruptions, through stochastic or robust optimization approaches. Integrating delivery scheduling variables and inventory considerations into a dynamic multi-period framework would further enhance the practical applicability of the model. Moreover, comparative studies between Weighted Goal Programming and other multi-objective optimization methods—such as Pareto-based optimization or evolutionary algorithms—could provide deeper insights into solution robustness and computational efficiency in large-scale distribution systems.

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