JoERRE: ISSN: 2392-5353 (Printer)
Journal of economics studies and researches in renewable energies E-ISSN: 2661-7528 (Online)
2026, 13(01), 341-356, https://asjp.cerist.dz/en/PresentationRevue/466

"ENHANCING TRANSPORT PLANNING THROUGH GRAPH THEORY: AN OPERATIONS RESEARCH APPLICATION USING WINQSB SOFTWRE – The Case of NAFTAL Company – Batna Unit"

Ramdane LOUNANSA, University Batna1, Algeria, ramdane.lounansa@univ-batna.dz

Received: 11/04/2026 Accepted: 26/05/2026 Published: 10/06/2026

Abstract: This study aims to highlight the contribution of operations research, in particular graph theory, to improving transport planning at NAFTAL – Batna unit, by designing a transport schedule that minimizes the time required to distribute fuel to service stations. The research addresses the problem of how the company can select optimal routes for its tanker trucks, based on its actual resources, by comparing the currently used routes with alternative routes generated using the WIN QSB software. A descriptive–analytical approach is adopted, relying on real data for travel times between the distribution center and ten fuel stations in the city of Batna, and on constructing a graph-based model to represent the transport network. The results show that the proposed routes significantly reduce the total travel time for all trucks compared to the existing routes, which implies a reduction in wasted time and associated costs. The study also reveals that NAFTAL does not effectively employ operations research techniques in its transport planning, and that integrating these tools can provide a powerful means to enhance distribution efficiency and support decision-making in the logistics function.

Keywords: operations research; transport planning; graph theory; fuel distribution; NAFTAL
JEL Codes: C44; R41; L91.

Citation : Lounansa, Ramdane. (2026). "Enhancing Transport Planning Through Graph Theory: An Operations Research Application Using WINQSB Softwre: The Case of NAFTAL Company – Batna Unit, *Journal of economics studies and researches in renewable energies*, 13(01), 341-356.

1. Introduction

Transport is a key activity in the modern economy, linking production and consumption areas by moving people, goods, and raw materials through complex multimodal networks (OECD, 2003). As economic activity becomes more dynamic and firms expand their geographical reach, the need to organise and plan transport operations scientifically grows, in order to provide services in the shortest possible time and at the lowest feasible cost (Hillier & Lieberman, 2021). Operations research has emerged as a powerful quantitative framework that supports decision makers in addressing planning, distribution, and routing problems in transport and logistics (Ahuja et al., 1993).

* **. Correspondant author**

ISSN: 2392-5353 (Printer)
E-ISSN: 2661-7528 (Online)
https://asjp.cerist.dz/en/PresentationRevue/466

In Algeria, NAFTAL is the main company responsible for marketing and distributing petroleum products nationwide, relying on a network of depots, pipelines, and road tankers to supply service stations (CREAD, 2021). The Batna unit faces several challenges in organising fuel deliveries to service stations while ensuring timely supply and controlling travel time and cost in a context of growing demand and urban congestion. Urban-transport studies on Batna indicate that road-network characteristics and increasing traffic volumes generate bottlenecks and reduce operational efficiency, which reinforces the need for analytical tools and structured planning (Mahdi & Hadda, 2011). This situation highlights the need to employ quantitative methods capable of representing the transport network and enabling management to select the most efficient routes based on actual operational data (Crainic & Laporte, 1998).

Against this background, the present study seeks to demonstrate the contribution of OR, and in particular graph theory, to improving transport planning at NAFTAL – Batna unit. The study builds a model based on travel-time data between the distribution centre and fuel stations, and compares the routes currently used by the company with alternative routes generated using specialised software (WIN QSB), following standard practice in network-based optimisation (Hillier & Lieberman, 2021). It aims to answer the following main question: How can OR techniques be utilised to support the choice of more efficient transport routes, thereby reducing distribution time and enhancing the logistics performance of the company (Crainic & Laporte, 1998)?

In light of these considerations, the central problem addressed in this study is how NAFTAL – Batna unit can design a more efficient transport schedule for fuel distribution that minimises total travel time, given its actual fleet and operational constraints. More specifically, the study asks whether the routes currently adopted by the company are truly efficient and to what extent the application of OR techniques can lead to better routing decisions and improved logistics performance (Savelsbergh & Van Woensel, 2016).

Accordingly, the study pursues the following objectives:

(i) to provide a brief conceptual overview of OR and its relevance to transport planning;

(ii) to analyse the current situation of fuel transport and distribution at NAFTAL – Batna unit, with a focus on the routes followed by tanker trucks;

(iii) to construct a graph-based model of the transport network using empirical data on travel times between the depot and service stations; and

(iv) to generate and evaluate alternative routes using specialised software, in order to assess potential time savings and efficiency gains.

Based on these objectives, the research is guided by two main hypotheses:

- The first hypothesis posits that NAFTAL does not systematically rely on OR methods in planning its fuel transport operations.

ISSN: 2392-5353 (Printer)
E-ISSN: 2661-7528 (Online)
https://asjp.cerist.dz/en/PresentationRevue/466

- The second hypothesis states that the set of routes currently used by the company is not optimal in terms of total travel time and that alternative routes derived from a graph-theoretic optimisation model can achieve lower travel times and, consequently, lower operating costs .

2. Literature review

2.1 Graph theory and operations research

Graph theory provides a natural language to model networks in which nodes represent locations and edges represent connections, carrying attributes such as distance, travel time, or cost. Modern graph theory, building on Euler's classic work on the Königsberg bridges, offers a rich set of results and algorithms for shortest paths, minimum spanning trees, flows, and routing, all of which have become central to OR applications in transport (Diestel, 2017). In network and transportation problems, OR uses graph models to design and analyse distribution systems, locate depots, and route vehicles efficiently (Ahuja et al., 1993).

Network-flow and routing models are among the most widely used OR tools in transport and logistics Crainic & Laporte, 1998). Algorithms for shortest paths, minimum spanning trees, and multi-commodity flows support decisions ranging from infrastructure design to detailed vehicle routing. Comprehensive OR textbooks present these models as standard techniques for minimising total travel time or cost in distribution systems, often with application examples in road and urban transport (Hillier & Lieberman, 2021; Taha, 2017).

In freight-transport and logistics, graph-based OR models are used to support fleet management, route design, and service scheduling, including case studies on fuel distribution and petroleum-product logistics (Russo & Comi, 2012). This literature underlines the importance of combining company-specific operational data with general OR algorithms to obtain practical decision-support tools (Savelsbergh & Van Woensel, 2016).

2.2 Transport planning, city logistics, and fuel distribution

Transport planning aims to organise transport systems so that they contribute to economic and social development while limiting negative environmental and social impacts (OECD, 2003). It requires analysing demand and supply, forecasting travel patterns, designing networks, and evaluating alternatives using criteria such as time, cost, safety, and sustainability (Hay, 1993). City-logistics research focuses specifically on urban freight transport, proposing measures and models to improve the efficiency and sustainability of goods distribution in cities (Russo & Comi, 2012).

Recent studies emphasise that urban freight systems face growing challenges due to congestion, environmental regulations, and new demand patterns, which call for integrated planning and decision-support systems (Iwan et al., 2024). Reviews of urban freight and city-logistics models show that routing, scheduling, and facility-location decisions are increasingly tackled with OR-based quantitative models (Russo & Comi, 2012). Applications often seek to minimise total travel time or distance while satisfying operational constraints, a

ISSN: 2392-5353 (Printer)
E-ISSN: 2661-7528 (Online)
https://asjp.cerist.dz/en/PresentationRevue/466

framework that closely matches the problem examined in this study (Thompson & Taniguchi, 2015).

In the Algerian context, empirical work on urban transport and city form highlights issues of congestion, service quality, and spatial imbalances in cities such as Batna (Mahdi & Hadda, 2011). At the same time, policy-oriented studies recognise that fuel distribution remains a strategic logistics activity, where NAFTAL manages a large network of stations under complex spatial and operational constraints. Analyses of NAFTAL's distribution system show that geographical dispersion and management practices can lead to inefficiencies and recommend more systematic use of analytical tools and quantitative methods (CREAD, 2021). These findings support the relevance of applying OR methods to NAFTAL's distribution problem.

3. Methodology

3.1 Research design

The study adopts a descriptive–analytical case-study design focusing on the fuel distribution operations of NAFTAL's Batna unit This approach is suitable for examining a real-world logistics system in depth, using detailed operational data and applying OR techniques to assess potential improvements .The empirical work proceeds in three stages: describing current routing practice, modelling the network as a graph, and generating and evaluating optimised routes using WIN QSB software (Hillier & Lieberman, 2021).

3.2 Data collection and network modelling

Operational data were obtained from NAFTAL Batna's records, including the list of service stations supplied by the unit, distances and travel times between the depot and each station, and travel times between pairs of stations in the city network (CREAD, 2021). The analysis concentrates on ten service stations in Batna served directly by the Batna depot, with distances from approximately 1 km to 7 km and corresponding average travel times from about 10 minutes to 50 minutes.

The distribution network is represented as a directed graph

G=(X,U)G=(X,U), where XX is the set of nodes (depot plus ten stations) and UU is the set of arcs representing feasible road connections (Diestel, 2017). Each arc is assigned a weight equal to the observed average travel time in minutes, following standard practice in OR transport models (Taha, 2017). Stations are grouped into lines (sub-tours) that can be served by individual trucks, and the sequence of visits within each line is the decision variable to be optimised (Crainic & Laporte, 1998).

3.3 Route construction and evaluation

The optimisation logic follows shortest-path and routing concepts that are widely used in OR for transport planning. For each truck line, the current route used by NAFTAL is codified as a path in the graph and its total travel time is computed using the travel-time matrix. WIN QSB

ISSN: 2392-5353 (Printer)
E-ISSN: 2661-7528 (Online)
https://asjp.cerist.dz/en/PresentationRevue/466

is then used to generate alternative sequences that satisfy operational constraints (starting and ending at the depot, capacity considerations, and fixed station groups) but minimise total travel time (Hillier & Lieberman, 2021).

Rather than solving a full vehicle-routing problem for the entire fleet, the study uses a constructive line-by-line approach to produce practically implementable improvements (Crainic & Laporte, 1998). For each truck, the optimised route is compared with the existing route, and time savings are calculated per tour as well as qualitatively assessed in terms of potential operational benefits (Savelsbergh & Van Woensel, 2016).

4. Case study: NAFTAL Batna fuel distribution

4.1 Company and network context

NAFTAL is the national company responsible for marketing and distributing petroleum products in Algeria through a network of depots, pipelines, road tankers and rail tank wagons (Ratoul, 2006). The Batna unit plays a key role in supplying the regional market, relying on both pipeline connections from refineries (Skikda, Annaba, El Khroub) and an extensive road distribution system using tanker trucks of different capacities (internal NAFTAL data). The depot's storage capacity includes, among others, 24,000 m³ of gasoil, 12,000 m³ of regular gasoline, 4,000 m³ of premium gasoline and additional storage for lubricants, which supports continuous supply to local stations.

Within Batna City, the study considers ten service stations, including Aurasia (R0534), La Gare (Shermouti), Ben Boulaïd underpass (R0529), Benflis (500-dwellings), Kchida (Baazouzi), Constantine road (R0521), Biskra road (R0523), Sonatiba (Sari), 1200-dwellings station (Haddad), and Tazoult road (R0522) (Hawas, 2011). Distances from the depot range from about 1 km (10 minutes) for the nearest stations to about 7 km (50 minutes) for the farthest station on the Tazoult road. NAFTAL Batna operates different truck types with tank capacities of 30 m³, 27 m³, 25 m³ and 12 m³, and also rents 17 m³ trucks to cope with demand fluctuations (internal NAFTAL data).

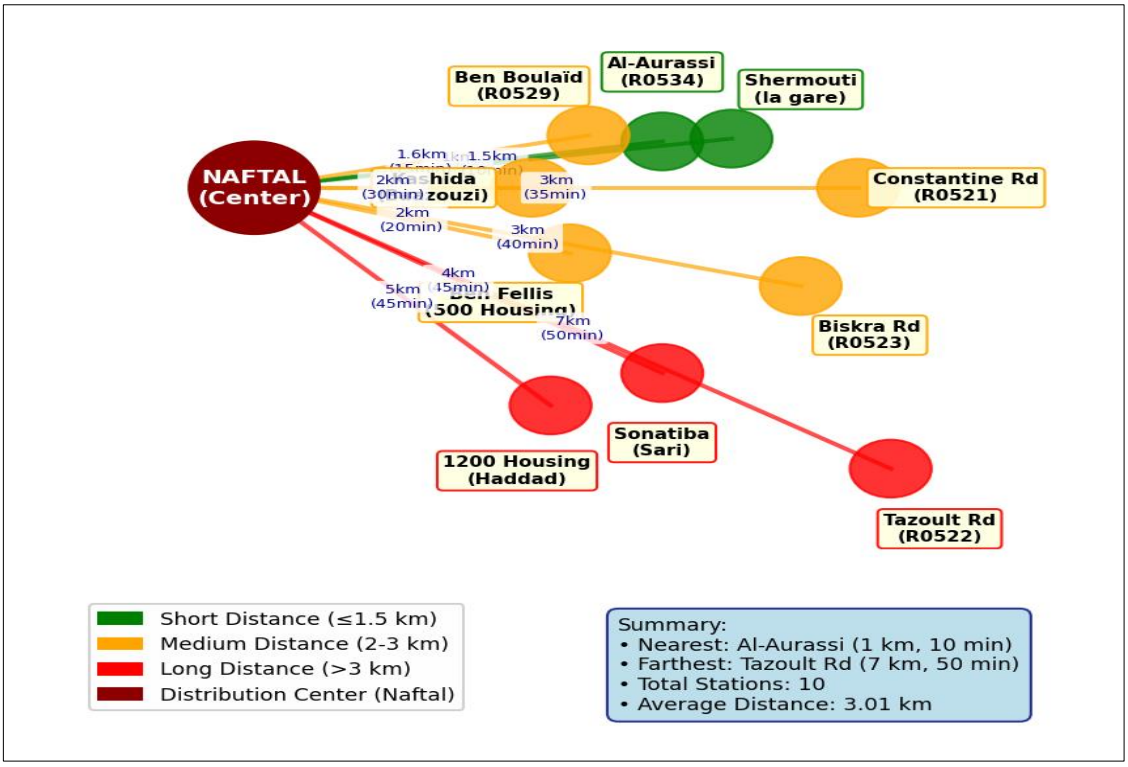
JoERRE:
Journal of economics studies and researches in renewable energies
2026, 13(01), 341-356,
ISSN: 2392-5353 (Printer)
E-ISSN: 2661-7528 (Online)
https://asjp.cerist.dz/en/PresentationRevue/466

Table (01): Table showing the distance between Naftal and gas stations in Batna city

From NAFTAL to station	Distance	Time
NAFTAL – Kchida station (Baazouzi)	2 km	30 min
NAFTAL – Constantine Road station (R0521)	3 km	35 min
NAFTAL – Aurasia station (R0534)	1 km	10 min
NAFTAL – Shermouti station (La Gare)	1.5 km	10 min
NAFTAL – Ben Boulaïd underpass station (R0529)	1.6 km	15 min
NAFTAL – Benflis station (500-Dwellings district)	2 km	20 min
NAFTAL – Biskra Road station (R0523)	3 km	40 min
NAFTAL – Sonatiba station (Sari)	4 km	45 min
NAFTAL – 1200-Dwellings station (Haddad)	5 km	45 min
NAFTAL – Tazoult Road station (R0522)	7 km	50 min

A transport diagram showing the distance between fuel stations and the distribution center (NAFTAL).

Figure (01): Transport network showing distances between the storage and distribution center (NAFTAL) and the fuel stations in Batna City.



A transport diagram showing the distance between fuel stations and the distribution center (NAFTAL).

ISSN: 2392-5353 (Printer)
E-ISSN: 2661-7528 (Online)
https://asjp.cerist.dz/en/PresentationRevue/466

Proximity Analysis: The Naftal distribution center enjoys close access to most gas stations in Batna. Three stations (Al-Aurassi, Shermouti, and Ben Boulaïd) lie within 1.6 km, enabling quick response times of 10-15 minutes. These nearby stations likely serve as high-priority points for frequent deliveries and emergency supply.

Distance Distribution: The stations split evenly between short-range (3 stations under 1.6 km), medium-range (4 stations at 2-3 km), and long-range (3 stations beyond 3 km). This spread suggests Naftal's central location effectively covers the urban core while requiring more logistical effort for peripheral areas.

Time-Distance Relationship: Travel times do not scale linearly with distance. For example, the 3 km trip to Constantine Road takes 35 minutes, while the 5 km trip to 1200 Housing takes 45 minutes. This pattern reflects urban traffic conditions, road quality, and route complexity rather than pure distance.

Operational Implications: The farthest station (Tazoult Road at 7 km, 50 minutes) may require different scheduling strategies—perhaps larger, less frequent deliveries or dedicated transport routes. The concentration of nearby stations allows efficient daily servicing, while distant stations need planned, optimized trips.

Overall Assessment: Naftal maintains reasonable geographic coverage across Batna, with 70% of stations reachable within 40 minutes. The distribution network appears well-positioned to serve the city's fuel demand with manageable logistics costs.

4.2 Current routing practice

In current practice, tanker routes are mainly determined based on the experience and judgement of operational staff, who group stations into tours and define visiting sequences without using formal optimisation models (Baqiya, n.d.). Each truck follows a predefined line that specifies the sequence of stations to be served during a delivery tour. Although these routes are operationally feasible, they have not been systematically evaluated in terms of time optimality, and the underlying travel-time matrix is not explicitly used in route construction.

The analysis performed in the original dissertation shows that, when travel times between stations are explicitly considered, several existing sequences are not minimal in terms of total time and alternative orders can reduce tour duration significantly (Hawas, 2011; Ratoul, 2006).

4.3 Graph-based route improvement

When the distribution network is treated as a directed graph and pairwise travel times are used to construct routes systematically, the resulting tours achieve lower total travel times than those obtained by intuitive planning. For example, three trucks starting from the depot and serving nearby stations such as Aurasia, La Gare and Ben Boulaïd underpass can be organised so that the nearest stations are visited in an order that minimises cumulative time, while alternative non-systematic orders lead to longer total durations (Hawas, 2011). Similar adjustments on a

ISSN: 2392-5353 (Printer)
E-ISSN: 2661-7528 (Online)
https://asjp.cerist.dz/en/PresentationRevue/466

second line combining Biskra road, Sonatiba and the 1200-dwellings station allow the planner to minimise back-tracking and redundant travel, thereby reducing total time per tour.

Although the exact numerical gains depend on the detailed travel-time matrix and constraints on loading quantities, the general pattern is clear: for all lines examined, the graph-based sequences produced lower total travel time than the current practice. This implies potential savings in fuel consumption, vehicle operating costs and driver time, as well as improved regularity and reliability of fuel deliveries to service stations (Maher, 2006; Ratoul, 2006).

Solving the problem using the shortest path theory

Step one: We will name the depot and the stations as follows:

1. Storage and Distribution Center: **CSD**.
2. Aurasia Station (R0534): point **A**.
3. La Gare Station (Shermouti): point **B**.
4. Ben Boulaïd Underpass Station (R0529): point **C**.
5. 500-Dwellings District Station (Benflis): point **D**.
6. Kchida Station (Baazouzi): point **E**.
7. Constantine Road Station (R0521): point **F**.
8. Biskra Road Station (R0523): point **G**.
9. Sonatiba Station (Sari): point **H**.
10. 1200-Dwellings District Station (Haddad): point **I**.
11. Tazoult Road Station (R0522): point **J**.

Step two: We will show the time required between each pair of points.

ISSN: 2392-5353 (Printer)
E-ISSN: 2661-7528 (Online)
https://asjp.cerist.dz/en/PresentationRevue/466

Table (02): Time required between the depot and each station, and between every pair of stations Time (in minutes)

Station	CSD	A	B	C	D	E	F	G	H	I	J
CSD	-	10	10	15	20	30	35	40	45	50	55
A	10	-	5	10	20	35	15	40	50	55	60
B	10	5	-	10	20	35	15	40	50	55	60
C	15	10	10	-	20	35	15	40	50	55	60
D	20	20	20	20	-	20	25	35	45	50	55
E	30	35	35	35	20	-	20	25	45	45	50
F	35	15	15	15	25	20	-	30	50	45	60
G	40	40	40	40	35	25	30	-	20	25	30
H	45	50	50	50	45	45	50	20	-	5	25
I	50	55	55	55	50	45	45	25	5	-	30
J	55	60	60	60	55	50	60	30	25	30	-

Source: Prepared by the authors based on data provided by the head of the Storage and Distribution Center (CSD – NAFTAL).

The table shows the time required between every pair of stations.

Step three: We will determine the distance in kilometres between the depot and each station, and between every pair of stations.

ISSN: 2392-5353 (Printer)
E-ISSN: 2661-7528 (Online)
https://asjp.cerist.dz/en/PresentationRevue/466

Table (03): shows the distance in kilometres between every pair of stations. Distance (in kilometres)

Station	CSD	A	B	C	D	E	F	G	H	I	J
CSD	-	1	1.5	1.6	2	2.5	3	5.5	6	6.5	8
A	1	-	0.3	0.51	2.1	1.53	2.53	5	4.3	3.72	4.62
B	1.5	0.3	-	0.23	1.76	1.45	2.8	4.7	4	3.45	4.48
C	1.6	0.51	0.23	-	1.57	1.47	3.02	4.5	3.76	3.21	4.35
D	2	2.1	1.76	1.57	-	1.63	4.55	2.95	2.73	2.24	4.63
E	2.5	1.53	1.45	1.47	1.63	-	3.6	4.1	4.35	3.85	5.72
F	3	2.53	2.8	3.02	4.55	3.6	-	7.47	6.63	6.1	5.91
G	5.5	5	4.7	4.5	2.95	4.1	7.47	-	2.94	2.95	6.34
H	6	4.3	4	3.76	2.73	4.35	6.63	2.91	-	5.44	3.53
I	6.5	3.72	3.45	3.21	2.24	3.85	6.1	2.95	5.44	-	3.4
J	8	4.62	4.48	4.35	4.63	5.72	5.91	6.34	3.53	3.4	-

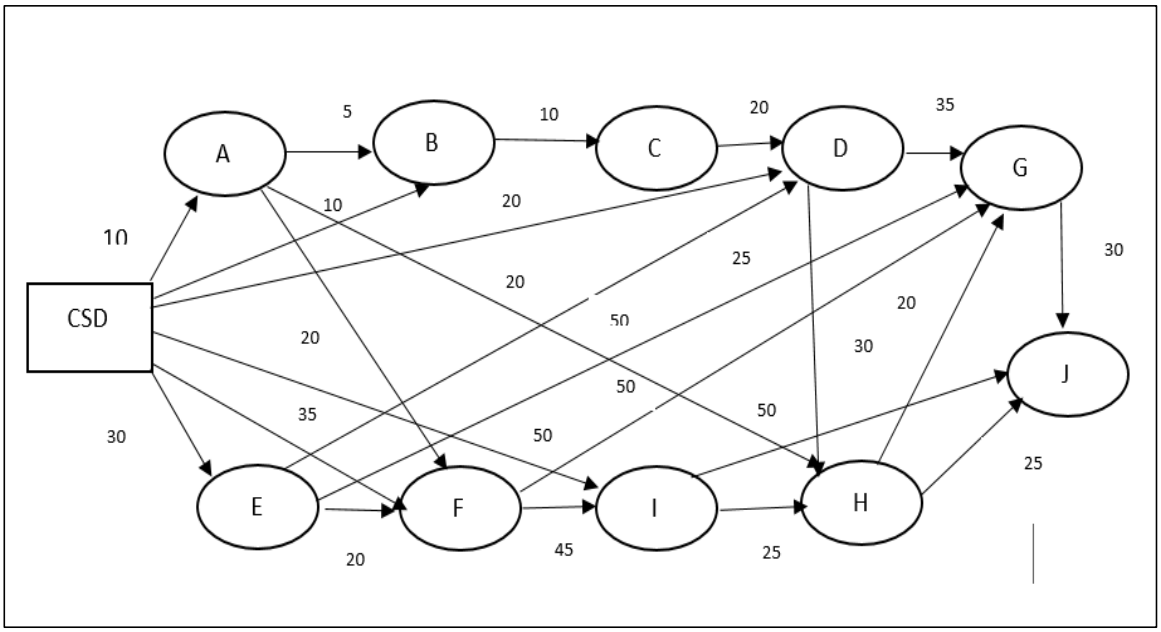
Source: Prepared by the authors based on data provided by the head of the Storage and Distribution Center (CSD – NAFTAL).

The depot distributes fuel according to the orders sent by the stations, and usually the head of the centre organises the tours as follows:

- The starting point is always the Storage and Distribution Center CSD (Centre de Stockage et de Distribution).
- **Truck 1**: unloads at station B, then passes station C and station D without unloading, then unloads at station E, and continues via stations F and I.
- **Truck 2**: unloads fuel at station D, then goes to station H, then to station A.
- **Truck 3**: unloads fuel at station F, then goes to station G, then to station E.
- **Truck 4**: unloads fuel at station E, then station D, then station H, passing through stations I and J without unloading.
- **Truck 5**: unloads fuel at station J, then passes stations A and C, unloads at station B, and then at station D.

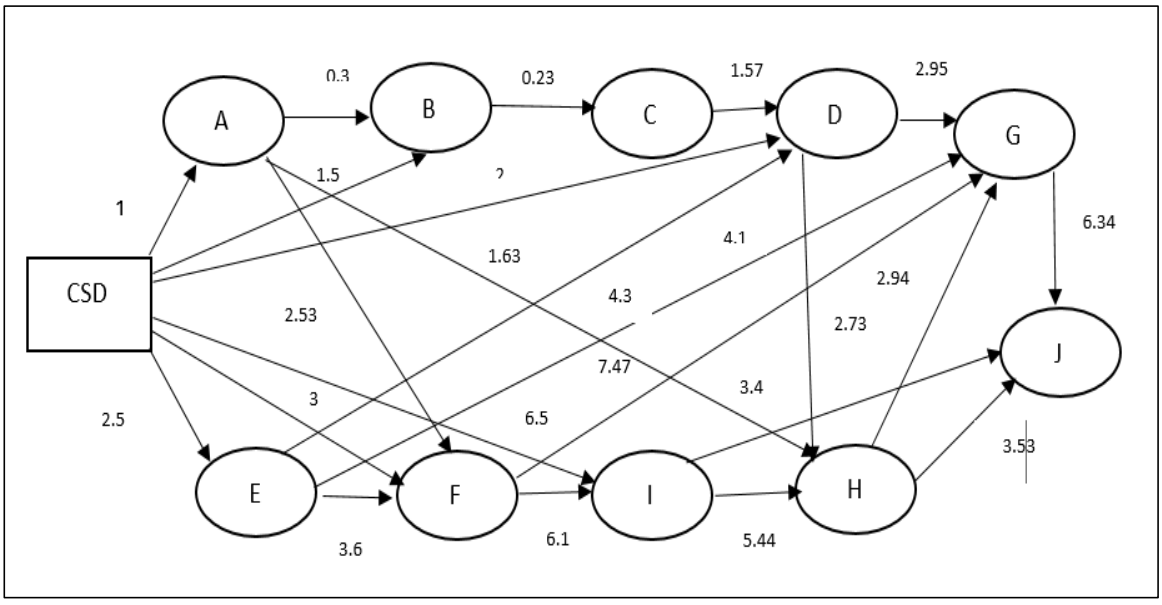
JoERRE:
Journal of economics studies and researches in renewable energies
2026, 13(01), 341-356,
ISSN: 2392-5353 (Printer)
E-ISSN: 2661-7528 (Online)
https://asjp.cerist.dz/en/PresentationRevue/466

Figure (02) Diagram: A schematic showing the time between the depot and the fuel stations (expressed in minutes), based on the distribution method used by NAFTAL's Storage and Distribution Center.



Source: Prepared by the authors based on data provided by the head of the Storage and Distribution Center (CSD – NAFTAL).

Figure (03) A diagram shows the distance (in kilometres) between the depot and the fuel stations, based on the distribution pattern used by the Storage and Distribution Center of NAFTAL



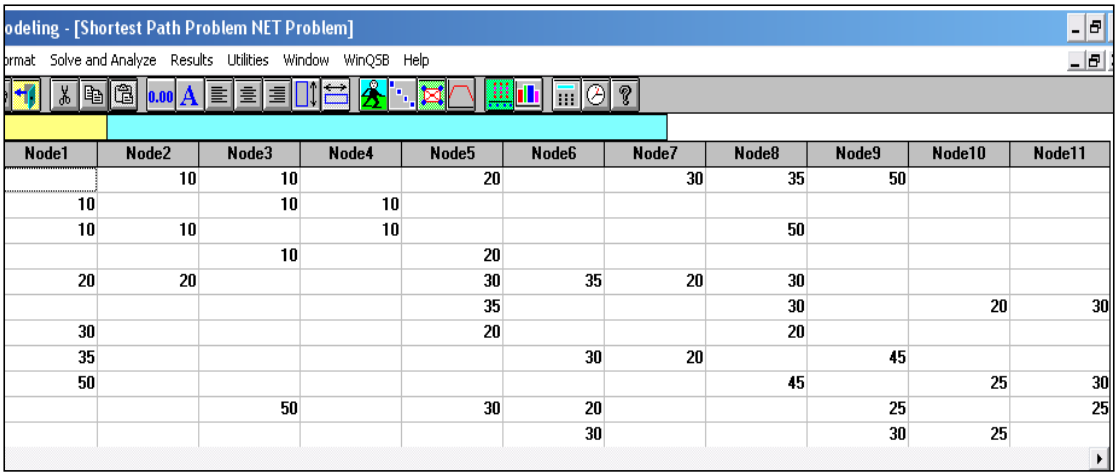
Based on the WIN QSB software and the network currently used by the company, the following results were obtained:

JoERRE:
Journal of economics studies and researches in renewable energies
2026, 13(01), 341-356,
ISSN: 2392-5353 (Printer)
E-ISSN: 2661-7528 (Online)
https://asjp.cerist.dz/en/PresentationRevue/466

Shortest-time route:

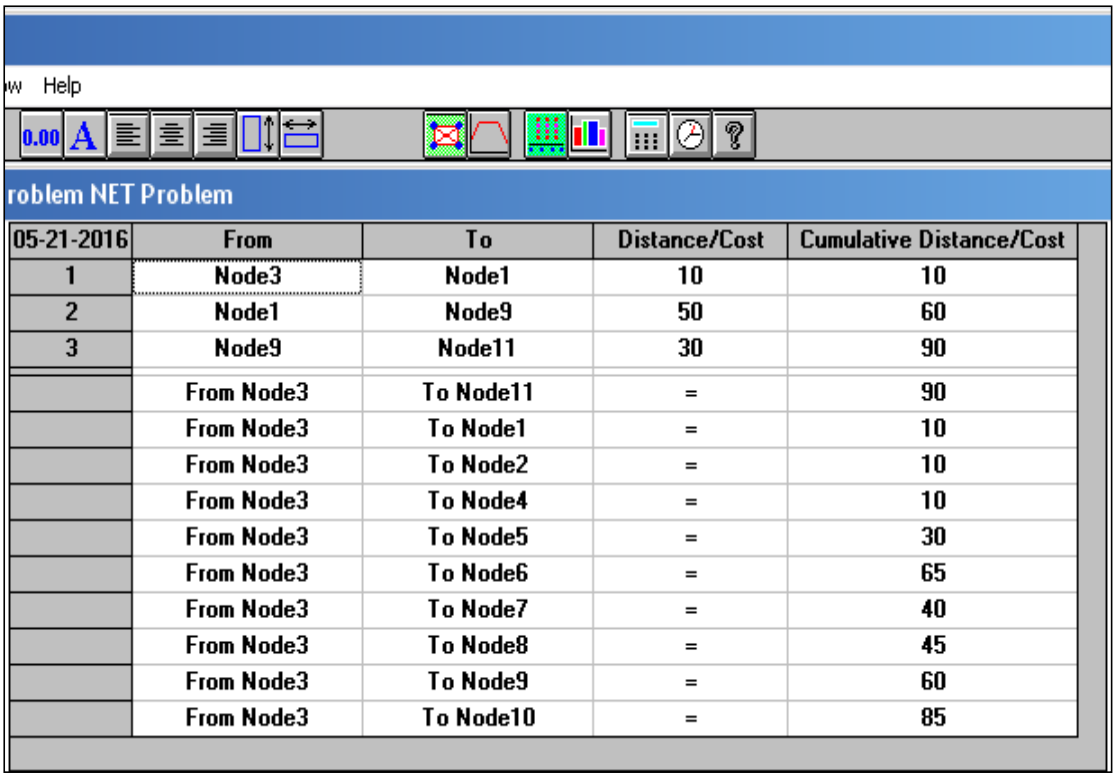
According to the routing pattern followed by the company in distributing its products, and after entering the time data as shown below:

Figure (04): Illustration of the data entered into the WIN QSB software



Node1	Node2	Node3	Node4	Node5	Node6	Node7	Node8	Node9	Node10	Node11
	10	10		20		30	35	50		
10		10	10							
10	10		10				50			
		10		20						
20	20			30	35	20	30			
				35			30		20	30
30				20			20			
35					30	20		45		
50							45		25	30
		50		30	20			25		25
					30			30	25	

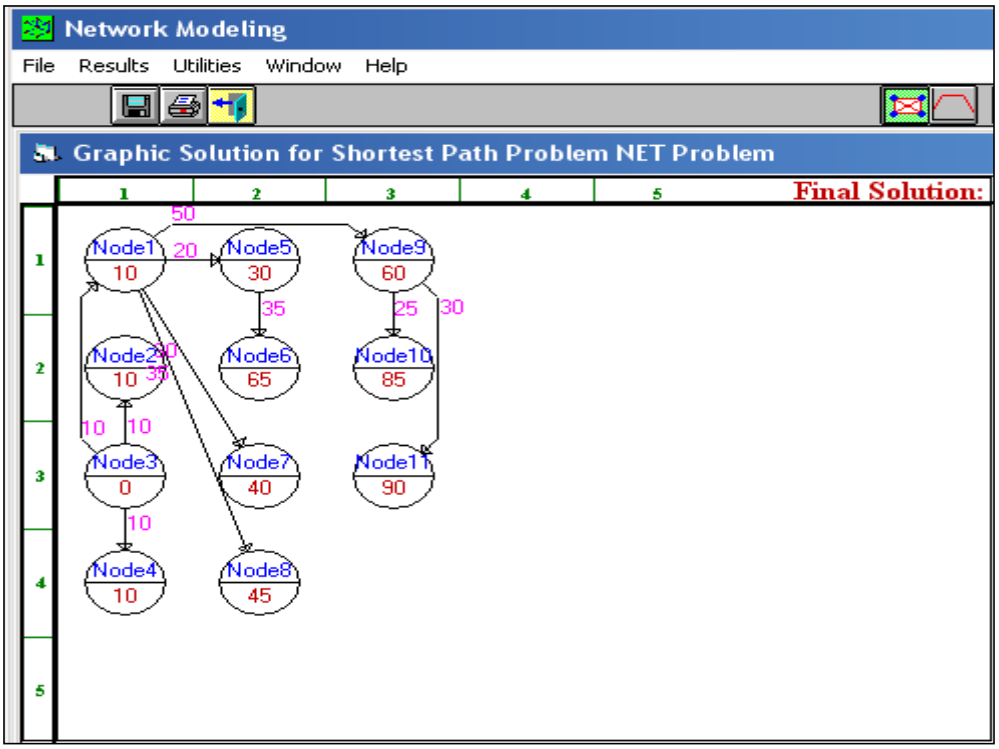
Figure (05): Results of WIN QSB software for the first truck's route



05-21-2016	From	To	Distance/Cost	Cumulative Distance/Cost
1	Node3	Node1	10	10
2	Node1	Node9	50	60
3	Node9	Node11	30	90
	From Node3	To Node11	=	90
	From Node3	To Node1	=	10
	From Node3	To Node2	=	10
	From Node3	To Node4	=	10
	From Node3	To Node5	=	30
	From Node3	To Node6	=	65
	From Node3	To Node7	=	40
	From Node3	To Node8	=	45
	From Node3	To Node9	=	60
	From Node3	To Node10	=	85

JoERRE:
Journal of economics studies and researches in renewable energies
2026, 13(01), 341-356,
ISSN: 2392-5353 (Printer)
E-ISSN: 2661-7528 (Online)
https://asjp.cerist.dz/en/PresentationRevue/466

Figure (06): Transport diagram of WIN QSB software for the proposed route of the first truck



From the program outputs, it is clear that when the truck follows the proposed route, it moves from B to A, then to point I, and finally reaches point J, taking a total time of 90 minutes, that is, 1 hour and 30 minutes. Therefore, the difference between the current route and the obtained (proposed) route is 35 minutes, which means that this route is better than the route currently used by the company.

Obtained route: La Gare station (Shermouti), then Aurasia station, then 1200-Dwellings station (Haddad), then Tazoult Road station.

Using the same method for the remaining points, the results are as follows.

- Truck 1: It unloads fuel at station B (10 minutes), then passes station C (10 minutes) without unloading, then station D (20 minutes) without unloading, then unloads at station E (20 minutes), then at station F (20 minutes), and finally at station I (45 minutes). The total time is 125 minutes. Practical study results:
  The optimal direction is towards stations B, A, I, J, with a total time of 90 minutes. The difference between the company's current route and the obtained route is 35 minutes; therefore, this route is better than the route currently used by the company.
- Truck 2 – current route: It unloads fuel at station F (35 minutes), then goes to station G (30 minutes), then to station E (25 minutes). The total time is 90 minutes. Practical study results: The optimal direction is towards stations F, I, J, with a total time of 60 minutes. The difference between the company's current route and the obtained route is 30 minutes; therefore, this is a better route than the one currently used by the company.

ISSN: 2392-5353 (Printer)
E-ISSN: 2661-7528 (Online)
https://asjp.cerist.dz/en/PresentationRevue/466

- Truck 3 – current route: It unloads at station D (20 minutes), then station H (45 minutes), then station A (50 minutes). The total time is 115 minutes. Practical study results: The optimal direction is towards stations D, J, H, with a total time of 65 minutes. The difference between the current route and the obtained route is 50 minutes; therefore, this is a better solution than the route currently used by the company.
- Truck 4 – current route: It unloads fuel at station E (30 minutes), then station D (20 minutes), then station H (50 minutes), passing through stations I (5 minutes) and J (30 minutes) without unloading. The total time is 135 minutes. Practical study results: The optimal direction is towards stations C, D, G, J, with a total time of 85 minutes. The difference between the current route and the obtained route is 50 minutes; therefore, this is a better route for the company.
- Truck 5 – current route: It passes station J (55 minutes), then station A (60 minutes), then passes station B (5 minutes) and station C (10 minutes) without unloading, then unloads at station D (20 minutes). The total time is 150 minutes. Practical study results: The optimal direction is towards stations J, H, D, A, with a total time of 75 minutes. The difference between the current route and the obtained route is 75 minutes; therefore, this is a better route for the company.

Finally, the routes obtained in the study are better than the routes currently used by the company.

5. Results and discussion

The empirical analysis compares, for five tanker trucks, the total travel time associated with the routes currently used by NAFTAL – Batna unit and the alternative routes generated by the optimisation model. For each truck, the original route reflects the sequence of fuel stations determined by operational practice, whereas the optimised route is obtained by applying the graph-based procedure in WIN QSB under the same operational constraints.

The results indicate a consistent reduction in total travel time across all trucks when the optimised routes are adopted. For the first truck, the company's route requires 125 minutes to complete its tour, while the optimised route reduces this duration to 90 minutes, representing a saving of 35 minutes. For the second truck, the current route takes 90 minutes whereas the proposed route reduces the time to around 60–65 minutes, yielding a gain of approximately 25–30 minutes. Similarly, the third truck's tour time drops from about 115 minutes (one hour and 55 minutes) to 60–65 minutes, with a saving of roughly 50–55 minutes. For the fourth truck, the travel time decreases from about 135 minutes (two hours and 15 minutes) to around 80 minutes, implying a reduction of about 50–55 minutes. Finally, the fifth truck's route is reduced from approximately 150 minutes (two hours and 30 minutes) to 75 minutes, representing a saving of 75 minutes.

These time savings are substantial when considered at the level of individual tours, and they become even more significant when aggregated over the number of trips performed daily or weekly. From a managerial perspective, the reduction in travel time can translate into lower

ISSN: 2392-5353 (Printer)
E-ISSN: 2661-7528 (Online)
https://asjp.cerist.dz/en/PresentationRevue/466

fuel consumption, better utilisation of the vehicle fleet, improved service reliability for fuel stations and, ultimately, a decrease in overall transport costs. The results therefore provide empirical support for the second hypothesis of the study, namely that the set of routes currently used by NAFTAL is not time-optimal and that alternative routes derived from an operations-research-based optimisation model can achieve better performance.

Moreover, the findings also have implications for the first hypothesis, which posited that NAFTAL does not systematically employ operations research methods in its transport planning. The observed gap between the performance of existing routes and that of the optimised routes suggests that routing decisions have been made largely on the basis of experience and heuristic judgement rather than on formal quantitative analysis. While practical knowledge remains important, the study shows that complementing it with systematic optimisation techniques can yield non-trivial performance gains. This underscores the potential role of operations research as a decision-support tool in the logistics management of fuel distribution.

6. Conclusion

This study set out to examine how operations research, and graph-theoretic modelling in particular, can contribute to improving transport planning at NAFTAL – Batna unit. By representing the fuel distribution network as a directed graph and using specialised optimisation software to generate alternative routing plans, the research compared the travel times associated with current routes and with optimised routes for five tanker trucks serving ten service stations.

The empirical results demonstrate that the optimised routes systematically reduce total travel time, in some cases by more than one hour per tour, thereby confirming that the company's existing routing practices are not time-efficient. These findings validate the study's hypotheses that NAFTAL does not systematically rely on operations research tools in its transport planning and that formal optimisation can produce superior routing solutions. Beyond the specific case of NAFTAL – Batna unit, the study illustrates more broadly how quantitative methods can be used to support logistics decisions in transport-intensive sectors.

From a practical standpoint, the study recommends that NAFTAL progressively integrate operations research techniques into its planning processes, starting with pilot projects at the unit level. This would involve training staff in the use of optimisation software, systematically collecting and updating data on travel times and routes, and incorporating quantitative analyses into routing and scheduling decisions. Future research could extend the present work by including additional operational constraints such as vehicle capacities, time windows at service stations and varying traffic conditions, or by comparing different optimisation approaches. Such extensions would further refine the understanding of how operations research can enhance the efficiency and reliability of fuel distribution systems.

ISSN: 2392-5353 (Printer)
E-ISSN: 2661-7528 (Online)
https://asjp.cerist.dz/en/PresentationRevue/466

7. References

Ahuja, R. K., Magnanti, T. L., & Orlin, J. B. (1993). *Network flows: Theory, algorithms, and applications*. Prentice Hall.

- Crainic, T. G., & Laporte, G. (Eds.). (1998). *Fleet management and logistics*. Springer.
- Diestel, R. (2017). *Graph theory* (5th ed.). Springer.
- Hay, A. (1993). *Transport for tomorrow's cities*. Routledge.
- Hillier, F. S., & Lieberman, G. J. (2021). *Introduction to operations research* (11th ed.). McGraw-Hill Education.
- OECD. (2003). *Delivering the goods: 21st century challenges to urban goods transport*. OECD Publishing.
- Taha, H. A. (2017). *Operations research: An introduction* (10th ed.). Pearson.
- Thompson, R. G., & Taniguchi, E. (2015). City logistics and urban freight transport. In M. M. Fischer & P. Nijkamp (Eds.), *Handbook of regional science* (pp. 1–17). Springer.

مقالات / دراسات محكّمة

- CREAD. (2021). Fuel distribution of NAFTAL company: Management issues and regional coverage. *Les Cahiers du CREAD, 37*(2), 145–170.
- Iwan, S., et al. (2024). Concept of the knowledge-based city logistics. *Sustainability, 16*(13), 5632.
- Mahdi, H., & Hadda, A. (2011). La circulation dans la ville de Batna (Est Algérien): Réalité et perspectives – Approche par les SIG. Communication, FIG Working Week.
- Russo, F., & Comi, A. (2012). City logistics: A review of modelling approaches. *Transport Reviews, 32*(4), 427–442.
- Savelsbergh, M. W. P., & Van Woensel, T. (2016). City logistics: Challenges and opportunities. *Transportation Science, 50*(2), 579–590.
- Taniguchi, E., Thompson, R. G., & Yamada, T. (2016). New opportunities and challenges for city logistics. *Transportation Research Procedia, 12*, 5–13.
- Hawas, M. (2011). Problématique de la mobilité urbaine dans les villes algériennes: Cas de Batna.

راتول، م .(2006) .بحوث *العمليات* (الطبعة الثانية). الجزائر : ديوان المطبوعات الجامعية.