Optimization of transport costs and CO2 emissions reduction policies in a continuous cycle supply chain: case study.

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Abstract. In this paper we analyze a distribution network and a waste collection network that adopt the same fleet of vehicles. This fleet is owned by a company that provides logistics and transport services in the Algerian territory. The objective of this work is to propose a logistics chain in circular economy (continuous cycle) by combining the transports of the two studied networks, taking advantage of the empty returns, in order to minimize the travel costs and to reduce the CO2 emissions. The purpose of this study is to investigate the impact of optimal vehicle usage in distribution networks and its influence on total supply chain costs and environmental effects.

1 Introduction

Technological advances and the current competition within companies offers more and more products and services that meet the requirements of customers. In this context, transport becomes one of the main resources involved in the supply chain and distribution networks (Benfriha et al 2020). In this context, transport is becoming one of the main resources involved in the supply chain and distribution networks, and is a challenge for many companies and researchers in the objective of minimizing transport costs on the one hand (Triqui.L et al 2016), and on the other hand, the huge amounts of greenhouse gases emitted by the means of transport (ECOFYS, 2010), where transport contributes to the emission of 15% of global greenhouse gases, of which 10.5% are due to road transport. This ratio will reach 30 to 50% of the emissions in 2050 (Nakicenovic & Swart, 2000) and given their negative impacts on the environment, has led to the emergence of the concept of sustainable supply chain. To survive in such an environment, companies must develop techniques and mechanisms that ensure cost-effective delivery with environmental preservation through the reduction of CO2 emissions while using the appropriate means of transportation.

In this context, transport management requires a decision-making choice related to the used means in terms of number and allocation, in terms of defining the best routing of its fleet, the traveled distance, and the emission rate of greenhouse gases, as well as the consumed energy amount. In this amalgam of constraints, several studies have been carried out with the objective of establishing the best allocation by using the most adequate means, which allows rapid delivery at a lower cost as well as a minimum rate in both energy consumption and CO2 emission. In this work, we will study the distribution and delivery of products for two different companies that adopt the same fleet of vehicles. This fleet is owned by a company that provides logistics and transport services. The objective of this work is to offer a logistics chain in a circular economy (closed loop) by combining the transport of the two studied networks, taking advantage of empty returns, in order to minimize travel costs and reduce CO2 emissions.

2 State of the art

The choice of this topic corresponds perfectly to the current global challenge which, on one hand, watches over the environment protection and, on the other hand, over competition, technological development and consumption. These features require more means of transport to ensure the customer satisfaction. Therefore, several researchers have looked into this type of network. Firstly, we will give an overview of the works carried out in this field.

The authors analyzed a vehicle routing problem in a distribution network using a heterogeneous vehicle fleet, taking into account financial and environmental constraints. Then, they compared several resolution approaches where they deduced that for this type of network, the best results are provided by the method AMSEO [1]. In this work, the authors determined an allocation of a transportation fleet that reduces energy consumption, by imposing additional costs on advance/late penalties and storage costs. They considered the impact of speed variation on the calculation of CO2 emissions, and proposed a constructive heuristic to overcome the complexity of the problem that has proven its effectivness for such

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problems [2]. The authors have implemented an approach which consists in decomposing a problem in a period into several problems of reduced periods. This approach allows for better planning and consequently minimizes empty distances and waiting times. The approach leads to a reduction in greenhouse gas emissions which are proportional to these features [3]. In this article, the authors propose an integrated scheduling method for production and transportation problems, in order to reduce carbon dioxide emissions without decreasing the benefits of suppliers [4]. In this article the authors have dealt with an integrated production and transport problem (IPTS) in an MTO (make to order) context. The problem being NP-difficult, a memetic algorithm (HSMO) based on the Head Space MA method has been proposed and has shown to be effective in dealing with this kind of problems [5]. This paper analyzes an integrated inventory and transport control problem with environmental considerations, an NP-Hard problem modeled by a MINLP model. The authors proposed a new heuristic to solve this kind of problems which gave good quality solutions [6]. In this article, the authors formulated a G-VRP and proposed techniques for its resolution. They performed numerical experiments which showed that these techniques work well compared to exact solving methods and can be used to solve large instances of problems [7]. This article establishes a framework for modeling CO2 emissions in a time-bounded VRP context, using the E-TDVRP model. They analyzed the effect of limiting the speed of vehicles on the generated amount of CO2 emissions [8]. In this study, the authors developed a mono period, multi objective mathematical model which aims to minimize the transportation cost for the distribution network, minimize CO2 emissions and maximize job creation in less developed regions under uncertainty constraints [9]. This study investigates the distribution network design problem using a two-objective ILRP model with heterogeneous fleets. Moreover, this study evaluates the environmental impact by measuring the quantity of CO2 emitted during transport activities [10]. In this case study, the authors used real data from already optimized supply chains to demonstrate that vertical supply chain optimizations can be further improved in horizontal collaboration. The main objective was to reduce the environmental impact by reducing transport emissions [11].

3 Problem description

In this work, we focus on transportation problems related to the distribution networks, which remain very complex since many decisions must be taken by integrating various constraints depending on the characteristics of, the type of transported goods, the quantities involved, their destination, means of transportation used in terms of capacity and number, environmental impact, etc.

The approached work is made up of two parts, the direct shipment part, for products delivery and distribution, and the reverse logistics part, for the collection and recycling of waste.

Part 01 : Direct shipment

The objective of this part is to develop an algorithm which ensures the allocation of transport vehicles according to the demand, for a distribution network that is composed of a central warehouse supplying several distribution centers geographically dispersed in different cities. Each distribution center is supplied by the central warehouse with uncertain and varied demands over a given time horizon.

The delivery of products from the central warehouse to the distribution centers is carried out using means of transport of different sizes with limited and well-defined capacities.

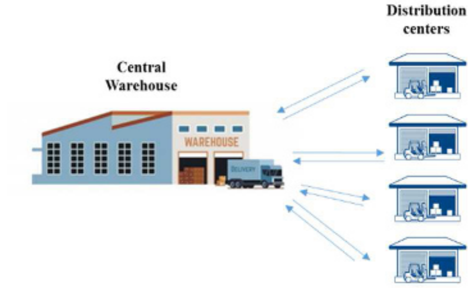


Figure 1. Illustration of the distribution network using direct shipment

Each vehicle has a fixed cost of use, a variable cost that depends on the transported quantity and the traveled distance, an energy consumption, and a CO2 emission rate. Other costs that can be added to this kind of network were not considered in this study, such as loading and unloading costs, just to simplify the initial study.

Part 02 : Reverse logistics

The second part concerns reverse logistics for a collection network made up of a recycling center and several collection points. Recovery is carried out using a fleet of vehicles of different capacities which is responsible for recovering the quantities intended for the treatment center, as shown in the following figure:

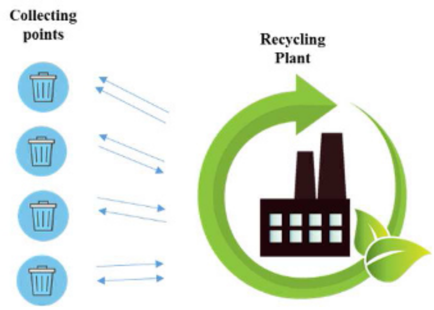


Figure 2. Illustration of waste recovery network using reverse logistics

In this context, we can clearly see that for the two proposed configurations, two separate fleets of vehicles are used to meet the various demands, whether for distribution centers or for collection points. Thus, delivery generates empty returns and therefore generates more CO2 emissions and higher energy consumption which depends on the itinerary of the vehicle. Therefore, in this study we plan to propose a configuration which allows to concatenate the two previous configurations, on one side, the distribution and the delivery, and on the other side, the recovery and the recycling of wastes, especially that the collection points and the distribution centers located at the same towns.

Part 03: Combination of both concepts

In this work, we propose a form of cooperation that allows to combine the delivery of the first network with the wastes recovery of the second network, minimizing the use of vehicles. This helps to minimize transport costs, reduce empty returns and consequently reduce energy consumption and CO2 emissions, while ensuring customer satisfaction. The objective of this configuration is to make use of the advantages of the first two configurations, while limiting their drawbacks. In this context, a real data experiment related to the Algerian company "EURL LOGICARS" serves as an application framework.

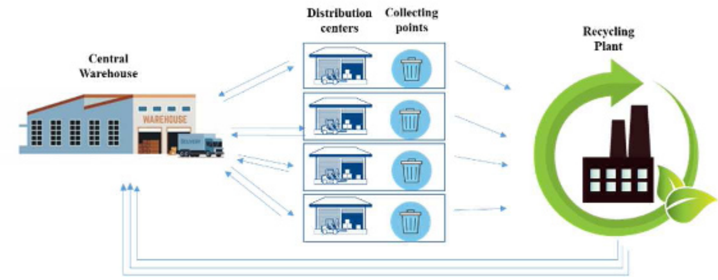


Figure 2. Illustration of combination of delivery and waste recovery networks

4 Company presentation

EURL LOGICARS is an Algerian company specialized in transport and distribution services. It has a fleet of 60 vehicles of different capacities, and serves customers throughout the country. It serves several companies with different types of products. The allocation and management of its vehicles are carried out in a rigorous and planned manner. Its main concern is to meet customers' requirements by delivering goods on time.

In this study, mathematical models have been proposed and implemented under the Cplex solver for each type of configuration. This allows to calculate the total transport costs, the CO2 emissions and to determine the best allocation for the two networks simultaneously. The model is presented below.

5 Mathematical formulation

5.1 parameters

i : central warehouse index
j : Destination towns of the distribution center index
k : Vehicles index
I : Central warehouses number
J : Destination towns number
K : Vehicles number
Cu_K : Cost of usage of the vehicle k
Cl_{ij} : Delivery unit cost from the central warehouse i to distribution center situated in the town j
$Cl2_{ji}$: Waste delivery cost
$Cl3_{li}$: Cost of returning empty vehicle from recycling plant l to central warehouse i
$Cl3_{ji}$: Cost of empty truck returning from the town j to the warehouse i
Cr_j: Out of stock cost in distribution center of the town j
Cap_k: Capacity of the vehicle k
D_J : Demand of distribution center j
$h1_k$: consuming rate of vehicle k when full
$h2_k$: consuming rate of vehicle k when empty
r_k: CO2 emission factor of the vehicle k
$Dist1_{ij}$: Distance between the central warehouse i and the town of distribution center j
$Dist2_{jl}$: Distance between the town j and recycling company l
$Dist3_{li}$: Distance between recycling plant l and central warehouse i
O_j: Waste quantities to be recovered from the town j
Z_{jik} : Boolean variable equals to 1 if the vehicle k travels from the town j to recycling company l
Vol_{jl}: Waste volumes delivered from the town j to recycling company l
M_{jk} : Number of vehicles used to supply recycling companies from the town j
Y_{ijk} : Boolean variable which equals to 1 when the vehicle k is used from the CW i to the DC town j
Z_{jlk} : boolean variable equals to 1 if the vehicle k travels from the town j to recycling company l
Ql_{ijk} : Delivered quantities to the DC of the town j from central warehouse i via the vehicle k
X_{ij} : Delivered quantities from the CW i to the DC of the town j
Q_j : Out of stock quantity of the DC of the town j
vol_{jl} : Waste volumes delivered from the town j to recycling company l
N_{jk} :Number of vehicles that visit the DC of the town j
R_{jk} : Number of vehicles making empty returns from DC of the town j towards central warehouse i
E : CO2 emissions of the whole network

5.2 The mathematical model

1st part : Delivery and Distribution network

$$\text{Minimize} Z = \sum_{j}\sum_{k} Cu_k * N_{jk}$$
$$+ \sum_{i}\sum_{j} Cl1_{ij} * X_{ij} * disl_{ij} +$$
$$\sum_{j} Q_j * Cr_j + \sum_{i}\sum_{j}\sum_{k} Clr1_{ji} * N_{jk} * distl_{ij}$$

Subject to

$$\forall j \in J : D_j = \sum_{k} Cap_k * N_{jk} + Q_j \quad (1)$$

$$\forall i \in I, j \in J, k \in K : N_{jk} \le M * Y_{ijk} \quad (2)$$

$$\forall i \in I, j \in J, k \in K : N_{jk} \ge Y_{ijk} \quad (3)$$

$$\forall i \in I, j \in J : X_{ij} - \sum_{k} Cap_k * N_{jk} = 0 \quad (4)$$

$$\forall j \in J : \sum_{i} X_{ij} = \sum_{i}\sum_{k} Ql_{ijk} \quad (5)$$

$$\forall i \in I, j \in J, k \in K : Ql_{ijk} \le B * Y_{ijk} \quad (6)$$

$$\forall j \in J : Q_j \le a \quad (7)$$

$$\forall j \in J : Q_j \ge 0 \quad (8)$$

$$\forall i \in I, j \in J, k \in K : Ql_{ijk} \ge 0 \quad (9)$$

$$\forall j \in J, k \in K : N_{jk} \ge 0 \quad (10)$$

$$\forall i \in I, j \in J, k \in K : Y_{ijk} \le 1 \quad (11)$$

CO2 Emissions calculation (Delivery and Distribution network)

$$E = \sum_{i}\sum_{j}\sum_{k} h1_k * r_k * Dist1_{ij} * N_{jk} + \sum_{i}\sum_{j}\sum_{k} h2_k * r_k * N_{jk} * Dist1ij \quad (12)$$

The constraints (1), (2) and (3) allow to define the number of trucks necessary to satisfy the demand of distribution centers by direct shipment, as well as the quantities out of stock. The constraint (4) allows to calculate the quantities delivered from the central warehouse i to the distribution center j, while the constraints (5) and (6) allow to calculate the quantity delivered from the central warehouse i to the distribution center j by each vehicle. The constraints from (7) to (11) express the domain of definition and the nature of the decision variables. We also note the non-negativity of the out of stock quantities, the number of trucks and the delivered quantities from the central warehouse i to the distribution center j by each vehicle. The equation (12) allows to calculate CO2 emissions of the whole network.

2nd part : Waste recovery

$$\text{Minimize} Z = \sum_{j}\sum_{k} Cu_k * M_{jk} + \sum_{j}\sum_{l} Cl2_{jl} * vol_{jl} * dist2_{jl}$$
$$+ \sum_{i}\sum_{j}\sum_{k} Clr2_{lj} * M_{jk} * dist2_{jl}$$

Subject to

$$\forall j \in J, l \in L : vol_{jl} \le \sum_{k} Cap_k * Z_{jlk} \quad (13)$$

$$\forall j \in J, l \in L : vol_{jl} \ge O_j \quad (14)$$

$$\forall j \in J, l \in L, k \in K : M_{jk} \le B * Z_{jlk} \quad (15)$$

$$\forall j \in J, l \in L, k \in K : M_{jk} \ge Z_{jlk} \quad (16)$$

$$\forall j \in J, k \in K : M_{jk} \ge 0 \quad (17)$$

$$\forall j \in J, l \in L : vol_{jl} \le \sum_{k} Cap_k * M_{jk} \quad (18)$$

$$\forall j \in J, l \in J, k \in K : Z_{jlk} \le 1 \quad (19)$$

CO2 emissions calculation (Waste recovery)

$$E = \sum_{j}\sum_{l}\sum_{k} h1_k * r_k * Dist2_{jl} * M_{jk} + \sum_{j}\sum_{l}\sum_{k} h2_k * r_k * Dist2_{jl} * M_{jk} \quad (20)$$

The constraints (13) and (14) allow to calculate the volumes of waste delivered from city j to the recycling company l. The constraints from (15) to (18) allow to calculate the number of vehicles necessary to transport these volumes. The constraint (19) defines the binary nature of the variable. The calculates of the CO2 emissions for each type of truck and each mode used, which can be either loaded when delivering or empty after unloading. Equation (20) calculates the consumption rate of the vehicle when it makes a delivery trip with an empty return taking into account the distance traveled while considering the CO2 emission factor of the vehicle k.

3rd part: Combination of both networks (distribution and waste recovery)

$$\text{Minimize} Z = \sum_{j}\sum_{k} Cu_k * N_j + \sum_{i}\sum_{j} Cl1_{ij} * X_{ij} * distl_{ij}$$
$$+ \sum_{j} Q_j * Cr_j + \sum_{j}\sum_{l} Cl2_{lj} * vol_{jl} * dis2_{jl}$$
$$+ \sum_{i}\sum_{j}\sum_{k} R_{jk} * Clr1_{ji} * disl_{ij} + \sum\sum\sum M_{jk} * Cl3_{li} * dist3_{li}$$

Subject to

$$\forall j \in J : D_j = \sum_{k} Cpa_k * N_{jk} + Q_j \quad (21)$$

$$\forall i \in I, j \in J, k \in K : N_{jk} \le M * Y_{ijk} \quad (22)$$

$$\forall i \in I, j \in J, k \in K : N_{jk} \geq Y_{ijk} \quad (23)$$

$$\forall i \in I, j \in J : X_{ij} - \sum_{k} Cpa_{k} * N_{jk} \quad (24)$$

$$\forall j \in J : \sum_{i} X_{ij} = \sum_{i} \sum_{k} Ql_{ijk} \quad (25)$$

$$\forall i \in I, j \in J, k \in K : Ql_{ijk} \leq B * Y_{ijk} \quad (26)$$

$$\forall j \in J : Q_{j} \leq a \quad (27)$$

$$\forall j \in J : Q_{j} \geq 0 \quad (28)$$

$$\forall i \in I, j \in J, k \in K : Ql_{ijk} \geq 0 \quad (29)$$

$$\forall j \in J, k \in K : N_{jk} \geq 0 \quad (30)$$

$$\forall j \in J, l \in L : vol_{jl} \leq \sum_{k} Cap_{k} * Z_{jlk} \quad (31)$$

$$\forall j \in J, l \in L : vol_{jl} \geq 0 \quad (32)$$

$$\forall i \in I, j \in J, l \in L, k \in K : Y_{ijk} \geq Z_{jlk} \quad (33)$$

$$\forall j \in J, l \in L, k \in K : M_{jk} \leq B * Z_{jlk} \quad (34)$$

$$\forall j \in J, l \in L, k \in K : M_{jk} \geq Z_{jlk} \quad (35)$$

$$\forall j \in J, k \in K : M_{jk} \geq 0 \quad (36)$$

$$\forall j \in J, l \in L : vlo_{jl} \leq \sum_{k} Cap_{k} * M_{jk} \quad (37)$$

$$\forall j \in J, k \in K : R_{jk} = N_{jk} - M_{jk} \quad (38)$$

$$\forall j \in J, k \in K : R_{jk} \geq 0 \quad (39)$$

$$\forall j \in I, j \in J, k \in K : Y_{ijk} \leq 1 \quad (40)$$

$$\forall j \in J, l \in L, k \in K : Z_{jlk} \leq 1 \quad (41)$$

CO2 emissions calculations (distribution and waste recovery)

$$\begin{aligned} E = & \sum_{i} \sum_{j} \sum_{k} h1_{k} * r_{k} * Dist\ 1_{ij} * N_{jk} \\ & + \sum_{j} \sum_{l} \sum_{k} h1_{k} * r_{k} * Dist\ 2_{jl} * M_{jk} \\ & + \sum_{i} \sum_{j} \sum_{l} \sum_{k} h2_{k} * r_{k} * Dist\ 1_{ji} * R_{jk} \\ & + \sum_{i} \sum_{j} \sum_{l} \sum_{k} h2_{k} * r_{k} * Dist\ 3_{ji} * M_{jk} \end{aligned} \quad (42)$$

The constraints (21), (22) and (23) allow to define the number of trucks necessary to satisfy the demand of distribution centers by direct shipment, as well as the quantities out of stock. The constraint (24) allows to calculate the quantities delivered from the central warehouse i to the distribution center j, while the constraints (25) and (26) allow to calculate the quantity delivered from the central warehouse i to the distribution center j by each vehicle. The constraints of (27) to (30) express the domain of definition of the variables. We also note the non-negativity of the out of stock quantities, the number of trucks and the delivered quantities from the central warehouse i to the distribution center j by each vehicle. The constraints (31) and (32) allow to calculate the volumes of waste delivered from city j to the recycling company l. The constraint (33) represents the link between the binary variable of both distribution and waste recovery networks. The constraints from (34) to (37) allow to calculate the number of vehicles necessary to transport recovered waste volumes. Constraints' (38) and (39) allow to calculate the number of vehicle's that comeback empty from the town j to central warehouse i

The constraints (40) and (41) define the binary nature of the variables. Equation (42) allows to calculate the CO2 emissions of the network considering the quantities of CO2 emitted during full and empty travel.

6 Results and discussion

For the implementation of our experiments, we considered a network made up of a set of customers (j = 4) where each customer has a demand to be satisfied in terms of product as well as the quantity of waste to recover, as specified in table 1-1. We also considered a set of vehicles where each vehicle has a specific capacity, a fixed transport cost and a variable delivery cost depending on the transported quantity, as represented in the following table:

Table 1: Parameters of the fleet of trucks

	Cap	Cu	h1	h2
Truck1	1500	3000	0,34	0,43
Truck2	2000	3500	0,34	0,43
Truck3	3000	5000	0,34	0,43

We applied our model on two different distribution areas, the first one for customers within a 200 km perimeter, and a second for customers within a 900 km perimeter. In both configurations (separated activities and combined activities), the cost of empty returns from recycling plant to central warehouse is CL3 =5 DZD. According to statistics given by the company, the average consuming rate of trucks is estimated to be 0,34 when it is empty, and 0,43 when the truck is full. The CO2 emission rate in our case is estimated to be 2,49 Kg CO2/L [12]. Information and results related to the first perimeter:

Table 2: Costs and parameters of the DCs to Town (Tj)

	Cl1	Clr1	Cr	D	Cl2	Clr2	O
T1	0.040	7	7	8000	0.015	7	4000
T2	0.055	10	10	9000	0.020	11	3000
T3	0.070	12	5	6000	0.030	9	2000
T4	0.060	13	6	10000	0.020	15	4000

Table 3: Inputs related to the first perimeter (200 Km)

	dist1	dist2
Town 1	100	120
Town 2	140	140
Town 3	160	100
Town 4	200	180

 https://doi.org/10.1051/e3sconf/202233600060

Table 4: Results for the case of using different fleets to ensure delivery and recycling in the first perimeter -200 Km-

> 200Km	Configuration 01	Configuration 02	Total
Cost function	364540	70020	434560
CO2 emissions	3527,4	1798,8	5326,2
Nomber of vehicles	12	6	18
Qr	0	0	0

Table 5: Results of the case of combining both concepts by using the returns to supply recycling plant in the first perimeter -200 Km-

> 200Km	Configuration 03
Cost function	389500
CO2 emissions	3939,2
Nomber of vehicles	12
Qr	0

Table 6: Inputs related to the fleet of the second perimetre -900 Km-

	dist1	dist2
Town 1	820	790
Town 2	410	540
Town 3	670	730
Town 4	530	610

Table 7 : Results for the case of using different fleets to ensure delivery and recycling in the second perimeter -900 Km-

> 900Km	Configuration 01	Configuration 02	Total
Cost function	1193410	238770	1432180
CO2 emissions	13709	8715,5	22424,5
Nomber of vehicles	12	6	18
Qr	0	0	0

Table 8: Results of the case of combining both concepts by using the returns to supply recycling plant in the first perimeter -900 Km-

> 900Km	Configuration 03
Cost function	1302250
CO2 emissions	14789
Nombre de véhicules	12
Qr	0

The Comparison between the two configurations

In order to see the interest of the proposed algorithm, we have compared the two experimental scenarios where the first scenario concerns the network with a perimeter of max 200 KM and the second scenario which concerns the network on a perimeter of 900km. The results obtained are given in the charts below.

Chart 1: Transport cost comparison between the total of the first and second configurations and the proposal in the first perimeter -200 Km-

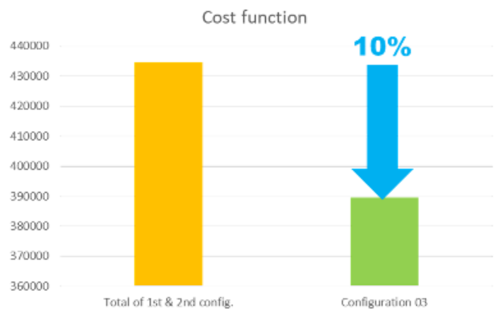


Chart 2: CO2 emissions comparison between the total of the first and second configurations and the proposal in the second perimeter -200 Km-

Chart 3: Resources comparison between the total of the first and second configurations and the proposal in the second perimeter -200 Km-

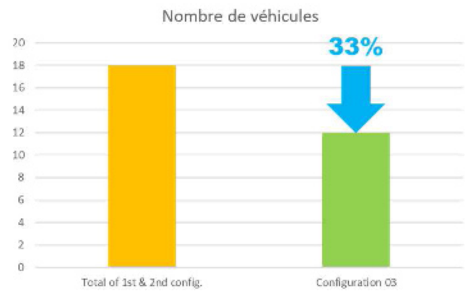


Chart 4: Transport cost comparison between the total of the first and second configurations and the proposal in the second perimeter -900 Km-

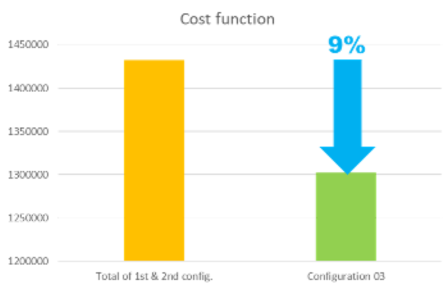


Chart 5: CO2 emissions comparison between the total of the first and second configurations and the proposal in the second perimeter -900 Km-

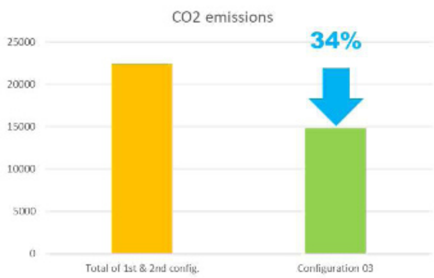
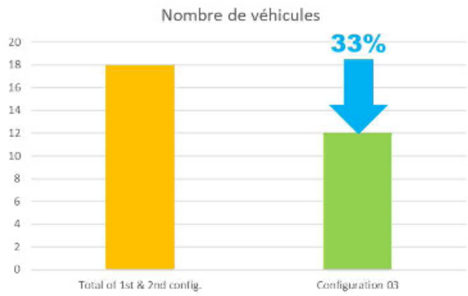


Chart 6: Resources comparison between the total of the first and second configurations and the proposal in the second perimeter -900 Km-



From the results obtained, we can see that the configuration that groups the distribution network with the collection network in a continuous cycle, allowed to reduce the costs by 10%, the CO2 emissions by 26%, and recourses used by 33%, for a restricted perimeter of 200 Km, when the reduction of the costs in a larger perimeter of 900 Km is 9%, the reductions of the CO2 emissions 34%, and the resources used were improved by 33%.

This difference in reduction rates is due to the traveled distance. In the first one, the distance where the vehicle is empty is much less than in the second perimeter. Consequently, using these empty returns to supply recycling plants with waste recovery will therefore considerably reduce costs, CO2 emissions and used resources.

From these results, we can see that the function of costs and CO2 emissions decreases with increasing distance. This can be explained by the use of an empty return vehicle to determine the best assignment from the first phase, which concerns the delivery of product, to the return to the first summit with a waste collection. The results obtained show that the decisions taken are promising in terms of customer satisfaction and CO2 emissions, however, the proposed solution requires an efficient and sharp management for the smooth running of the routes.

7 Conclusion

In this work, we have proposed an algorithm that combines a distribution network and a collection network in order to help decision-makers in their allocation choices. This allows the minimization of costs, the reduction of CO2 emissions, and the decrease use of trucks.

The obtained results show the effectiveness of the proposed model which allows to provide an improved solution in the environmental context.

Other works can take place in this problem, we can study the problem the multi-product case to allocate the different types of transport by product we also consider the deterioration of the means of transport in multi period and analyze the impact of costs and efficiency of our proposed approach, Then, apply this model on a large number of cities and use meta heuristics to define the optimal solution. We are going to develop another point which concerns to find the best method of benefits generated to encourage actors to participate and collaborate.

8 References

1. Mohammad Mojtahedia Amir, M. Fathollahi-Fard, Reza Tavakkoli-Moghaddam, SidneyNewtond, September 2021, Sustainable vehicle routing problem for coordinated solid waste management.

2. Mojtaba Salehi, Mahdi Jalalian, Mohammad Mahdi Vali Siar, November 2017, Green transportation scheduling with speed control: trade-off between total transportation cost and carbon emission

3. Nizar El Hachemi, Michel Gendreau Louis, Martin Rousseau, March 2013, A heuristic to solve the synchronized log-truck scheduling problem

4. Yoshitaka Tanimizu Katuhumi Amano, 2016, Integrated Production and Transportation Scheduling for Multi-objective Green Supply Chain Network Design

5. Zhaoxia Guo, Leyuan Shib, Longchao Chen, Yong Liang, January 2017, A harmony search-based memetic optimization model for integrated production and transportation scheduling in MTO manufacturing

6. A.I. Benfriha, L. Sari-Triqui, A.E. Bougloula, M. Bennkrouf. « The Impact of Products Exchange in Multi-Levels Multi-Products Distribution Network» second international conference on Embedded & Distributed Systems (EDiS) 03November2020, Oran.Doi:https://doi.org/10.1109/EDiS49545.2020.9296441

7. Zhaoxia Guoa Leyuan Shib Longchao Chena Yong Liang, January 2017, A harmony search-based memetic optimization model for integrated production and transportation scheduling in MTO manufacturing

8. Sevgi Erdoğan, Elise Miller-Hooks, January 2012, A Green Vehicle Routing Problem

9. O. Jabali, T. Van Woensel, A.G. de Kok, April 2012, Analysis of Travel Times and CO2 Emissions in Time-Dependent Vehicle Routing

10. Nassibeh Janatyan, Mostafa Zandieh, Akbar Alem-Tabriz & Masood Rabieh, February 2021, A robust optimization model for sustainable pharmaceutical distribution network design: a case study

11. Aymen Aloui, Nadia Hamani, Ridha Derrouiche & Laurent Delahoche, February 2021, Assessing the benefits of horizontal collaboration using an integrated planning model for two-echelon energy fficiency-oriented logistics networks design