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APPLICATION OF WEB-BASED DECISION SUPPORT SYSTEM FOR SUBSIDIZED 3 KG LPG DISTRIBUTION ROUTE OPTIMIZATION USING CLARKE AND WRIGHT SAVINGS ALGORITHM

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Abstract

The distribution of subsidized 3 kg LPG cylinders often relies on manually planned routes based on drivers' experience, resulting in inefficient distribution operations. This study aims to develop a web-based Decision Support System integrated with WebGIS visualization for optimizing subsidized 3 kg LPG distribution routes using the Clarke and Wright Savings Algorithm. The research method consisted of problem analysis, literature review, data collection, route optimization, system development, and system evaluation. Route optimization was performed using demand data from 22 LPG outlets while considering vehicle capacity constraints. The optimization results generated five distribution routes with a total travel distance of 85.87 km, compared with 98.78 km for the company's existing routes, resulting in a distance reduction of 12.91 km (13.06%). System verification showed that the system produced results identical to manual Clarke and Wright Savings calculations. Blackbox Testing indicated that all system functions operated successfully, while User Acceptance Testing (UAT) achieved a score of 91.8%, indicating a very high level of user acceptance. These results demonstrate that the developed system can support more efficient and systematic LPG distribution planning.

Keywords: 3 kg LPG Distribution; Route Optimization; Clarke and Wright Savings Algorithm; Decision Support System; WebGIS

Abstrak

Distribusi LPG 3 kg bersubsidi masih banyak dilakukan menggunakan perencanaan rute secara manual berdasarkan pengalaman pengemudi sehingga berpotensi menghasilkan rute yang kurang efisien. Penelitian ini bertujuan mengembangkan Decision Support System berbasis web yang terintegrasi dengan visualisasi WebGIS untuk mengoptimalkan rute distribusi LPG 3 kg bersubsidi menggunakan Algoritma Clarke and Wright Savings. Metode penelitian meliputi analisis masalah, studi literatur, pengumpulan data, optimasi rute, pengembangan sistem, dan evaluasi sistem. Proses optimasi dilakukan menggunakan data permintaan dari 22 pangkalan LPG dengan mempertimbangkan kapasitas kendaraan. Hasil optimasi menghasilkan lima rute distribusi dengan total jarak tempuh 85,87 km, lebih rendah dibandingkan rute aktual perusahaan sebesar 98,78 km, sehingga menghasilkan pengurangan jarak tempuh sebesar 12,91 km (13,06%). Verifikasi menunjukkan bahwa hasil sistem identik dengan perhitungan manual Algoritma Clarke and Wright Savings. Pengujian Blackbox menunjukkan seluruh fungsi sistem berjalan dengan baik, sedangkan User Acceptance Test (UAT) memperoleh nilai 91,8% yang menunjukkan tingkat penerimaan pengguna yang sangat tinggi. Hasil penelitian menunjukkan bahwa sistem yang dikembangkan mampu mendukung perencanaan distribusi LPG secara lebih efisien dan terstruktur.

Kata Kunci: Distribusi LPG 3 kg; Optimasi Rute; Clarke and Wright Savings Algorithm; Decision Support System; WebGIS

INTRODUCTION

Indonesia is one of the developing countries that continues to strengthen its energy sector through policies that support energy security and economic development. In 2007, the government introduced a household energy conversion program, shifting the use of subsidized kerosene to Liquefied Petroleum Gas (LPG) as a more efficient, economical, and environmentally

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friendly energy source (Lesmana et al., 2021). Since then, 3 kg LPG cylinders have become the primary energy source for households and Micro, Small, and Medium Enterprises (MSMEs) because of their affordability through government subsidies and widespread availability across various regions (Sumaragatha et al., 2025; Sunardhi et al., 2025).

To meet public demand, 3 kg LPG cylinders are distributed by PT Pertamina through a supply chain network consisting of LPG terminals, agents, and official LPG distribution outlet (Azzahra & Santosa, 2021; Kaligis & Qisti, 2025). Distribution is further supported by retailers located in residential areas, enabling easier access for consumers and helping meet the daily energy needs of households and Micro, Small, and Medium Enterprises (MSMEs) through a more accessible and flexible supply system (Sumaragatha et al., 2025).

Although a distribution network for 3 kg LPG cylinders has been established from terminals to retailers, efficiency issues remain common. These include varying customer demand, limited vehicle capacity, delivery time constraints, and differences in customer locations and distances (Armanda et al., 2023; Fatnita & Lukmandono, 2020). In addition, distribution routes from agents to outlets are often determined based on habit or experience rather than the shortest distance and spatial conditions, leading to longer delivery times, higher costs, and reduced distribution efficiency (Hermanto et al., 2020).

This issue highlights the need for a support system for the distribution of 3 kg LPG cylinders that can help agents plan distribution more effectively, systematically, and efficiently (Ningsih & Sari, 2025). Distribution route planning requires not only information on the distances between outlets but also the management of visit sequences that take into account geographical conditions and distribution patterns. Without systematic calculations, distribution routes tend to be inefficient and can increase operational costs. In this study, route optimization focuses on minimizing travel distance while considering vehicle capacity constraints, whereas travel time and distribution cost factors are beyond the scope of the optimization process. In addition to route optimization, the system also needs to support delivery schedule management and distribution visualization. Interactive map visualization allows users to view outlet locations, distribution routes, and delivery sequences, thereby supporting more effective distribution planning and decision-making(Li & Li, 2022; Rachmawati & Firarianti, 2024).

To support the distribution route optimization process, this study utilizes the Clarke and Wright Savings Algorithm based on the Capacitated Vehicle Routing Problem (CVRP) (Juwita et al., 2026; Liu et al., 2023; Simamora et al., 2026). The algorithm is used to generate more efficient delivery routes by taking into account vehicle capacity and outlet locations (Hafizah & Husein, 2023; Ningsih & Sari, 2025). However, in this study, the algorithm was not only used for route optimization but was also integrated into a web-based system equipped with WebGIS visualization features, so that the optimization results could be directly applied to the operational activities of 3 kg LPG distribution.

Several studies have demonstrated that the Clarke and Wright Savings Algorithm is capable of producing more efficient distribution routes compared with other routing methods. Pasha and Suseno (2025) compared the Clarke and Wright Savings Algorithm with the Sequential Insertion method in bread distribution and reported that the Clarke and Wright Savings Algorithm generated a shorter travel distance of 131 km compared to 134.1 km obtained by the Sequential Insertion method. Similarly, Rangkuti and Mustofa (2022) compared the Clarke and Wright Savings Algorithm with the Ant Colony Optimization (ACO) algorithm for waste collection routing and found that the Clarke and Wright Savings Algorithm produced a shorter total travel distance of 906.73 km, whereas the ACO algorithm resulted in 946.28 km. In another study, Riginianto and Setiafindari (2024) compared the Clarke and Wright Savings Algorithm with the Nearest Neighbor algorithm for egg distribution and showed that the Clarke and Wright Savings Algorithm achieved a travel distance of 106.5 km, while the Nearest Neighbor algorithm generated a longer route of 124.4 km. These findings indicate that the Clarke and Wright Savings Algorithm is capable of producing more efficient distribution routes than several alternative routing methods and remains a suitable approach for solving distribution routing problems.

The Clarke and Wright Savings Algorithm has also been widely applied in 3 kg LPG distribution route optimization and has consistently demonstrated its effectiveness in reducing travel distance and improving distribution efficiency under vehicle capacity constraints. Ningsih and Sari (2025) applied the Clarke and Wright Savings Algorithm to optimize 3 kg LPG distribution routes and reduced the total travel distance from 110.1 km to 90.9 km, resulting in a distance reduction of 19.2 km. Similarly,

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Hafizah and Husein(2023) reported that route optimization reduced the total travel distance from 43.48 km across three existing routes to 35.98 km using only two optimized routes. Furthermore, Juwita et al. (2026) achieved a substantial reduction in total travel distance from 1,122 km to 516.7 km, resulting in a distance saving of 605.3 km or 53.9%. These findings demonstrate that the Clarke and Wright Savings Algorithm is effective in minimizing travel distance and improving the efficiency of LPG distribution operations across different distribution scenarios.

Based on previous studies, the application of the Clarke and Wright Savings Algorithm in 3 kg LPG distribution has primarily focused on route optimization calculations, with limited integration into operational decision-support systems. In addition, features such as distribution scheduling and route visualization are rarely incorporated into a single platform. Therefore, this study develops a web-based Decision Support System that integrates the Clarke and Wright Savings Algorithm, distribution scheduling, and WebGIS-based route visualization to support more effective and structured distribution planning. The main contribution of this research is the implementation of route optimization within an integrated operational system that enables users to perform distribution scheduling, generate optimized routes automatically, and visualize distribution routes interactively through digital maps.

RESEARCH METHODS

The conceptual structure referred to as the research framework organizes the research steps and procedures and illustrates the logical sequence of the overall research process. The research framework provides a systematic foundation for designing, conducting, and interpreting the research results appropriately (Yulianto & Cholil, 2026). Figure 1 shows the research framework used in this study.

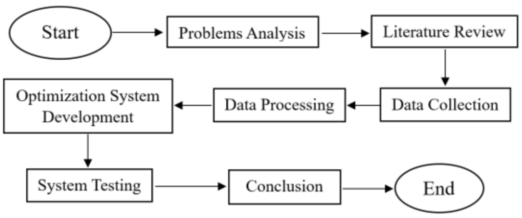

Figure 1. Research Framework

Based on the research stages shown in Figure 1 each stage of the research implementation can be described as follows:

Problems Analysis

The distribution issues surrounding subsidized 3 kg LPG cylinders were analyzed based on the route-planning process, which is still carried out manually based on agents' habits or experience; as a result, the distribution routes used are not necessarily efficient. Additionally, differences in outlet locations, variations in LPG demand, and vehicle capacity limitations make the distribution process more complex and potentially increase delivery times and operational costs. Distribution schedule management is also not yet integrated with route visualization, so a Decision Support System is needed to support route optimization, delivery schedule management, and distribution visualization in a more effective and structured manner.

Literature Review

The literature review was conducted by analyzing various references related to the distribution of 3 kg LPG cylinders, distribution route optimization, Decision Support Systems, Geographic Information Systems (GIS), WebGIS, and the Clarke and Wright Savings Algorithm. The review was conducted through journals, books, and previous research to understand the concepts, methods, and technologies relevant to this research. Furthermore, the literature review was also used to identify the limitations of previous studies and to serve as a basis for system design and the selection of appropriate optimization methods to support the distribution of 3 kg LPG more effectively and efficiently.

Data Collection

Data collection was conducted to gather the data needed for system development and the optimization of 3 kg LPG distribution route. The data collected included LPG agent data, outlet data, outlet addresses, LPG demand volume, distribution vehicle capacity, and delivery schedules.The data was obtained through direct observation, documentation, and interviews with relevant parties to ensure its accuracy in reflecting the actual conditions of 3 kg LPG distribution in the field.

Data Processing

Data processing is carried out to transform the collected data for use in route optimization and system development. Base addresses are converted into geographic coordinates, namely latitude and longitude, using geocoding services to support location visualization on digital maps and the distribution optimization process.

Optimization System Development

Optimization system development focuses on developing a Decision Support System to

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support subsidized LPG distribution. Route optimization is performed using the Clarke and Wright Savings Algorithm. Route optimization is performed using the Clarke and Wright Savings Algorithm to generate more efficient distribution routes based on distance savings while considering vehicle capacity (Sakilah et al., 2024; Sitompul & Husein, 2025). The basic concept of route merging in the Clarke and Wright Savings Algorithm is illustrated in Figure 2.

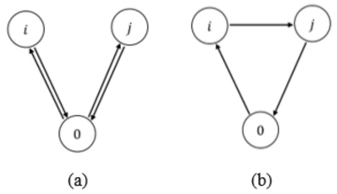

Figure 2. Illustration of Clarke and Wright Savings Algorithm

Initially, customers $i$and $j$are served through two separate routes as shown in Figure 2(a). The total travel distance is :

$$D_a = C_{0i} + C_{i0} + C_{0j} + C_{j0} \quad (1)$$

After both customers are combined into a single route as shown in Figure 2(b), the total distance becomes:

$$D_b = C_{0i} + C_{ij} + C_{j0}$$

Therefore, the savings value obtained from combining the two routes is:

$$S_{ij} = D_a - D_b$$

which yields:

$$S_{ij} = C_{0i} + C_{0j} - C_{ij}$$

where C_{i0} represents the distance from outlet i to the agent, C_{0j} represents the distance from the agent to outlet j, and C_{ij} represents the distance between i and outlet j (Azahra & Habiburrohman, 2025; Peric et al., 2024; Sekarningtyas et al., 2023). The value of S_{ij} indicates the amount of distance savings obtained when two individual routes are combined into a single distribution route (Melani et al., 2025). The highest savings value is used as the basis for combining distribution routes while considering vehicle capacity constraints (Az-zahra & Fauzi, 2023). The system also utilizes digital mapping services to display outlet locations, distribution routes, and vehicle visit sequences on the WebGIS map. This aims to provide a system that can assist LPG agents in planning distribution activities more effectively, systematically, and conveniently for daily operational use.

System Testing

System testing is conducted to ensure that all features of the developed Decision Support System function properly according to the needs of 3 kg LPG distribution. The testing includes outlet data management, distribution schedule input, route optimization, and WebGIS route visualization, as well as validating the generated distribution routes based on demand data and vehicle capacity.

Conclusion

Conclusions are drawn based on the results of system testing and evaluation. The conclusions describe the extent to which the developed system is able to meet user needs and support operational activities effectively. In addition, the conclusions also explain the effectiveness of the system implementation and the potential for further development to improve system performance and functionality in the future.

RESULTS AND DISCUSSION

Results

1. Outlet Dataset Used in Route Optimization

The route optimization process was conducted using outlet data obtained from PT. Mandiri Utama Bersama. The complete database consists of 56 registered LPG outlets. However, the optimization scenario presented in this study uses 22 outlets selected based on the distribution schedule on a particular delivery date. Each outlet record contains geographic coordinates (latitude and longitude) and LPG demand quantities, which are used as input parameters in the Clarke and Wright Savings Algorithm. A sample of the outlet dataset used in this study is presented in Table 1.

The outlet dataset serves as the basis for distance matrix generation, savings calculation, and route formation. Geographic coordinates are utilized to determine inter-location distances through routing services, while demand data are used to ensure that the generated routes satisfy vehicle capacity constraints.

Table 1. Outlet Dataset Used in Route Optimization

No	Outlets	Latitude	Longitude	Demand	C_{0i}
1	Gas Station 14.201.1152	3.537845	98.663162	80	9.59 km
2	Benny Kasnin	3.581602	98.701757	100	1.04 km
3	Diah Indrawaty	3.524733	98.676845	100	9.07 km
4	Dina Safitri	3.569575	98.721103	160	3.45 km
5	Edi Putra	3.586909	98.711151	60	2.53 km
6	Erika Dewi	3.575993	98.693668	100	0.63 km
7	Fachriza	3.620661	98.682156	140	6.72 km
8	Hamzad Miraja	3.576215	98.699195	160	0.01 km
9	Hartono	3.574268	98.699699	120	0.35 km
10	Herman	3.536925	98.732628	140	10.03 km
11	Hermansyah, H.	3.575919	98.709052	160	1.66 km
12	Ibrahim Malik	3.580315	98.706202	140	1.66 km
13	Iwan	3.647255	98.698108	140	10.41 km
14	Juliana	3.613309	98.676301	120	6.42 km
15	M Rifai	3.535616	98.673836	100	8.29 km
16	Muhammad Asyari	3.577884	98.695778	120	0.57 km
17	Rafiqoh	3.579973	98.699322	160	0.64 km
18	Rezeki Pinem	3.655592	98.687964	140	13.43 km
19	Ridho Awaluddin	3.611059	98.687257	60	6.25 km
20	Sugiarto	3.574459	98.709609	140	1.75 km
21	Suripto	3.526042	98.671057	140	9.58 km
22	Yanti Nst	3.597856	98.721616	100	4.83 km

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Table 1 shows a sample of the outlet dataset used in the optimization process. The selected outlets exhibit varying LPG demand levels ranging from 60 to 160 cylinders, indicating differences in distribution requirements among locations. These variations are considered during route construction to ensure that vehicle capacity constraints are satisfied.

2. Distance Matrix and Savings Calculation

After the outlet dataset was established, a distance matrix was generated to determine the travel distances between the LPG agent (depot) and each outlet, as well as between outlet pairs. The depot is represented as node 0, while each outlet is represented as nodes i and j. The distance values were obtained based on the geographic coordinates of the outlets and were used as the primary input for the Clarke and Wright Savings Algorithm.

Table 2. Sample of Distance Matrix

ID	Agent	1	2	3	4	5	...	21	22
Agent	0.00	9.59	1.04	9.07	3.45	2.53	...	9.58	4.83
1	9.59	0.00	10.13	3.69	11.17	11.15	...	3.46	15.04
2	1.04	10.13	0.00	9.60	3.56	1.65	...	10.11	3.95
3	9.07	3.69	9.60	0.00	10.64	10.63	...	0.71	14.52
4	3.45	11.17	3.56	10.64	0.00	3.08	...	11.15	5.46
5	2.53	11.15	1.65	10.63	3.08	0.00	...	11.13	2.51
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋱	⋮	⋮
21	9.58	3.46	10.11	0.71	11.15	11.13	...	0.00	15.03
22	4.83	15.04	3.95	14.52	5.46	2.51	...	15.03	0.00

Table 2 presents a sample of the distance matrix generated from the outlet dataset. The matrix contains the travel distances between the depot and each outlet, as well as the distances among outlets, which serve as the basis for route optimization.

Using the distance values obtained from the distance matrix, savings values were then calculated for each pair of outlets. The savings value represents the reduction in travel distance achieved when two outlets are served within the same route instead of separate routes. The savings values were calculated using Equation (1).

As an example, the savings value for outlet pair (1,2) was calculated as follows:

$$S_{ij} = C_{i0} + C_{0j} - C_{ij}$$

$$S(1,2) = C(1,0) + C(0,2) - C(1,2)$$

$$S(1,2) = 9.59 + 1.04 - 10.13$$

$$S(1,2) = 0.50$$

After calculating the savings values for all outlet pairs, the results were sorted in descending order. The outlet pairs with the highest savings values were prioritized during the route construction process while ensuring that vehicle capacity constraints were satisfied.

Table 3. Savings Values Sorted in Descending Order

No	Outlet (i)	Outlet (j)	C_{0i} (km)	C_{0j} (km)	C_{ij} (km)	S_{ij} (km)
1	Iwan	Rezeki Pinem	10.41	13.43	2.61	21.23
2	Diah Indrawaty	Suripto	9.07	9.58	0.71	17.94
3	M Rifai	Suripto	8.29	9.58	1.47	16.40
4	Gas Station 14.201.1152	M Rifai	9.59	8.29	1.77	16.11
5	Gas Station 14.201.1152	Suripto	9.59	9.58	3.46	15.71
⋮	⋮	⋮	⋮	⋮	⋮	⋮
230	M Rifai	Yanti Nst	8.29	4.83	13.74	-0.62
231	Suripto	Yanti Nst	9.58	4.83	15.03	-0.62

Table 3 shows the savings values ranked from the highest to the lowest. These values were used as the basis for combining outlets into distribution routes. The route construction process based on the sorted savings values is presented in the following section.

3. Route Optimization Results

Based on the sorted savings values presented in Table 3, route construction was performed by sequentially combining outlet pairs with the highest savings values. During this process, vehicle capacity constraints were considered to ensure that the total demand assigned to each route did not exceed the available vehicle capacity. The route merging process continued until no further feasible combinations could be made. As a result, several optimized distribution routes were formed, each consisting of outlet combinations that provide the highest possible travel distance savings while satisfying capacity constraints. The optimized route construction results are presented in Table 4.

Table 4. Distribution Route Construction Results

Route	Urutan Rute	Outlets	Total load	Total Distance (Km)
Route 1	Agent - 14 - 53 - 36 - 2 - 28 - Agent	Agent → Diah Indrawaty → Suripto → M Rifai → Gas Station 14.201.1152 → Herman → Agent	560 Tabung	32.67
Route 2	Agent - 21 - 46 - 56 - 18 - 30 - 11 - Agent	Agent → Erika Dewi → Ridho Awaluddin → Yanti Nst → Edi Putra → Ibrahim Malik → Benny Kasnin → Agent	560 Tabung	17.27
Route 3	Agent - 31 - 45 - 24 - 33 - Agent	Agent → Iwan → Rezeki Pinem → Fachriza → Juliana → Agent	540 Tabung	26.33
Route 4	Agent - 25 - 26 - 44 - 40 - Agent	Agent → Hamzad Miraja → Hartono → Rafiqoh → Muhammad Asyari → Agent	560 Tabung	2.30
Route 5	Agent - 29 - 51 - 16 - Agent	Agent → Hermansyah, H. → Sugiarto → Dina Safitri → Agent	460 Tabung	7.30
		Total	2680 Tabung	85.87

The optimization results generated by the system were compared with the results obtained through manual Clarke and Wright Savings Algorithm calculations. Both approaches produced identical route configurations and total travel

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distances, indicating that the system correctly implements the Clarke and Wright Savings Algorithm.

Table 5. Optimization Result Verification

Indicator	Manual Calculation	System Result
Number of Routes	5	5
Total Distance (km)	85.87	85.87
Total Load Served	2680	2680
Capacity Constraint	Satisfied	Satisfied

4. Comparison and Efficiency Analysis of Distribution Routes

To evaluate the effectiveness of the Clarke and Wright Savings Algorithm, the optimized distribution routes were compared with the actual routes currently used by the company. The comparison was performed based on the total travel distance required to serve the same set of outlets on the selected distribution schedule. The comparison results are presented in Table 5.

Table 6. Route Optimization Performance Comparison

Performance Indicator	Actual Company Route	Optimized Route
Number of Routes	5	5
Total Distance (km)	98.78	85.87
Distance Reduction (km)	–	12.91
Distance Reduction (%)	–	13.06%

As shown in Table 6, the optimized route generated using the Clarke and Wright Savings Algorithm reduced the total travel distance from 98.78 km to 85.87 km, resulting in a distance reduction of 12.91 km. This improvement was achieved by constructing routes based on savings values while considering vehicle capacity constraints. The percentage of distance reduction is calculated as follows.

$$\text{Distance Reduction (\%)} = \frac{\text{Actual Distance} - \text{Optimized Distance}}{\text{Actual Distance}} \times 100\%$$

$$\text{Distance Reduction (\%)} = \frac{98.87 - 85.87}{98.78} \times 100\%$$

$$= \frac{12.91}{98.78} \times 100\%$$

$$= 13.06\%$$

The calculation shows that the optimized route achieved a distance reduction of 13.06% compared with the company's existing distribution route. This result indicates that the Clarke and Wright Savings Algorithm can improve distribution efficiency by generating shorter travel distances while maintaining operational feasibility.

5. Comparison of Actual and Optimized Route Sequences

In addition to evaluating the total travel distance, a comparison was conducted between the actual distribution routes used by the company and the optimized routes generated using the Clarke and Wright Savings Algorithm. This comparison aims to illustrate how outlet assignments and visit sequences were reorganized to achieve a more efficient distribution route configuration. The comparison results are presented in Table 6.

Table 7. Comparison of Actual and Optimized Route Sequences

Route	Actual Route Sequence	Optimized Route Sequence
1	Agent → 27 → 2 → 53 → 14 → 36 → Agent	Agent → 14 → 53 → 36 → 2 → Agent
2	Agent → 33 → 46 → 44 → 40 → 21 → Agent	Agent → 21 → 46 → 56 → 18 → 30 → 11 → Agent
3	Agent → 31 → 45 → 24 → 30 → Agent	Agent → 31 → 45 → 24 → 33 → Agent
4	Agent → 56 → 18 → 26 → 25 → Agent	Agent → 25 → 26 → 44 → 40 → Agent
5	Agent → 16 → 51 → 29 → 11 → Agent	Agent → 29 → 51 → 16 → Agent

Table 7 shows that the optimized routes differ from the actual routes in terms of outlet grouping and visit sequence. The Clarke and Wright Savings Algorithm reorganized outlet assignments by combining outlets that produced higher savings values into the same route while satisfying vehicle capacity constraints. As a result, the optimized routes achieved a shorter total travel distance than the routes currently used by the company.

6. System Implementation and Evaluation

The developed Decision Support System for subsidized 3 kg LPG distribution has been successfully implemented, and its functionality can be observed through the user interfaces provided by the system. The system has a workflow that illustrates the operational process, starting from user login and distribution schedule input to route optimization and route visualization. The overall system workflow is illustrated in Figure 2.

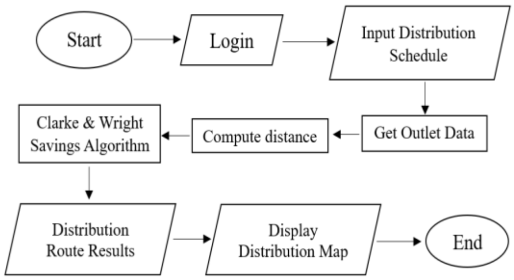

Figure 3. System Workflow

A. System Implementation

The implementation of the developed system is demonstrated through its main user interfaces, which support distribution schedule input, route optimization, route visualization, and schedule monitoring. Several main interfaces of the developed system are presented in the following figures.

1.) Login Page

Figure 4. Login Page

Figure 4 shows the login page used by users to access the system by entering username and password.

2.) Dashboard Page

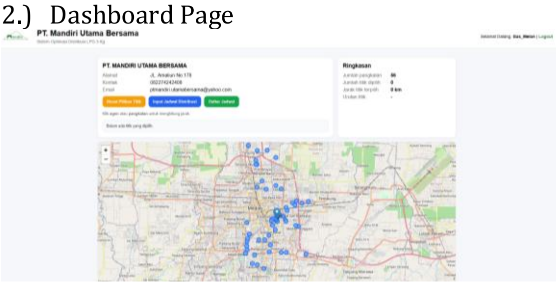

Figure 5. Dashboard Page

Figure 5 shows the dashboard page displayed after the user successfully logs into the system. This page provides access to the main system features and displays an interactive map that allows users to select distribution points and view the distance between locations.

3.) Schedule Input Page

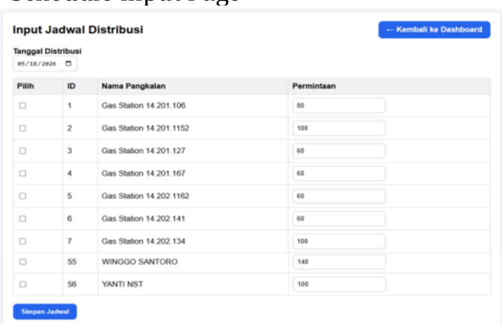

Figure 6. Schedule Input Page

Figure 6 shows the distribution schedule input page used to manage distribution schedules by selecting the distribution date and entering the LPG demand quantity for each outlet. After the data is entered, users can save the distribution schedule through the save button provided at the bottom of the page.

4.) Distribution Route Result Page and Route Visualization

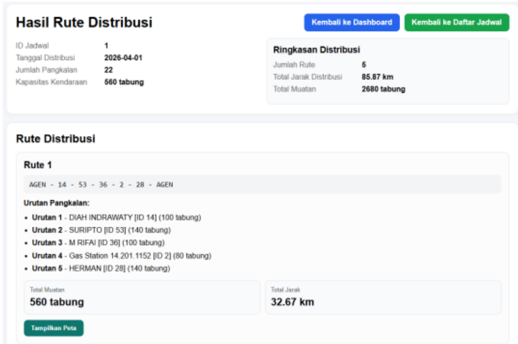

Figure 7. Distribution Route Result Page

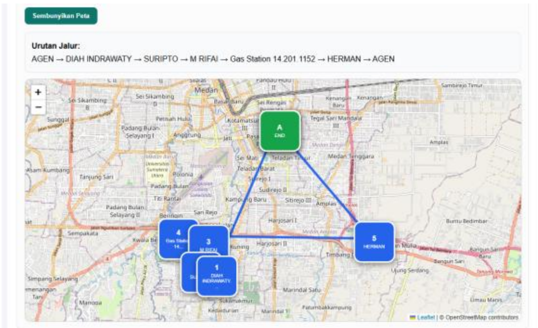

Figure 8. Route Visualization

Figures 7 and 8 show the distribution route results and route visualization. After the distribution schedule is saved, the system displays route optimization results, including distribution details, route summaries, outlet visit sequences, total load, and travel distance. An interactive map is also provided to visualize the optimized routes between the agent and outlets.

5.) Distribution Schedule List Page

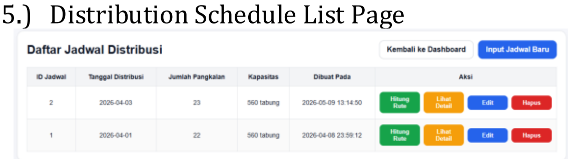

Figure 9. Distribution Schedule List Page

Figure 9 shows the Distribution Schedule List page, which displays previously saved distribution schedules along with related distribution information. In the action section, the system provides several buttons, including the Calculate Route button to return to the distribution route result page, the View Detail button to display detailed schedule information, the Edit button to modify distribution schedule data, and the Delete button to remove distribution schedules from the system.

B. Blackbox Testing

The developed system was evaluated to ensure that all implemented features operated according to the specified functional requirements. Functional testing was conducted using the Blackbox Testing method, which focuses on verifying system functionality based on user inputs and expected outputs without examining the internal program code. The results of the Blackbox Testing are presented in Table 8.

Table 8. Blackbox Testing Results

Test Scenario	Expected Result	Result	Status
Login	User successfully logs into the system	Success	Pass
Logout	User successfully logs out from the system	Success	Pass
Manage Outlet Data	Outlet data can be added, edited, and deleted	Success	Pass
Input Distribution Schedule	Schedule data saved successfully	Success	Pass
Generate Distance Matrix	Distance matrix generated successfully	Success	Pass
Calculate Savings Values	Savings values calculated successfully	Success	Pass
Generate Optimized Route	Optimized route generated successfully	Success	Pass
View Route Visualization	Route displayed correctly on the map	Success	Pass
View Route Details	Route sequence and distance displayed correctly	Success	Pass
Generate Distribution Report	Report displayed successfully	Success	Pass

As shown in Table 8, all tested functions operated as expected and achieved successful results. These findings indicate that the developed system meets the specified functional requirements and can support the route optimization process effectively.

C. User Acceptance Test (UAT)

User Acceptance Testing (UAT) was conducted to evaluate user perceptions regarding the usability and usefulness of the developed system. Respondents were asked to assess several aspects of the system using a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The questionnaire statements and evaluation results are presented in Table 9.

Table 9. User Acceptance Test (UAT) Results

No	Statement	Average Score
1	The system is easy to use.	4.5
2	The user interface is easy to understand.	4.3
3	The route optimization feature works properly.	4.7
4	The route visualization feature is helpful for distribution planning.	4.8
5	The generated routes support distribution activities effectively.	4.7
6	The system provides useful information for decision making.	4.6
7	Overall, I am satisfied with the developed system.	4.5
	Average	4.59

To further evaluate the level of user acceptance, the average score obtained from the questionnaire responses was converted into a percentage value. The calculation is presented as follows.

$$\text{UAT Score} = \frac{\text{Average Score}}{\text{Maximum Score}} \times 100\%$$

$$\text{UAT Score} = \frac{4.59}{5} \times 100\%$$

$$\text{UAT Score} = 91.8\%$$

The obtained UAT score of 91.8% indicates a very high level of user acceptance toward the developed system. This result suggests that users perceive the system as useful, easy to use, and effective in supporting LPG 3 kg distribution planning and route optimization activities.

Discussion

The implementation results show that the developed system is capable of supporting subsidized 3 kg LPG distribution activities more effectively through the integration of route optimization and digital map visualization. By applying the Clarke and Wright Savings Algorithm, the system automatically generates distribution routes based on outlet demand and vehicle capacity constraints, allowing route planning to be performed more systematically than conventional manual approaches. The integration of route optimization into the Decision Support System also enables users to obtain optimization results directly through the system interface, while the WebGIS visualization feature assists users in understanding and monitoring distribution routes spatially through interactive digital maps.

The effectiveness of the Clarke and Wright Savings Algorithm can be observed from its ability to identify outlet combinations that provide the greatest travel distance savings. In this study, the highest savings value was obtained for the outlet pair Iwan–Rezeki Pinem, with a savings value of 21.23 km. This indicates that combining visits to these outlets within the same route produces a substantial reduction in travel distance compared to serving them separately. By prioritizing outlet pairs with high savings values, the algorithm is able to construct more efficient distribution routes while reducing unnecessary depot-to-outlet travel.

In addition to savings values, vehicle capacity constraints significantly influence the route construction process. Route merging is only performed when the combined outlet demand remains within the vehicle capacity limit, ensuring that the generated routes are operationally feasible. As a result, the optimization process balances distance reduction and delivery capacity requirements simultaneously. Compared with the actual distribution routes used by the company, the optimized routes reduced the total travel distance from 98.78 km to 85.87 km, resulting in a distance reduction of 12.91 km or 13.06%. These findings indicate that the proposed approach is more efficient than the company's existing manually planned routes, as it produces shorter distribution routes while maintaining the same service coverage and vehicle capacity constraints.

CONCLUSIONS AND SUGGESTIONS

Conclusion

The developed Decision Support System successfully integrates distribution scheduling, route optimization using the Clarke and Wright Savings Algorithm, and interactive route visualization into a single platform for subsidized 3 kg LPG distribution. The system generated optimized distribution routes that reduced the total travel distance from 98.78 km to 85.87 km, resulting in a distance reduction of 12.91 km (13.06%) compared with the company's existing distribution routes. In addition, the system achieved a User Acceptance Test (UAT) score of 91.8%, indicating a very high level of user acceptance. These findings demonstrate that the proposed system can support distribution planning more effectively and systematically while contributing to the implementation of route optimization techniques within a practical Decision Support System environment.

Suggestion

Future development of the system can include dynamic outlet data management features, such as adding, editing, and deleting outlet data directly through the user interface, to improve system flexibility and usability. In addition, the system can be enhanced by incorporating real-time traffic information, travel time considerations, and time-dependent routing mechanisms so that the generated routes better reflect actual road conditions. The integration of intelligent optimization approaches, such as AI-based routing techniques, may further improve route quality and adaptability, while the development of a mobile application version could increase accessibility and support distribution activities in the field.

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