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Transportation Distribution Analysis to Reduce Carbon Emissions

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Abstract

This study aims to investigate the role of PT. TBBM Tanker Car transportation distribution in distributing fuel oil with its tree logic in realizing a green energy system. The primary focus lies in enhancing the efficiency of transportation distribution to facilitate the utilization of green energy through route enhancements. The study underscores the significance of devising efficient transportation distribution routes and advocating for modifications in the quantity and type of tanker car fleets used in its operations. The Saving Matrix Method yielded results from the improvement of the existing Route 17 Routes to 7 Routes, which showed improvements to 10 routes. Consequently, the efficiency of the 17 routes, which provided 17 tanker cars, was improved to 7 routes, indicating a need for 7 tanker cars. A tanker car with a 32 KL capacity operates on Route 1 from gas stations 16, 15, and 14. A tanker car with a 32 KL capacity operates on Route 2 from gas stations 13, 12, and 11. A tanker car with a 32 KL capacity operates on Route 3 from gas stations 10, 9, and 8. Route 4 operates from gas stations 7 and 6, using a tanker car with a capacity of 24 KL; Route 5 operates from gas stations 4 and 3, using a tanker car with a capacity of 24 KL. Route 6 utilizes a 32 KL tanker car from gas stations 2 and 1, while Route 7 utilizes a 24 KL tanker car from gas stations 17. By utilizing only 7 tanks from 17 tankers, we anticipate a significant reduction in carbon emissions, ensuring environmental sustainability.

Keywords: distribution, cars, emissions, routes.

INTRODUCTION

Energy resources produced by minimizing environmental impacts and promoting sustainability are known as green energy. Green energy is known for its positive contribution to environmental conservation and reducing greenhouse gas emissions. One of the main advantages of green energy is its ability to reduce carbon emissions. By not producing significant greenhouse gas emissions during its production and use, green energy supports climate change mitigation efforts. Green energy supports the concept of sustainable development by minimizing negative impacts on the natural environment, maintaining ecosystem balance, and ensuring the availability of resources for future generations. The development and application of green energy technology are becoming increasingly important in facing the challenges of climate change and providing sustainable energy sources for the needs of the modern world. Fuel oil (BBM) is a primary need that has a major impact

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on the national economy. Fuel is one of the important energy sources to meet the energy needs of the community, such as transportation, industry, and housing. As Indonesia experiences population growth and industrial development, the demand for fuel availability is on the rise.

In order to compete in the era of globalization, PT. TBBM is committed to operating its business based on corporate principles and governance. Its vision is to "become a world-class national energy company" and its mission is to "run an integrated oil, gas, and new renewable energy business, based on strong commercial principles." PT. TBBM has appointed Pertamina Patra Niaga as Sub Holding Commercial & Trading to oversee business and operations, including fuel trading and handling, fleet management, and depot administration. With the development of technology and innovation, PT. TBBM manages its fleet of tankers to distribute and deliver its fuel oil.

This research aims to create new distribution and transportation channels that connect producers with consumers more efficiently. We hope to improve energy distribution management by designing optimal distribution channels, thereby reducing time and cost. This step will also assist in overcoming common challenges in conventional distribution systems, like inefficient routes or excessive fleet use. Additionally, this research focuses on efforts to enhance the efficiency of fuel oil (BBM) transport fleets. By conducting a more optimal route analysis, we can minimize the fleet of tankers without compromising distribution capacity. Thus, savings in distribution operations not only have an impact on lower costs but also increase the efficiency of resource use, both in terms of energy and logistics. Another objective is to establish a value chain that promotes green energy and aids in the reduction of carbon gas emissions. We can significantly reduce carbon emissions from energy distribution by reducing the number of fleets in operation. This is an important step in supporting the transition to a more environmentally friendly and sustainable energy distribution system, in line with the global commitment to reduce negative impacts on the environment.

METHOD

This study uses several methods to obtain relevant and in-depth data. One of the main methods used is direct observation. With this method, researchers can directly see the distribution and transportation process, including the routes used, fleet activities, and potential problems in the field. This observation enables the collection of factual data that is not only descriptive but also contextual, taking into account the real conditions at the research site. This study also utilizes documentation methods to store and analyze supporting evidence, in addition to observational data. This documentation includes written notes, operational reports, photos, and other relevant data from related companies or institutions. This approach guarantees a robust foundation for the collected data, enabling it to serve as a reliable reference for further analysis. Other methods are data inventory and interviews.

This study uses various analysis techniques to process and evaluate the data obtained. One of the main focuses is analyzing data on bio-solar fuel shipments from Pertamina to consumers, including distribution patterns, shipping volumes, and logistics efficiency. Additionally, we conducted an analysis on the fuel transportation's tonnage capacity, aiming to assess the fleet's optimal distribution of bio-solar. This study also considers the distance between the sending depot and the consumer gas station to determine the most efficient route that can reduce travel time and distribution costs. To measure distribution efficiency, this study uses a mathematical approach such as a saving matrix. This technique helps in calculating the efficiency of the distance and cost between the initial data and the optimization results obtained through the saving matrix simulation. Researchers can identify the extent of

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improvement in distribution efficiency, including routes, fleet usage, and fuel savings, by comparing the initial data and the analysis results.

The research stages begin with problem identification, followed by literature studies and field studies to formulate problems and identify research objectives. The next stage is data collection and processing, including calculating capacity, distance, and efficiency. We carry out data analysis and interpretation after processing the data to understand the relationship between variables and evaluate the effectiveness of the proposed distribution route. The final stage involves drawing conclusions from the analyzed data and making recommendations for more efficient and environmentally friendly distribution strategies.

RESULT AND DISCUSSION

Based on the obtained data, we know that PT. TBBM uses a tree logic distribution method. This method employs a strategy where each gas station establishes a unique distribution route, utilizing a dedicated fleet of tankers. In this case, there are 17 distribution routes serving 17 gas stations in Bojonegoro; each route uses one tanker with a carrying capacity of 32 tons. The use of tree logic distribution allows each gas station to receive direct supplies without any route merging or collective distribution. Although this approach is simple and provides clarity in distribution, this method can pose challenges in terms of operational efficiency, such as high fuel consumption and carbon emissions, because tankers must travel separately for each route. We need to conduct further analysis to determine whether the Tree Logic Distribution method is the most efficient approach. By considering the potential for optimization through methods such as the saving matrix, there may be opportunities to reduce the number of fleets used and create more efficient routes, thereby reducing operational costs and environmental impacts.

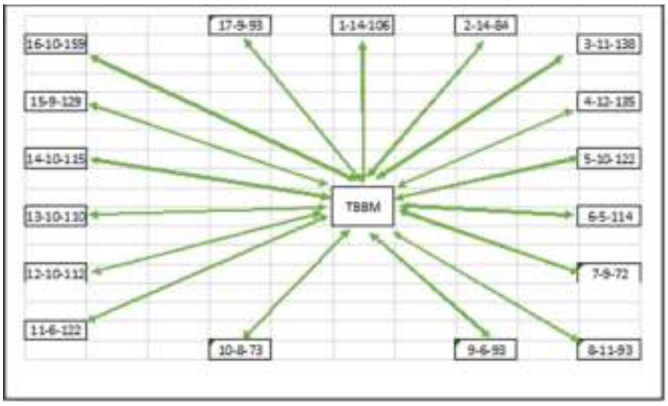

Figure 1. Distribution Route of PT. TBBM

Gas Station Data, Daily Sales, Tanker Truck Capacity and Distance

To calculate the Saving Matrix, data is required regarding gas stations and their locations, including the geographic coordinates or complete address of each gas station. We use this information to calculate the distance between each gas station and the sending depot. Digital maps, GPS, or other geographic information systems can obtain location data. Additionally, this distance data serves as the foundation for designing more efficient distribution routes by minimizing unnecessary trips. Besides determining the location, we also need to gather data on the fuel sales at each gas station. Each gas station must receive the volume of fuel sales (measured in liters or tons) within a specific timeframe. This data is important to ensure that each gas station gets sufficient supplies according to its operational

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needs. By combining location data and sales information, the Saving Matrix calculation process can produce a new distribution scheme that is more efficient in terms of distance, time, and resources while increasing the efficiency of the overall logistics system.

Table 1. Gas Station Data, Sales, MT and Distance

No	SPBU	WIL	No. CD	Address	Sales Per Day/Ton	MT-KL	Distance
1	SPBU	54621	01	Jetak	14	32	106
2	SPBU	54621	02	Prayungan Sumberejo	14	32	84
3	SPBU	54621	03	Jalakan Padangan	11	32	138
4	SPBU	54621	05	Kebonagung Padangan	12	32	135
5	SPBU	54621	07	Mlaten Kalitidu	10	32	122
6	SPBU	54621	09	Ngraseh Dander	5	32	114
7	SPBU	54621	10	Blongsong Baureno	9	32	72
8	SPBU	54621	11	Balenrejo Balen	11	32	93
9	SPBU	54621	12	Sugihwaras	6	32	93
10	SPBU	54621	14	Trojalu Baureno	8	32	73
11	SPBU	54621	15	Temayang	6	32	122
12	SPBU	54621	16	Leran Kalitidu	10	32	112
13	SPBU	54621	17	Kalirejo Bjn	10	32	110
14	SPBU	54621	18	Panjunan Kalitidu	10	32	115
15	SPBU	54621	19	Sudu Kalitidu	9	32	129
16	SPBU	54621	20	Purworejo Padangan	10	32	159
17	SPBU	54621	25	Kedungbondo Balen	9	32	93

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Distance Between Gas Stations

We calculate the distance between two gas stations.

Table 2. Distance between gas stations

No	SPBU	WIL	No. CD	Address	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	SPBU	54621	01	Jetak	0	23	31	26	17	12	31	14	24	33	24	13	11	11	22	36	19
2	SPBU	54621	02	Prayungan Sumberejo	23	0	54	47	39	24	9	10	21	11	31	35	20	33	44	58	7
3	SPBU	54621	03	Jalakan Padangan	31	54	0	5	21	41	62	44	48	63	46	30	41	21	11	6	50
4	SPBU	54621	05	Kebonagung Padangan	26	47	5	0	15	32	57	39	43	58	41	25	36	16	6	9	46
5	SPBU	54621	07	Mlaten Kalitidu	17	39	21	15	0	27	47	30	40	49	39	15	27	6	10	24	35
6	SPBU	54621	09	Ngraseh Dander	12	24	41	32	27	0	32	15	14	34	12	19	18	21	32	41	20
7	SPBU	54621	10	Blongsong Baureno	31	9	62	57	47	32	0	18	30	4	39	42	28	41	52	66	16
8	SPBU	54621	11	Balenrejo Balen	14	10	44	39	30	15	18	0	12	20	21	25	11	24	35	48	6
9	SPBU	54621	12	Sugihwaras	24	21	48	43	40	14	30	12	0	32	9	34	22	35	47	54	20
10	SPBU	54621	14	Trojalu Baureno	33	11	63	58	49	34	4	20	32	0	41	45	30	43	54	68	17
11	SPBU	54621	15	Temayang	24	31	46	41	39	12	39	21	9	41	0	31	26	32	44	52	27
12	SPBU	54621	16	Leran Kalitidu	13	35	30	25	15	19	42	25	34	45	31	0	23	10	20	35	31
13	SPBU	54621	17	Kalirejo Bjn	11	20	41	36	27	18	28	11	22	30	26	23	0	21	32	46	16
14	SPBU	54621	18	Panjunan Kalitidu	11	33	21	16	6	21	41	24	35	43	32	10	21	0	11	25	29
15	SPBU	54621	19	Sudu Kalitidu	22	44	11	6	10	32	52	35	47	54	44	20	32	11	0	16	40
16	SPBU	54621	20	Purworejo	36	58	6	9	24	41	66	48	54	68	52	35	46	25	16	0	59

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				Padangan																	
17	SPBU	54621	25	Kedung bondo Balen	17	7	50	46	35	20	16	6	20	17	27	31	16	29	40	59	0

Calculation of Saving Matrix

We calculate the distance savings in the Saving Matrix by combining the routes of two gas stations into a single trip. We use a formula that combines the distance from the first gas station to the TBBM with the distance from the second gas station to the TBBM, and then subtracts the direct distance between the first and second gas stations.

Table 3. Saving Matrix

From/ To	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	0	167	213	215	211	208	147	185	175	146	204	205	205	210	213	229	180
2	167	0	168	172	167	174	147	167	156	146	175	161	174	166	169	185	170
3	213	168	0	268	239	211	148	187	183	148	214	220	207	232	256	291	181
4	215	172	268	0	242	217	150	189	185	150	216	222	209	234	258	285	182
5	211	167	239	242	0	209	147	185	175	146	205	219	205	231	241	257	180
6	208	174	211	217	209	0	154	192	193	153	224	207	206	208	211	252	187
7	147	147	148	150	147	154	0	147	135	141	155	142		146	159	165	149
8	185	167	187	189	185	192	147	0	174	146	194	180	154	184	187	204	180
9	175	156	183	185	175	193	135	174	0	134	206	171	192	173	175	198	166
10	146	146	148	150	146	153	141	146	134	0	154	140	181	145	148	164	149
11	204	175	214	216	205	224	155	194	206	154	0	203	153	205	207	229	188
12	205	161	220	222	219	207	142	180	171	140	203	0	209	227	231	246	184
13	205	174	207	209	205	206	154	192	181	153	206	209	206	204	207	223	187
14	210	166	232	234	231	208	146	184	173	145	205	227	0	0	258	256	272
15	213	169	256	258	241	211	149	187	175	148	207	231	204	258	0	272	182
16	229	185	291	285	257	232	166	204	198	164	229	246	207	256	272	0	193

17	180	170	181	182	180	187	149	180	166	149	188	184	273	272	182	193	0

Route Change Order

The order of route changes is to sort the results of the Saving Matrix from the largest value to the smallest value by paying attention to the origin of the gas station.

NO	SPBU	SPBU	SM	NO	SPBU	SPBU	SM	NO	SPBU	SPBU	SM	NO	SPBU	SPBU	SM	NO	SPBU	SPBU	SM
1	S.3.	S16	291	31	S.3.	S11	214	61	S.6.	S9	193	91	S.2.	S13	174	121	S.10.	S15	148
2	S.4.	S16	285	32	S1	S3	213	62	S.16.	S17	193	92	S.8.	S9	174	122	S1	S7	147
3	S.14.	S17	272	33	S1	S15	213	63	S.6.	S8	192	93	S.9.	S14	173	123	S.2.	S7	147
4	S.15.	S16	272	34	S1	S5	211	64	S.8.	S13	192	94	S2	S4	172	124	S.5.	S7	147
5	S.3.	S4	268	35	S.3.	S6	211	65	S.4.	S8	189	95	S.9.	S12	171	125	S.7.	S8	147
6	S.4.	S15	258	36	S.6.	S15	211	66	S.11.	S17	188	96	S.2.	S17	170	126	S1	S10	146
7	S.14.	S15	258	37	S1	S14	210	67	S.3.	S8	187	97	S.2.	S15	169	127	S.2.	S10	146
8	S.5.	S16	257	38	S.4.	S13	209	68	S.6.	S17	187	98	S2	S3	168	128	S.5.	S10	146
9	S.3.	S15	256	39	S.5.	S6	209	69	S.8.	S15	187	99	S1	S2	167	129	S.7.	S14	146
10	S.14.	S16	256	40	S.12.	S13	209	70	S.13.	S17	187	100	S.2.	S5	167	130	S.8.	S10	146
11	S.12.	S16	246	41	S1	S6	208	71	S1	S8	185	101	S.2.	S8	167	131	S.10.	S14	145
12	S.4.	S5	242	42	S.6.	S14	208	72	S.2.	S16	185	102	S.2.	S14	166	132	S.7.	S12	142
13	S.5.	S15	241	43	S.3.	S13	207	73	S.4.	S9	185	103	S.9.	S17	166	133	S.7.	S10	141
14	S.3.	S5	239	44	S.6.	S12	207	74	S.5.	S8	185	104	S.7.	S16	165	134	S.10.	S12	140
15	S.4.	S14	234	45	S.11.	S15	207	75	S.8.	S14	184	105	S.10.	S16	164	135	S.7.	S9	135
16	S.3.	S14	232	46	S.13.	S15	207	76	S.12.	S17	184	106	S.2.	S12	161	136	S.9.	S10	134
17	S.6.	S16	232	47	S.6.	S13	206	77	S.3.	S9	183	107	S.2.	S9	156	SPBU	SPBU	MS	V-
18	S.5.	S14	231	48	S.9.	S11	206	78	S.4.	S17	182	108	S.7.	S11	155	S.15.	S16	272	V
19	S.12.	S15	231	49	S.11.	S13	206	79	S.15.	S17	182	109	S.6.	S7	154	S.3.	S4	268	V
20	S1	S16	229	50	S1	S12	205	80	S.3.	S17	181	110	S.7.	S13	154	S.14.	S15	258	V
21	S.11.	S16	229	51	S1	S13	205	81	S.9.	S13	181	111	S.10.	S11	154	S.4.	S5	242	-
22	S.12.	S14	227	52	S.5.	S11	205	82	S1	S17	180	112	S.6.	S10	153	S.5.	S6	209	V
23	S.6.	S11	224	53	S.5.	S13	205	83	S.5.	S17	180	113	S.10.	S13	153	S.12.	S13	209	V
24	S.13.	S16	223	54	S.11.	S14	205	84	S.8.	S12	180	114	S.4.	S7	150	S.13.	S14	204	-
25	S.4.	S12	222	55	S1	S11	204	85	S.8.	S17	180	115	S.4.	S10	150	S.11.	S12	203	V
26	S.3.	S12	220	56	S.8.	S16	204	86	S1	S9	175	116	S.7.	S15	149	S.16.	S17	193	-
27	S.5.	S12	219	57	S.13.	S14	204	87	S.2.	S11	175	117	S.7.	S17	149	S.8.	S9	174	V
28	S.4.	S6	217	58	S.11.	S12	203	88	S.5.	S9	175	118	S.10.	S17	149	S.2	S3	168	-
29	S.4.	S11	216	59	S.9.	S16	198	89	S.9.	S15	175	119	S.3.	S7	148	S.1.	S2	167	V
30	S1	S4	215	60	S.8.	S11	194	90	S.2.	S6	174	120	S.3.	S10	148	S.6.	S7	154	V
																S.10.	S11	154	-
																S.9.	S10	134	

Figure 2. Route Change Sequence

Saving Matrix Route Change Image

The route change image can be seen in figure 3.

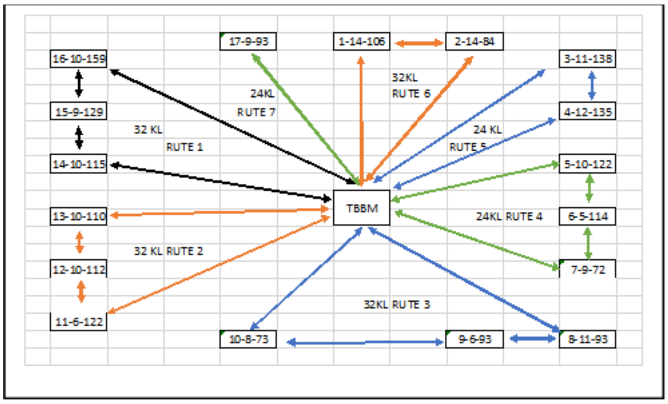

Figure 3. Saving Matrix Route Changes

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The Saving Matrix's route change calculation yielded results that reduced the initial distribution of 17 individual routes to just 7 more efficient ones. This change not only reduced the number of routes but also increased the efficiency of the use of the tanker fleet, thereby minimizing the distance traveled and fuel consumption. We designed each route based on the analysis of the distance between gas stations and the fuel delivery needs at each location. The first route serves gas stations 16, 15, and 14 using one tanker with a transport capacity of 32 kiloliters (KL). The second route combines gas stations 13, 12, and 11, also using a tanker with the same capacity, namely 32 KL. Furthermore, the third route covers gas stations 10, 9, and 8, which still use tankers with a capacity of 32 KL. We designed these three routes to optimize deliveries to gas stations in close proximity to each other. The fourth route uses a tanker with a capacity of 24 KL to serve gas stations 7, 6, and 5, as the volume of delivery requirements on this route is smaller. The fifth route exclusively serves gas stations 4 and 3, utilizing a 24 KL tanker to ensure the transport capacity aligns with the distribution needs. We achieve efficiency on these routes by using a smaller tanker capacity, ensuring it remains optimal without excess capacity. In the sixth route, a 32 KL tanker unites gas stations 2 and 1, while a 24 KL tanker exclusively serves gas station 17 on the seventh route. The seventh route adjusts the use of a smaller capacity tanker to meet the delivery needs of the gas stations. This change shows that distribution optimization can reduce the number of fleets used, produce more energy-efficient routes, and reduce carbon emissions due to travel efficiency.

CONCLUSION

The study's results indicate that the Saving Matrix calculation can optimize the distribution from 17 tanker fleets to just 7 fleets. The reduction in the number of fleets demonstrates significant efficiency in PT. TBBM's operations, enabling the company to save 10 fleets, thereby reducing its operational burden and enhancing distribution efficiency. The optimized route optimizes the use of each fleet by ensuring a more efficient distance and shorter travel time. We anticipate achieving both operational efficiency and a positive environmental impact with the reduction of 10 tanker fleets. The reduction in the number of fleets contributes to reducing fuel consumption and carbon emissions, which in turn can maintain environmental quality. This reduction in carbon emissions is in line with the company's efforts to be more environmentally friendly while supporting efforts to reduce the negative impacts of climate change.

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