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The Effectiveness of Using the Vogel Approximation Method to Reduce the Cost of Electrical Power Transmission: A Case Study Using MATLAB Programming

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Abstract

The transportation problem is a critical economic activity for productive institutions, serving as a key component of the production process. By identifying the most efficient routes for delivering goods or services, it helps minimize transportation times and reduce overall production costs. Consequently, organizations and their management prioritize optimizing transportation methods to achieve cost efficiency. To address rising transportation expenses while ensuring timely and cost-effective delivery, careful planning using scientific methods is essential. This study examines the cost of transmitting electrical energy from power generation stations—including steam, gas, diesel, hydroelectric, imported, and investment power plants—to distribution companies such as Baghdad Electricity Distribution, Central Electricity Distribution, Northern Electricity Distribution, Middle Euphrates Electricity Distribution, and Southern Electricity Distribution. Due to the unavailability of actual transportation costs between supply and demand centers, a MATLAB-based simulation program was developed to generate transportation costs based on production and demand data from the 2022 annual report of the Iraqi Ministry of Electricity. Additionally, transmission line lengths were factored in to construct a transportation cost matrix. The Vogel Approximation Method (VAM) was applied using MATLAB programming to determine the optimal cost function. The results demonstrated a substantial reduction in total electricity transmission costs: the initial actual cost was minimize Z = 55,776,380,275, while the optimized cost after implementing VAM decreased to minimize Z = 3,703,030,260*. This highlights the effectiveness of VAM in significantly lowering transportation expenses.

Key Words: Transportation problems; Vogel's Approximation Method (VAM); MATLAB programming, Linear programming; electrical distribution companies.

1. Introduction

The Logistics Challenge is a frequent issue in operations analysis and is classified as a specific form of network efficiency issue. The approach employs a distinct data arrangement that is characterized by a transportation network. Transportation systems are crucial in operations and supply networks. Transportation difficulties typically include establishing a cost strategy for conveying a singular item from multiple sources to various destinations. The objective is to minimize shipping costs for transporting goods to fulfill the requirements of each consumption area while ensuring that each delivery facility functions inside the limits of its ability in Pratihar, J., Kumar et al. (2021).

Linear programming involves optimizing linear functions under specific conditions, with the aim of maximizing or minimizing values. This optimization technique is commonly used to solve transportation problems within the scope of operations research. These transportation problems also include balanced and unbalanced scenarios, with the goal of reaching Initial Basic Feasible Solutions (IBFS) and reducing costs, aiming to achieve optimal results in the end in Pratihar, J., Kumar et al. (2021) and Madamedon, S. (2023).

The roots of transportation problems trace back to the scholar Hitchcock in 1941, who developed transportation problem algorithms during World War II. These problems are crucial in supply chain management, optimization techniques, and various fields such as mathematics, engineering, business, and economics. In 1947, Koopmans.C.T presented a study titled "The Optimal Use of the Transportation System," which was later developed by George B. Dantzig in 1963. In 1951, George B. Dantzig and others studied the Modified Distribution Method

(MODI) to obtain the optimal solution, while the Stone Stepping method was proposed by Cooper and A. Charnes in 1954.As for the Vogel Approximation Method (VAM), it was proposed by Vogel in 1958 in Madamedon, S. (2023).

The VAM method has gained prominence in several practical applications because it provides the best possible initial basic feasible solution (IBFS) and a highly efficient or nearly optimal solution. This has led to the proposal of new methodologies for selecting IBFS by several researchers, including (Amaliah et al., 2019; Karagul & Sahin, 2020), who compared it with the traditional VAM method in terms of performance efficiency. Banik, D., & Hasan, Z. (2018), also proposed the modified Vogel's approximation method (MVAM) in 2011. Which states that instead of selecting the row/column with the highest penalty cost, MVAM selects the three rows or columns with the highest penalty cost. Jain also introduced the Maximum Difference Approach in 2022 as an innovative method for determining IBFS, providing a direct and efficient solution that generally outperforms the variance analysis in the MVAM method. Amaliah et al. (2022) also proposed a study on transportation costs and presented a new approach to the selection of supply stations to reach the optimal solution for balanced problems.

The research problem focuses on studying an important sector of the Iraqi economy, specifically the electricity sector and, more precisely, the production of electrical energy in power generation stations. The lack of studies addressing the transportation problem due to the unavailability of data has been an obstacle for many researchers. Therefore, overcoming these obstacles by generating initial costs and building a transportation matrix for the transportation problem from supply centers to demand centers using MATLAB is a significant contribution. It also provides decision-makers with a clear view of studying the optimal allocation problem and reducing transportation costs based on the actual data of demand quantities and the future actual need for electricity in Iraq.

The main objective of paper is including the possibility of reducing the quantities of electrical energy distribution supplied by the main power generation stations in Iraq. Therefore, it is important to conduct a study that describes the solution to the transportation problem, represented by reaching optimal consumption. Additionally, the amount of surplus from the distribution of consumed electrical energy can be determined using scientific methods by calculating the optimal transportation cost according to the Vogel Approximation Method (VAM).

2. Related work

The Democratic Republic of Congo (DRC) possesses an estimated hydropower potential of one hundred gigawatts (100 GW) and substantial quantities of oil, natural gas, and coal. The Democratic Republic of the Congo possesses a significant daily solar power possibility, valued at 4 to 6 kilowatt-hours per square meter per day (kWh/m²/day) of Global Horizontally Irradiation (GHI). It possesses a substantial biomass energy potential of between 300 to 700 Gigawatt-hours annually from farm waste. This research examines Kruskal's technique, Vogel's approximations approach, and the adapted transmission method as effective optimization techniques for electrical system design, specifically regarding energy distribution in the DRC (P. O. Kalonda and A. M. Omekanda,2020).

This study examines MATLAB code programmers for all stages of addressing Sequential Logistic Linear Optimizations Issues with Fuzzy Unknown Information on Probabilistic Distributed Space (STLPPFI), including algorithmic outlines. A MATLAB code system for solving STLPPFI issues is suggested, incorporating various concepts such as the Alpha-Cut method, Truth The degrees method, Linear Fuzzy Participation Functions (LFMF), Circular Fuzzy Numbers, The triangle Fuzzy Numbers, Linear Fuzzy Sorting Functions (LFRF), The expectations Weighted The combination method (EWS), and case analysis through the second requirement test of the alpha-cut method (Azeez, H. N., & Ameen , A. O. ,2024) .

The document provides a numerical illustration of an approach to the transportation issue employing the northwestern technique, the approach with the lowest cost in the matrices, the row lowest method, and Vogel's Approximations Method (VAM). The combined use of computer programming and optimization was relevant to actual conditions. The transportation was conducted using medium-load trucks. The producers and consumers of commodities were physically situated inside the boundaries of the country of Poland. The proposed model was substantiated by a numerical illustration, accompanied with explanation and visualization of the data produced. The execution of the suggested solution allows the user to construct an optimal transit plan based on certain parameters (Szkutnik-Rogoż, Joanna, et al.2021).

This study seeks to address a robust mobility problem, whereby the unreliable variables are defined by triangular Fermatean numbers that are fuzzy. Fermatean fuzzy sets present a comparatively innovative and broader alternatives, equipping administrators with more adaptable tools for handling uncertain information during the process of making decisions.

According to our literature review, there is no algorithm available for fuzzy solid transportation problems that include triangle Fermatean numbers that are uncertain. Consequently, this study extends current Vogel's approximations technique for deriving the initial basic attainable solution (IBFS) of classical issues in transportation to encompass Fermatean uncertain solid transport issues (Shivani, and Deepika Rani.,2024).

This paper presents a methodology for addressing nonlinear features through nuclear waves, alongside a system for comprehensive nuclear base problem extraction, categorization, and decision-making. It emphasizes research on nuclear base state forecasting technology, concentrating on enhancing the precision of fault identification in nonlinear circumstances and the technical approaches for enhancing state accuracy in forecasting. It provides efficient technical support for the development and application of mechanical powertrain monitoring and diagnostic technology. A defect detection technique utilizing kernel techniques is proposed. Considering the attributes of this approach in addressing nonlinear issues, the investigation into kernel feature extraction, The experimental findings indicate that the numerical analysis of typical disorganized time series forecasting and the operational state forecasting of a specific ship's main steam-powered turbine unit have yielded favorable outcomes, with the average proportional error for single-step state forecasting at 1.7881% and the average compared error for 30-step forecasting at 3.3983% (Guo, et al,2021).

One of the most significant and effective applications of statistical analysis in addressing business challenges has been in the actual distribution of products, usually known issues with transportation. The objective is to reduce shipping costs from one site to another, ensuring that the requirements of each destination are fulfilled and that all shipping locations function within their capacity. We can formulate an issue regarding transportation and resolve it via the simplex method, similar to any linear algorithm. The unique nature of the transportation problem enables us to employ a more efficient and cost-effective solution than the simplex method. This study does a comparative analysis of various approaches for evaluating transportation costs, selecting those that minimize expenses and maximize profit (Sirait, M., et al.,2025).

The study introduces sophisticated mathematical solutions for certain sectors aimed at optimizing technological processes, hence fostering development and enhancing sustainability in smart cities. The primary focus was on essential urban development sectors, specifically the application of algorithms utilizing artificial intelligence within oversight control networks

(SCADA-type, including Virtual SCADA) for technological processes related to sewage treatment systems, particularly treating sewage, and waste disposal systems. The innovation of the proposed solution lies in the application of forecasting diagnostic equipment utilizing multi-threaded distinct models that facilitate decision-making processes in the administration of complicated technological procedures and dispersed networks (such as smart fluid grids, smart wastewater treatment plants, and smart waste disposal systems). It addresses optimal control challenges for intelligent objects that change through an intuitive representation of information regarding the process, the controlling object, and the control mechanism itself. The learning method entails continuous validation and modifying of information, with the outcomes of this modifying employed to inform control choices (Gaska, K., & Generowicz, A., 2020).

This study proposes a stochastic economical dispatch model that incorporates thermal units (fuel generators), solar arrays, and wind energy transformation systems. Wind acceleration, radiation from the sun, and consumption of electricity are acknowledged as stochastic variables. The inaccessibility of each generator type is also taken into account. The solution strategy employs the technique of Monte Carlo and non-linear constraint optimization. The ideal solution encompasses univariate and multivariate probability, descriptive statistics, clustering, and bidirectional analysis. The suggested approach produces the likely probabilities of system residual price, heating (fuel-based) generations, solar and wind energy generations, and load dropping. The suggested concept and technique are used in a case study of the Northern Chilean electrical system (Zhao, Z., et al.2025).

The primary emphasis at this stage pertains to the optimization of the cars' charging manner. Consequently, this study first implements the suggested multi-objective optimization by presenting its method and detailing the modelling of its goal variables together with their respective constraints. Furthermore, the weighted sum method is utilized subsequent to the normalization of all utility operations, and multiple investigations are conducted to identify optimal solutions according to the prioritization of some objectives over others. Upon completion of all computations, a simulation utilizing Matlab software is executed, and findings are analyzed and compared. The simulation findings have validated the mathematical calculations, thereby demonstrating the efficacy of the suggested technology (Merhy, G., et al.2021).

A developed online update structure for the management of energy (EMS) in a multiple modes hybrid electrical powertrain utilizes collaboration between an asynchronously advantageous actor–critic (A3C)-based deep learning (DRL) agents and a model of Markov chains (MCM). The DRL agent routinely revises the energy administration policy. The MCM accelerates the policy updating procedure by producing several potential future drive cycles based on recent past driving data and providing them to participants in the training procedure. With the aid of the MCM, the suggested A3C-based energy administration system may produce a foreseeable-optimal policy for any uncertain drive cycles in the near future (Biswas, A., et al.2021).

3. The Transportation Problem

There are many problems discussed in operations research, and the transportation problem is one of the widely used and discussed issues in linear programming for operations research, which is directly applied in our daily activities in the field of logistics and supply chain. It helps solve problems related to the distribution and transportation of resources from different sources to different destinations so that the transportation cost is optimal for the goods. The units of resources to be provided from the source to the destination are the primary objective so that the transportation cost is minimal and the profit is maximized. The transportation problem(Weerasinghe, B. A., Perera, H. N., & Bai, X. (2024)) occurs in the company because of a lack of supplies or the organization's restricted ability to distribute from multiple locations (supply) to multiple destinations (consumer), Hassan, E. E. D. H., & Zaazou, Z. A. (2022) and Petropoulos, F., et al. (2024).

To illustrate the operation of the network model for the transportation problem, Figure (1) shows the objective of transportation problem models, which is to identify the optimal method for satisfying the requirements of demand points (n) utilizing the obtainable resources to provide points (m).

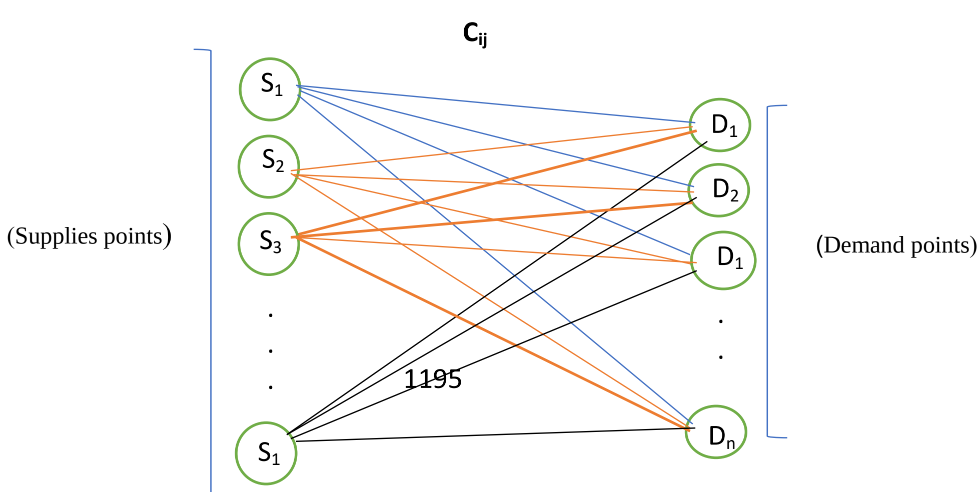

Figure 1: Shows a network model for transportation problems.

In Figure (1), S1-Sm represent the sources and D1-Dn represent the destinations (Hassan, T. M. H. T., & Masrom, M. (2022)) and (Weerasinghe, B. A., Perera, H. N., & Bai, X. (2024)). It is the cost (Cost) and it is the number of units being shipped from the supply point (Supply) i to the demand point (Demand) j. Therefore, the main objective is to determine the number of units transported from source i to demand j in such a way that the total transportation cost is minimized. Assuming that the costs are linear, the general form of the linear programming for the transportation problem is:

$$minimize\ Z = \sum_{i=1}^{m} \sum_{j=1}^{n} c_{ij} x_{ij} \quad \dots (1)$$

$$subject\ to$$

$$\sum_{i=1}^{m} x_{ij} \leq S_i \quad (i = 1,2,\dots,m) \quad Supply\ Contraints \quad \dots (2)$$

$$\sum_{j=1}^{n} x_{ij} \geq D_j \quad (j = 1,2,\dots,n) \quad Demand\ Constraint \quad \dots (3)$$

$$x_{ij} \geq 0 \ \ and\ integer\ for\ all\ i,j$$

Where:

Z : The objective function is to minimize the total transportation cost.

c_{ij} : The transportation cost per unit from source (i) to destination (j).

x_{ij}: Units of the goods sent from the source (i) to the destination (j).

S_i : The quantities supplied from source (i).

D_j : The quantities required to destination (j)

If the total supply $\sum_{i=1}^{m} S_i$ equals the total demand $\sum_{j=1}^{n} D_j$, then the problem is to be a balanced transportation problem. In the case of multiple sources to demand locations with different transportation methods, the problem becomes more complex as these sources and locations increase and diversify, and it is referred to as an unbalanced transportation problem. This results in the difficulty of evaluating the objective to be achieved, which is the lowest possible transportation cost (Sathishkumar, P., & Gunasekaran, M. (2021)) and (Hlatká, M., Bartuška, L., & Ližbetin, J. (2017)).

The transportation problem requires certain conditions to be met for its study, which are as follows:

1- There is a specific, known, and quantifiable capacity for the facilities from which goods are transported, while the requesting entities for those goods must also prove their need and measure it quantitatively.

2- Establishing different routes for shipping goods from display locations to demand locations, so that one can choose from among the alternative routes.

3- Fixing the cost required to transport a single unit of goods from shipping locations to demand locations in order to maintain the linear property.

To solve the transportation problem, the following stages must be designed: (Pratihar, J., et al. (2021)).

1- Building the transportation matrix, then designing a feasible basic solution, which can be determined in several ways, including the northwest corner method or the least cost method.

2- Testing the optimality of the solution by determining the cost of each empty cell (non-basic variables) in order to know the possibility of reducing the total transportation cost that was occupied in the initial solution, as the optimality of the solution is achieved when the cost of all unoccupied cells is negative or equal to zero.

3- Building additional solutions using the unoccupied cells that achieve the greatest reduction in total transportation cost, meaning introducing basic variables into the solution to make them basic, and by repeating steps (2, 3) to obtain the optimal solution. To convert the linear programming model in equation (1) and figure (1) according to the above conditions for studying the transportation problem model, the transportation matrix is constructed as follows:(Hatem, W. A., & Erzaij, K. R. (2020, July)).

Table 1: The General Form of the Transport Matrix.

Source	Destination				Supply
	D1	D2	…	Dn	
S1	C_{11}	C_{12}	...	C_{1n}	s_1
S2	C_{21}	C_{22}	...	C_{1n}	s_2

…	...	...	...	...	...
Sm	C_{m1}	C_{m2}	...	C_{mn}	s_m
Demand	d_1	d_2	...	d_n	

In the table above, D1, D2, ..., Dn represent the destinations to which products/goods will be delivered from different sources, and S1, S2, ..., Sm represent the supply from source Sm. dn is the demand from destination Dn. As for Cmn, it is the cost of delivering the product from source Sm to destination Dn.

4. Methods for Solving the Transportation Problem Model

In order to improve transportation costs (the lowest possible cost) for products, certain solution methods are used, including the following: (De Bock, K. W., et al. (2024)).

4.1. (North West Corner (NWC)) :

The distribution technique for product allocation initiates from the upper left edge of the table or from the cell located in the initial columns and initial row. The optimal outcome for this approach is suboptimal due to the allocation's disregard for the expense of transportation.

4.2. (Least Cost) :

The allocation of items via transportation commences from the cell exhibiting the minimal expense of transportation. Distribution outcomes derived from the smallest cost approach are typically more successful and productive than those produced by the northwest region approach.

4.3.(Vogel's Approximation Method (VAM)) :

The optimization method is carried out by finding the difference between the two smallest costs.

4.4.(Russel Approximation Method (RAM)) :

The optimization process begins by finding the highest cost for each row and column in the transportation table.

4.5. (MODI Modified Distribution (MODI)) :

The optimization is carried out by adjusting the result of the Northwest Corner Method (NWC) using the Least Cost Method.

4.6.(Stepping Stone Method) :

Improvement processes are implemented by filling in the empty cells resulting from the previous methods.
It is worth noting that the aforementioned methods have their own advantages and disadvantages. In our study, we will highlight the Vogel Approximation Method (VAM).

4.7.(Vogel's Approximation Method (VAM)) :

The Vogel Approximation Method (VAM) is a computational technique and an enhanced variant of the Lowest Costs Approach. The VAM typically yields a superior initial answer compared to alternative approaches. The utilization of the VAM approach for a particular issue does not ensure the attainment of a perfect solution. Nonetheless, an excellent result is consistently achieved with minimal effort.

In general, the VAM method provides an initial solution that is ideal or close to the optimal solution for small-sized transportation problems. Additionally, solving transportation problems using the Vogel Approximation Method (VAM) will lead to an optimal solution when compared to the Northwest Corner Method or the Least Cost Method. The mechanism of the VAM method relies on the following steps: (De Bock, K. W., et al. (2024)).

- The repercussions cost is determined by calculating the distinction between the two lowest uneven values in all the columns and rows of the cost table.
-We determine the row or column with the maximum penalty cost, and in the event of a tie, pick at random the rows or columns associated with the greatest difference.
- Upon finding the columns or rows with the greatest disparity, a value is allocated to the variable that incurs the minimal transit cost inside that row or columns.

-The columns or rows with a total of 0 is removed.
- The previous steps are repeated until all the available units (resources) are distributed to the required units (demand).

5. Result and Discussion

The importance of studying the transportation problem model lies in the improvements that positively reflect on the progress of any establishment from both economic and technological perspectives. In our study, data from the Ministry of Electricity will be taken, related to the study of the cost of transporting electrical energy from power generation stations (supply), which include (steam power stations, gas power stations, diesel and hydroelectric stations, imported and investment power stations) to electrical distribution companies (demand), which include (Baghdad Electricity Distribution Company, Middle Electricity Distribution Company, North Electricity Distribution Company, Middle Euphrates Electricity Distribution Company, and South Electricity Distribution Company). Table (2) shows the capacity of the electricity distribution companies and the number of stations affiliated with each company, as follows:

Table 2: Shows the Amount of Energy Produced by The Type of Power Generation Plants for The Year 2021.

Supply Stations	Amount of Energy Produced MWH
Steam Power Stations	28919785
Gas Power Stations	50161947
Diesel + Hydroelectric Power Stations	93105494
Imported and Investment Power Stations	41464957

The total	210332990

Source: Based on the annual statistical report (2022), Department of Informatics and Systems, Central Statistics Division, as per the researcher's work. Iraqi Ministry of Electricity website / Annual Statistical Report for 2022.

Table 3: Shows the Amount of Energy Supplied to Electrical Distribution Stations for the Year 2021.

Demand Stations	Amount of Energy Produced MWH(2021)	Scope of Areas
Electricity of Baghdad	32245367	Karkh, Rusafa, Sadr
Middle Electricity	16520044	Diyala, Ramadi, Anbar, Wasit
Northern Electricity	20881363	Ninewa, Salah al-Din, Kirkuk
Middle Euphrates Electricity	19015177	Babylon, Najaf, Karbala, Diwaniya
Southern Electricity	35063666	Basra, Dhi Qar, Al-Muthanna, Maysan
The total	123725617	

Source: Based on the annual statistical report (2022), Department of Informatics and Systems, Central Statistics Division: Iraqi Ministry of Electricity website / Annual Statistical Report for 2022.

According to experts, the cost of producing electrical energy ranges between (10-50) dollars per kilowatt-hour (KWh) depending on the distance and geographical distribution. It also includes the operational costs of the stations and fuel costs. As for the transportation cost, which includes the construction costs (stations), operation, network maintenance, in addition to the costs of energy production itself. Therefore, the cost of transporting a single unit from the supply area to the demand area varies based on the aforementioned reasons and the topography of the supply area and the specific equipment of the electricity system. Due to the unavailability of data showing the transportation costs per unit of electrical energy production measured in megawatt-hours in Iraq, a simulation program was written in the programming language (MATLAB) to generate the transportation costs from the production stations to the distribution stations based on the data available in tables (2, 3) as shown in appendix (1). The transportation cost was calculated as shown in the following table:

Table 4: Shows the Estimated Transportation Costs Based on Simulation from Production Stations to Distribution Stations (In Dollars).

Distribution Stations / Production Stations	Electricity of Baghdad	Northern Electricity	Middle Electricity	Middle Euphrates Electricity	Southern Electricity	Offer
Steam Power Stations	20 **644807340**	**522033415**	**495601320**	**665532000**	**1402546640**	**28919785**

Gas Power Stations	15 **483680500**	20 **417627260**	25 **413001100**	30 **570455200**	35 **1222241600**	**50161947**
Diesel + Hydroelectric Power Stations	**806134175**	**626440090**	**578712960**	**761607080**	**1578534840**	**93105494**
Imported and Investment Power Stations	30 **967360010**	35 **731411555**	40 **706400200**	45 **855683140**	50 **1753183300**	**41464957**
The Demand (the Supplied load)	**32245367**	**20881363**	**16520044**	**19015177**	**35063666**	

Through Table (4), it becomes clear that the transportation problem is unbalanced because the supply quantities are higher than the demand quantities. Therefore, a fictitious demand source was added to the transportation matrix, and the quantity that achieves balance between supply and demand quantities was included. As shown in Table (5):

Table 5: Shows the Estimated Transportation Costs After Adding the Fictitious Source.

Distribution Stations / Production Stations	***Electricity of Baghdad***	***Northern Electricity***	***Middle Electricity***	***Middle Euphrates Electricity***	***Southern Electricity***	***Fake Source***	***Supply***

Steam Power Stations	20 644807340	522033415	495601320	665532000	1402546640	0	28919785
Gas Power Stations	15 483680500	20 417627260	25 413001100	30 570455200	35 1222241600	0	50161947
Diesel + Hydroelectric Power Stations	806134175	626440090	578712960	761607080	1578534840	0	93105494
Imported and Investment Power Stations	30 967360010	35 731411555	40 706400200	45 855683140	50 1753183300	0	41464957
The Demand	32245367	20881363	16520044	19015177	35063666	89926566	213652183

In Table (5), it is clear that the total of the generation stations equals the total of the demand stations, amounting to (213652183) megawatt-hours. This means that the transmission matrix has become balanced.

According to Table (5), the total transportation cost according to Equation (1) amounted to

$$\textit{minimize } Z = \mathbf{644807340} \times (\mathbf{20}) + \mathbf{522033415} \times (\mathbf{25}) + \mathbf{495601320} \times (\mathbf{30}) + \cdots + \mathbf{1753183300} \times (\mathbf{50})$$

$minimize\ Z = 575776380275$

To extract the results for the lowest cost and optimal allocation for the transmission of electrical energy from production stations to processing stations, a program was written in (MATLAB) as shown in Appendix (2) to calculate the optimal transportation cost function using the Vogel's approximation method, based on the steps outlined in section (G). After applying the steps, the results were as shown below:

Table 6: Shows the Optimal Allocation Matrix Based on The Results of MATLAB Program.

	Fake Source	Southern Electricity	Middle Euphrates Electricity	Middle Electricity	Northern Electricity	Electricity of Baghdad
Steam Power Stations	**28919785**	**0**	**0**	**0**	**0**	**0**
Gas Power Stations	**3325582**	**20881363**	**16520044**	**9434958**	**0**	**0**
Diesel + Hydroelectric Power Stations	**0**	**0**	**0**	**9580219**	**35063666**	**48461609**
Imported and Investment Power Stations	**0**	**0**	**0**	**0**	**0**	**41464957**

As for the objective function to calculate the minimum total transportation cost, it is:

$minimize\ Z = 3703030260$

6. Conclusions

In this study, the costs of transmitting electrical energy were generated based on the available real data specific to the processing stations and demand areas from the processing centers to the demand centers, and the transportation cost matrix was calculated to solve the transportation problem based on the Vogel Approximation Method (VAM) using MATLAB software. It has been observed that this program will assist most operations researchers who model large transportation problems and wish to use the Vogel Approximation Method as a solution technique to reach the optimal solution with minimal effort. The study concluded that the Vogel Approximation Method (VAM) achieved the best objective function for reducing transportation costs from supply stations to demand stations in the electrical system in Iraq.
However, the most important recommendations reached by the study are:

1- Relying on modern programs to estimate cases of information unavailability in solving transportation problems of all kinds, as they contribute to reaching an optimal solution in dealing with the transportation issue, thereby reducing the total transportation cost and determining the optimal quantities transported from processing stations to electricity demand stations.
2- Utilizing the research findings by decision-makers to find the lowest cost for a complete transfer.
3- Using methods to address known transportation issues by utilizing the generated data.

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