An Algorithm for Transport Optimization as the Effect of the European Green Deal and Climate Neutrality Goals

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The exponential growth of the world population in the last decades (approx. eight billion people in 2022), corroborated with spectacular development of various sectors of activity such as transport, construction, information, and communication technology, etc. exert a worrying pressure on limited natural resources. Moreover, climate change, environmental degradation, increasing pollution, recent armed conflicts are increasingly real existential threats to the global population in general and to the old continent in particular. In this context, the European Green Deal (EGD) comes to counteract such unhealthy developments and proposes to transform Europe into a society with a modern, high performing and resource-efficient economy, with a goal of achieving climate neutrality by 2050. EGD involves a series of legislative measures that will support and implement policies on financial and competitive issues related to climate, energy, industry, sustainable and smart mobility, agriculture and biodiversity conservation and protection. From the EGD perspective, the objectives of this research have focused on the transport sector, with a view to ensuring safe, sustainable, green, and smart mobility. The main result of the research consists of the optimization algorithm developed and implemented by authors at one of the largest alliances transport, which calculates the best option for the delivery of goods, respecting the price lists and the proposed carbon dioxide emissions targets. At the same time, in the light of the results and conclusions of the research, the general implications regarding the financial and competitive aspects of the EGD are analysed, as well as the particular ones, specific to the alliance that is the object of the case study.
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1 Introduction

As the knowledge-based information society is in full expansion, humanity is facing increasingly more crises generated by independent or neutral factors, but, to a considerable extent, generated even by individuals and organizations. Thus, along with financial, nutritional, ecological, or other crises, we are faced, since 2019, with a strong health crisis generated by the pandemic effect of the coronavirus disease. Systemically perceived as a direct consequence of the principle of external complementarity specific to cyber environments, this health crisis exhaustively impacts the spheres of human existence - personal, professional, and social. In the context of this status quo, in December 2019 the European Commission submits to the European Parliament the document entitled the *European Green Deal* - *Europe's new growth strategy*. The action is strongly scientifically based, both from a theoretical perspective, and especially a practical one, measurable through the prism of the April 2019 Eurobarometer on climate change [1]. The key objective of the EGD is to achieve climate neutrality by 2050 at EU level by transforming Europe's society and economy. This transformation will need to be fair, equitable (through the Just Transition Mechanism - JTM), cost-effective and socially balanced [2]. In order to achieve this goal, the EGD proposes a series of key actions, which will be materialized through the implementation of specific policies in strategic areas such as climate change, energy quality and affordability, the industrial strategy for a clean and circular economy, sustainable mobility and common agricultural policy, biodiversity conservation and protection and the integration of sustainability into all EU policies. Moreover, EGD is at the same time a lifeline out of the COVID-19 pandemic. Therefore, it is to be financed with a third of the € 1.8 trillion investment from the Next Generation EU Recovery Plan, as well as funds from the EU's seven-year budget [3]. To sum up, the EGD aims to metamorphose the EU economy for the future in a sustainable way by developing and implementing profoundly transformative policies [4]. The fifth package of these policies aims to accelerate the transition to sustainable and smart mobility, starting from a worrying reality, the fact that the transport sector is accountable for a quarter of EU greenhouse gas emissions [5].

The aim of this research is to determine the scale of the impact of the EGD on the transport industry, from the perspective of the EGD goal of achieving climate neutrality in Europe by 2050. The scientific construction is built on a case study developed by the authors in one of the largest alliances transport - Renault-Nissan-Mitsubishi. The transport sector has been chosen because, according to European studies [5], the degree of pollution generated by this industry is constantly increasing. According to the EGD objectives, in order to ensure climate neutrality, a 90% reduction in transport emissions by 2050 is needed, and all modes of transport - road, rail, air and sea - will have to participate in this goal. In this sense, the research will focus on the analysis, design, and implementation of a transport optimization algorithm within the RNM alliance. In the analytical-scientific approach, the financial and competitive aspects required by the adoption of a transport optimization algorithm will be considered. It will also be considered and will be part of the environmental analysis of the algorithm for optimizing the calculation of carbon emissions, in close correlation with the European directives on achieving the objectives of the Paris Agreement. [6]. The transport sector is now one of the pillars of the healthy development of a society, and the authors systematically address the field in their scientific concerns [7] [8].

Given that the transport sector is responsible for a quarter of the European Union's (EU) greenhouse gas emissions, and that this percentage is constantly rising, research is needed to identify a transport optimization algorithm to reduce greenhouse gas emissions, thus contributing to the ecological European goal. Moreover, the primary working hypothesis is to ensure greater efficiency of the transport system by stimulating multimodal transport. The research data comes from the case study developed by the authors in the RNM alliance. This data is processed as input within the computer algorithms used. The research method uses well-established, but specific algorithms, both for reducing costs and transport distances, and for calculating carbon emissions, based on the European Renewable Energy Directive and the regulation of CO_2 emission performance standards for cars and trucks. The main result of the research consists of the optimization algorithm developed and implemented by authors at the RNM alliance, which calculates the best option for the delivery of goods, respecting the price lists and the proposed carbon dioxide emissions targets. At the same time, in the light of the results and conclusions of the research, the general implications regarding the financial and competitive aspects of the EGD are analysed, as well as the particular ones, specific to the alliance that is the object of the case study.

This paper is structured in five parts. The first part presents the literature review, focusing on the main measures taken by the EU leadership on the one hand, but also by the Member States, on reducing the negative climate impact generated by the transport sector. At the end of the first part, the context of the applied research and the case study are outlined. The second part of the paper contains the research methodology and the way of collecting data to develop the transport optimization algorithm for the proposed case study. The third part is dedicated to the analysis of the financial and competitive dimensions of the impact of ensuring climate neutrality in Europe by 2050 through EGD on the transport industry, exemplified through the case study represented by the RNM alliance. The fourth part includes the analysis of the impact of the developed transport optimization algorithm on the decarbonization phenomenon of the European economy, based on the reduction of carbon emissions. The last part of this research is dedicated to the discussions and conclusions obtained as a result of the financial, competitive, and environmental results generated by the implementation of the transport optimization algorithm. At the same time, the synthesis of the research results, future directions of scientific research in the field of the proposed topic are described.

2 Status Quo in the field

Climate change poses an imminent and potentially irreversible threat to humanity and biodiversity, and therefore requires the widest possible cooperation to date. The Paris Agreement is a legally binding international climate change treaty. Although the concerns over climate change intensified in the 2000s, only at the end of the span it gains an adequate amount of attention to become a global effort. As a result, in November 2014, the world's two biggest emitters of greenhouse gas emissions, United States of America and China, signed an agreement on climate change. One year later, the Paris Agreement was signed at the 21st United Nations Climate Change Conference (COP 21) on climate change that took place between November and December and came into force in November 2016. More than one hundred heads of state at the Conference highlighted how much climate transformation must happen. Its main purpose is to limit global warming to less than 2° C compared to pre-industrial levels recorded in 1990. A significant demand from civil society, a long-term emissions goal, is also integrated. It states that the emissions neutrality must be attained by the year 2050 that sends an important signal to global markets [9].

A key factor in the acceptance of the Paris Agreement is the change in strategy: the bottom-up approach is chosen, compared to the old top-bottom approach, through which local communities take measures that support the common objective [10]. To achieve this long-term goal, states are participating in an effective and appropriate international effort to achieve climate neutrality by 2050. Ambitious efforts to combat climate change aim to reduce net greenhouse gas emissions within the European Union by at least 55% by 2030, compared to the 1990 reference level. The agreement is built on the principle of collective but differentiated responsibilities and on the principle of equity and is a milestone in the process of accelerating the global reduction of greenhouse gas emissions. At the same time, it is the first binding agreement that draws all nations into a common cause. The participants agreed to communicate their own contributions every five years in order to adapt the objectives. All signatory parties (196 representatives) also agreed to inform the public about the outcome of their efforts to achieve the main objectives [6]:

- *long-term temperature target* - the goal is to limit global temperature rise to well below 2° C.
- *global peak and climate neutrality* - states aim to reach the peak of greenhouse gas emissions as soon as possible, with the ultimate goal of achieving climate neutrality by the middle of the century.
- *mitigation* - The agreement stipulates binding commitments for each state to provide, report and maintain the level of national contributions; at the same time, five-year cycles of transparent reporting of national plans are established; each report will be the basis for the next period by which more ambitious targets than the previous ones will be set. It involves all actors to announce and regularly update national programs that must be implemented, to mitigate climate changes. [11]
- *voluntary cooperation / market-based and non-market approaches* - The Agreement

recognizes the need for voluntary cooperation between States in order to enable more significant goals to be set; it also establishes principles for cooperation involving the international transfer of greenhouse gas emission mitigation results.
- *financial, technological, and capacity-building assistance* - developed Member States must support developing countries with financial resources and technological assistance to develop a clean, climate-resilient future; the provision of resources must lead to a balanced path between mitigation and adaptation; every two years, developed countries will have to provide information on the level of support they will provide in the future.

Given that climate change is a complex and long-lasting phenomenon that cannot simply be changed, global involvement is needed. One of the states involved in this process is Germany. The plan adopted by its own government includes a 40% reduction in emissions from the transport sector, reaching 42% by 2030. In numerical terms, this goal is equivalent to the emission of up to ninety-eight million tonnes of CO_2 per year [12].

To reduce the level of CO_2 emitted into the atmosphere, it is necessary to reduce the consumption of oil, natural gas, and coal. Solar, wind, or biomass energy cannot always replace fossil fuels. Taking this into account, Germany has chosen to use another environmentally friendly fuel. Specifically, Germany has adopted a strategy on the use of liquid hydrogen as a substitute fuel in transport, requiring minor modifications to internal combustion engines. The initial proposal, submitted by the Minister of the Environment, Svenja Schulze, was adopted on February 3, 2021. In order to achieve results, the Federal Government decided to allocate seven billion Euros for the development of hydrogen-based technologies, another two billion being allocated to international partnerships. The results obtained will be applied in road and sea transport. The adopted law transposes the EU directives on renewable energy in transport, according to which the transport sector must reach a share of renewable energy of 14% by 2030. However, Germany aims to reach the 28% threshold, considerably exceeding the required target, becoming a pioneer of renewable energy in transportation [12].

Another contributor to freight innovation is Sweden. In this country, the transport sector is responsible for a third of carbon dioxide emissions, half of which is generated by freight transport. As part of the EGD, Sweden is committed to developing an independent fossil fuel transportation system by 2030. Thus, in 2016, the Swedish government inaugurated a catenary system dedicated to trucks on a two km section of the E16 motorway, becoming the first electric motorway in the world. For two years, the system produced by Siemens has been assessed to see if it can become part of a national project [13].

Today, the technology is being evaluated in several pilot projects, with Germany and Sweden leading the way. The biggest obstacle to a large-scale launch is the initial investment in infrastructure. From a technical point of view, the assembly is based on a pantograph and hybrid trucks specially modified in partnership with the manufacturer Scania, capable of traveling at speeds of up to 90 km/h. They are powered by zero-emission efficiency. This approach is similar to that used by trams and trains, but in addition, thanks to hybrid technology, trucks have the ability to travel outside the lines, while maintaining the flexibility of traditional trucks. Pantograph catenary (PAC) system is used to transfer the energy from the catenary structure to the truck. Between the pantograph and the contact cable of the catenary a force must occur for a truck to move on an electric railroad structure [14].

The main benefit of this method is the efficient use of electricity. The trucks used are more efficient than those that use hydrogen for travel. Thus, they have the highest transport efficiency, with a level of 77% compared to 62% for those that use batteries, 29% for hydrogen and 20% for traditional ones. At the same time, compared to those that use batteries, it is not necessary to produce batteries, a process that uses a considerable number of resources. The development of electrified infrastructure also consumes a substantial number of resources, but once built, it can be used overall. In addition, these trucks are even lighter, no longer requiring heavy batteries, which means that they can carry a larger volume of goods [15]. This method is the cheapest way to meet the zero-carbon footprint. The Swedish government plans to electrify 2,000 kilometres by 2030. In August 2017, a similar system was installed in Germany on a 10-kilometer stretch of road near Frankfurt. This initiative was also adopted in Carson, California, USA [16]. The third European country to join this initiative is Italy where, in the north of the country, a network of six kilometres has been built near Milan [17].

An analysis performed on I-5 California highway between wireless and catenary power transfer systems shows that important financial savings can be achieved from using highway electrification over gasoline. Considering the annual vehicle miles travelled, the gas and electricity costs, the potential savings is substantial for electric vehicles over internal combustion engines. The results are shown in table no. 1 [18].

Pilot projects have also been launched in Sweden, testing other electrical technologies, such as the development of the first wireless electric road. The construction consists of the installation of cables under the asphalt that connects the airport to the centre of Gotland. Using the induction method, the current is transmitted to the moving vehicles. Inductive charging technology comes from the Israeli company Electreon [19]. The mode of operation and technical details are presented in [20].

Romania has also taken concrete steps in combating emissions through the Rabla Clasic and Rabla Plus programs, which offer scrapping bonuses (in the form of eco-bonus vouchers) for the permanent decommissioning of an old car. Tickets can be used to purchase a new car with emissions of up to 160g CO_2 / km [21]. The value of the eco-bonus is higher when purchasing hybrid vehicles. In addition, eco-bonuses are offered for each vehicle that is at least 15 years old and has a Euro 3 or lower pollution rate. Under the Rabla Plus program, subsidies of 10,000 Euros are granted for the purchase of an all-electric car, and of 5,000 Euros for a plug-in hybrid type whose carbon dioxide emissions are below the threshold of 80g CO_2 / km. In the form adopted for 2022, the obligation to scrap a used vehicle was introduced. Can take part in this program all citizens with residence in Romania who owns a vehicle older than 8 years. Old cars must have vital components (engine, wheels, car body, etc.) [22].

Table 1. Potential savings *Source:* [18]

Annual Miles	6836 million
Energy Used (kWh)	1776 million
Gas Costs ($)	820 million
Electricity Costs ($)	222 million
Annual Savings ($)	598 million

These programs stimulate the renewal of the car fleet by scrapping used, polluting vehicles, both for individuals and legal entities. Rabla Clasic has existed since 2007 in various forms, the most recent being detailed in the Integrated National Plan in the field of Energy and Climate Change 2021-2030 prepared by the Romanian Government and published in April 2020 [23]. The plan was implemented because of the EU's obligation on each Member State under the Paris Agreement. Following the success of the program, financial resources were supplemented in 2021 by 60 million Euros [24] [25].

These are just a few examples of measures that signatory governments of the Paris Agreement are taking concrete steps to implement environmentally friendly solutions so that climate neutrality is achieved within the proposed period. In addition to these, private companies also identify methods by which they can reduce the level of greenhouse gases. In addition to making the fleet more efficient by purchasing vehicles that use efficient traditionally engines or do not use internal combustion engines, but electrical or

based on hydrogen, there is also the possibility of increasing their efficiency using distribution planning software systems. They can manage the company's fleet of cars and the goods to be delivered to identify an optimal delivery route in terms of transport costs. By streamlining the distances travelled or even the number of vehicles needed to deliver the same volume of orders, companies align themselves with the EGD and support the reduction of CO_2 emissions. The advantages of using such a software system, as well as various implementation methods, are presented in [26], [27] and [28].
Such a software that has the ability to reduce the greenhouse emissions by optimizing transportation *was developed by the authors*. Having at its centre the objective of efficiency, the application responds to current needs, having the possibility of producing substantial savings. In order to illustrate as accurately as possible, the scientific approach and to perceive as concretely as possible the dimensions of the research, we must place the case study in the international economic context. Thus, the RNM alliance is a strategic partnership formed between the French carmakers Renault and Nissan and Japanese Mitsubishi Motors, respectively. It is one of the most profitable and longest-lasting large association in corporate history [29]. It currently owns ten major brands: Renault, Nissan, Mitsubishi, Dacia, Lada, Infiniti, Alpine, Renault Samsung, Venucia and Datsun. In 2017, the alliance ranked first in the ranking of car manufacturers with over 10.6 million units sold worldwide [30]. The organization is based on a cross-sharing strategic partnership: Renault owns 43.4% of Nissan's voting shares, and Nissan owns 15% of Renault's non-voting shares. This partnership assures the participants that each company acts in the interest of the other members while its own brands maintain their cultural identity and independence. With 22 years of active cooperation, the Alliance has over 420,000 employees and 122 factories, spare parts centres, IT labs, technology centres and innovation labs in thirty-nine countries around the world. The declared goal of the RNM Alliance in terms of ecology is "NEUTRAL CARBON by 2050" [31]. In Romania, the local branch is called Renault Commercial Roumanie (RCR) and is responsible for all commercial activities of the Renault, Nissan, and Dacia brands locally. Specifically, the representative office manages the distribution of vehicles in the network of commercial agents, distributes spare parts in the approved service workshops, offers post-purchase services and carries out customer studies and other specific commercial activities [32].

3 Algorithm for transport optimization and reduction of greenhouse gas emissions

The objective of this research is to analyse, design and develop, at the level of the RNM alliance, an algorithm for transport optimization that, through implementation, will have a significant positive impact from a financial, competitive, and environmental perspective. The aim is to create a software around the algorithm that will streamline delivery by reducing transit times, the number of trucks required, and the time required to prepare shipments. All orders are to be processed through the application, regardless of the nature of their delivery, thus stimulating multimodal transport, which involves all types of transport: road, rail, air, and sea [33]. In 2021, RCR purchased this specialized computerized freight management system.
Description of the functional mechanism. Information such as customer addresses, their requirements for limiting the number of trucks delivered daily, transport scheme (capacity of each carrier to deliver goods on each route according to tonnage and ADR specifications - ***A****greement on International Carriage of* ***D****angerous Goods by* ***R****oad*), allocation of customers by areas and routes and price lists are found in multiple primary documents such as Microsoft (MS) Excel and MS Word. These are used by transport pilots in their daily work. Employees have the task of efficiently grouping customer orders, respecting the delivery restrictions for each customer and the transport capacity of the shipping company. During each day, they analyse the orders

placed by customers and create trucks of different capacities needed for optimal loading. At the same time, it also verifies the necessary ADR, provided that it respects the delivery schedules of the carriers.

Compatibility of input data. The first step in setting up the new software system is to standardize MS files and develop automated import capabilities to ensure data compatibility. The information is retrieved from files and translated into relational databases so that it can be used in various processes. They are the basis of the entire system, as the information is used in every process and action taken automatically by the application, or manually by the users. Thus, their understanding, standardization and transposition into a relational database are critical activities in the development of the entire IT ecosystem. The basic information about the company's customers is taken from the existing ERP system and stored in its own nomenclature. Their most important attributes are:

- *customer code (the unique connection key between the two systems).*
- *name*
- *the route it is assigned*
- *location information*

The information participates in all future flows: importing orders, route optimization algorithm, confirmation of deliveries, reporting, etc. For the most efficient way possible, this information is imported via MS Excel or CSV (Comma Separated Values) text files. The established template contains all the information necessary for the computer system to work. In addition to basic customer information, restrictions are also required. Given that the majority of customers consist of car services within the localities, the delivery capacity is limited by road infrastructure or local rules. Thus, each customer can have restrictions on the type of machine accepted and the ability to unload the goods. In this sense, there is a maximum threshold for each type of car that can be downloaded in one day. All this information is also imported from MS Excel or CSV text files.

Distribution by delivery areas and routes (zoning-routing). For the order delivery operation to be as efficient as possible, customers are divided into zones and routes. There are four types of areas depending on the type of transport: national road, international road, sea, and air. As with customers, there are different rules for each type of area that must be followed. For road deliveries, there is a limited number of trucks provided by carriers. They are also scheduled to arrive on the ramp at certain times and can deliver dangerous goods (ADR) only on certain days, being limited in capacity. A paying agency for logistics services is established for each area. Each area has several routes. There are seven routes for national transport: Argeș, Dâmbovița, Bucharest, Sibiu, Bacău, Vâlcea and Craiova. For the routes Bacău, Bucharest and Sibiu, if orders belonging to several customers are loaded on a carrier (delivery type LTL - *Less Than Truckload* - a customer's goods are less than the transport capacity), the delivery destination is a logistic platform. This is located in Bucharest for the first two routes, and in Sibiu for the third. The reason behind this decision is to make long-distance transport as close as possible to a concentration of customers. The delivery of goods from the platform to the final customers is made by small vehicles that can reach the city centre. This is called capillary delivery or *milk-run* and is organized and managed by carriers. In the case of the other four routes, even if the transport is LTL, stops are planned for each customer.

For international road transport eighteen routes have been defined: France (divided into Villeroy, Flins and Cergy), Germany (divided into Bruhl and Lissendorf), Hungary (Gyor), Poland (Warsaw), Italy (San Colombano), Austria (Stokerau), Moldova (Chisinau), Ukraine, Belarus, Turkey (Yalova), Spain, Belgium, United Kingdom, Bulgaria, and Russia. In the case of deliveries to France which cannot accept at least half of the truck, they can be grouped in several routes. The transit time can be two days in case of urgent deliveries (with two drivers) or four days (with one driver).

Maritime deliveries are made through the port of Constanța. The trucks used are container-type to facilitate their loading on ships. The software optimally groups the orders so that as few trucks as possible are needed. Shipping is made to South Africa, Algeria, Argentina, Colombia, and Morocco. The destinations of air routes are South Africa, Colombia, and Morocco (not managed by the software system at this stage of development).

The algorithm. The purpose of the transport optimization algorithm is to determine as few trucks as possible to deliver all orders, considering restrictions on volume, tonnage, carrier delivery capacity and customer reception. At the time of automatic order import, the application calculates the estimated volume and price of grouped delivery (LTL) used by the delivery algorithm. Subsequently, the optimal delivery option is determined by comparing the price of the groupage with that of the direct delivery.

The algorithm selects the maximum truck type allowed for the customer who is being processed, then takes over the existing orders in the system. These are sorted by multiple criteria, such as: urgent orders, ADR requirement, maximum delivery date, stock orders, and volume. The algorithm also checks the weight limit of the truck and assigns orders without exceeding it. After a customer has been processed, the initially chosen trucks are replaced with the smallest ones, large enough for the assigned orders, respecting the transport scheme of the beneficiary.

Following these steps results in one or more trucks for each customer. Customer orders can be delivered in dedicated trucks or in bulk. Since the price of groupages is calculated linearly according to volume or floor area, it is determined from the import of orders, the delivery cost for a groupage truck (LTL) being the sum of the costs of the assigned orders. While the route optimization algorithm is running, it is checked if there are trucks with an occupancy threshold of more than 50% (this threshold can be modified as needed). For these, the costs of direct delivery (FTL - *Full Truck Load*) are calculated, costs that vary depending on the type of truck, **distance,** or destination. For each customer, there is a pre-calculated charging distance from the charging point. If the FTL price is lower than the LTL price, their processing will not continue.

Grouping of trucks on the route. The trucks remaining from the previous step are trucks that contain orders from only one customer, in an insufficient volume to be optimal in terms of costs. In an attempt to optimize deliveries, the algorithm groups several shipments belonging to customers on the same route. In an iterative process, the application takes over each truck and tries to unify it with another one on the same route. In the process of unifying two vehicles, there is the possibility of allocating a third truck of higher capacity, in which the initial transport orders will be moved. The increase in capacity is done respecting the delivery capacity of the carrier. There is also the possibility to activate the grouping at the zone level. This setting is used for deliveries to France, in which case all three routes are grouped: Flins, Villeroy and Cergy. The grouping results in a smaller number of trucks containing orders belonging to more than one customer. An intermediate step in calculating distances and optimizing the delivery order is required to determine the delivery costs for groupages.

Displaying results. For the processing of unplanned orders, in the application that implements the optimization algorithm there are three buttons, one for each type of transport: national, international, and maritime, respectively. The runtime of the algorithm is less than one minute, and the result is shown in figure no. 1. The window is divided into several panels that display various information. The Summary panel (on the left) graphs the number of orders allocated per truck, the total number of orders, the number of resulting trucks, the distance travelled, and the distribution of time by type of activity. Several tabs are available at the bottom of the screen: commands included in the algorithm (stops), available vehicles, race summary, details, unallocated races, and errors.

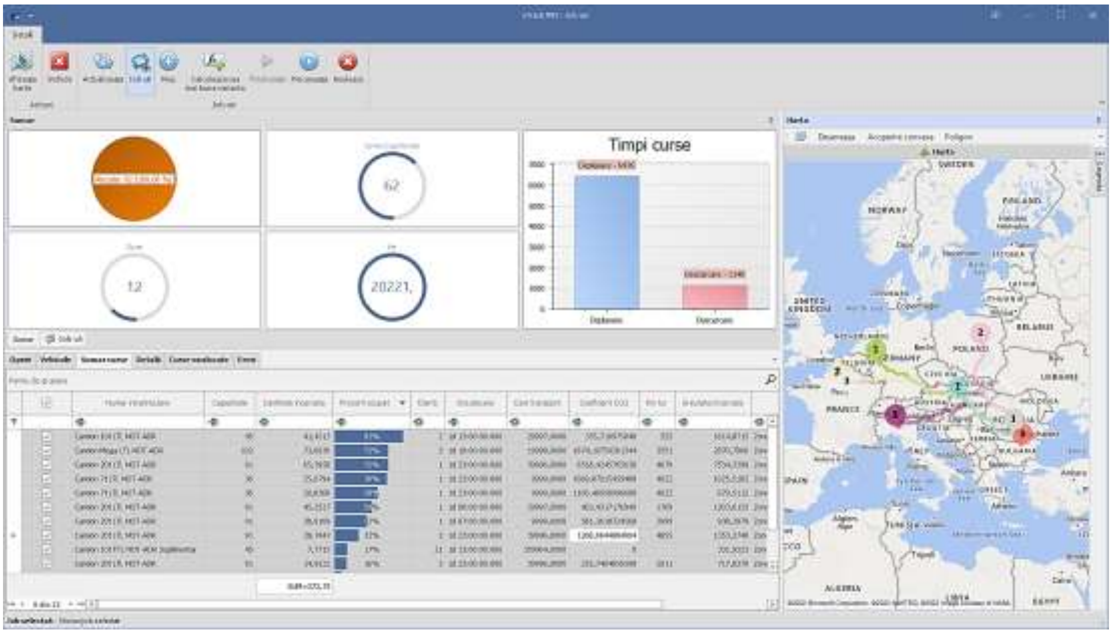

Fig. 1. The result of the optimization algorithm

The Transports Summary tab displays a record for each resulting truck. First of all, the type of truck required (10 TO, 7 TO, Mega, etc.) is displayed, if it is a direct race or grouping (full truck load – FTL or less than truckload – LTL), if it requires ADR authorization and if it exceeds the restrictions of the customer or the carrier. The departure time is calculated according to the working schedule of the warehouse. The transport cost is calculated according to the price lists configured in the financial module, and the CO_2 coefficient according to the algorithm presented in the fourth chapter. Transport pilots use this panel to plan deliveries. First, they forward the estimated number of trucks to the carriers. After confirmation, the trucks are processed and transformed into concrete orders. On the right side of the screen is the map on which the resulting routes can be displayed. It uses distinct colours to track each race.

4 EGD's financial and competitive implications for the transport sector

The key actions proposed by the EGD, materialized through the implementation of specific policies, will be financed with 600 million EUR from the Fund allocated to the Recovery Plan. In addition, the EU's budget for the next seven years will provide funds to alleviate the climate problems of this century. In addition, each state involved in the agreement will allocate significant sums from the national budget to fight for climate neutrality. Given the substantial costs, they must be weighed against the financial benefits.

Given that the transport sector accounts for around 5% of the EU's gross domestic product and offers more than ten million jobs, it is a key sector for European companies and global supply chains. One of the European Commission's main objectives is to reduce greenhouse gas emissions by 55% [34]. In order to achieve this goal, the Commission is promoting low and zero emission vehicles. Vehicle manufacturers are urged by governments to invest in technology to save oil and reduce greenhouse gas emissions. They have shown that they can reach the drastic limits imposed, the sales of electric cars being above expectations. Compared to 2020, sales increased by 168%. However, these values should be seen as a comparison with the low level of the first six months of

2020, when they decreased by 19% compared to the same period of 2019 [35]. By 2021, electric vehicle sales were three to eight times higher in most states compared to conventional vehicle sales, with their share in global sales reaching 6.3%. Most of them were sold in Europe, where the share of electric vehicles reached 14%, from 7% in 2020 [35].

In 2005, the EU launched the European Union's Emissions Trading System (EU ETS), the most ambitious attempt to reduce carbon emissions at the time [36]. A limit has been imposed on the amount of carbon dioxide that can be emitted into the atmosphere each year by companies operating in the partner countries of this system. Each company is allocated a fixed allowance, which is converted into the system's currency. Companies must stay within these indemnities, otherwise fines will be levied. Those who have a surplus of allowances have the opportunity to sell them to more polluting companies. This will ensure that emissions are reduced in the sectors where it is cheapest to reduce them. The Commission reduces the level of allowances every year so that the level of greenhouse gas emissions gradually decreases. The certificate operates in all European Union countries, Iceland, Liechtenstein, and Norway.

From 2026, transport will adhere to this system, which will lead to the need to strictly monitor the level of emissions and to comply with the number of allowances offered [37]. Thus, the use of a transport management software system in order to monitor the level of emissions and to report correctly this level becomes all the more important. This is considered to be a critical element in reducing greenhouse gas emissions in terms of costs. The transport optimization algorithm presented in this study is a supporting element of the EU ETS and is at the same time a strategic advantage for the RNM Alliance, with appreciable financial and competitive implications in the context of the EGD.

5 Decarbonising the European economy by reducing carbon emissions

Due to the growth of road transport, the transport industry has developed dramatically in recent years, reaching 43.5% between 1990 and 2017, according to the European Environment Agency [38]. Unfortunately, road transport is also the main source of greenhouse gas emissions in Europe, accounting for 71.7%. At the same time, transport in general is responsible for more than 25% of EU greenhouse gas emissions [38]. Given this situation, counterbalancing measures are becoming increasingly necessary so that the environmental impact is minimized.

Considering the statistical data presented, the optimization of road transport plays a particularly key role in reducing greenhouse gas emissions. The route optimization algorithm, developed in this study, contributes to the reduction of CO_2 emissions by optimizing the transport load. This reduces the number of trucks needed to transport goods and reduces distances, both nationally and internationally.

Carbon dioxide is the best-known greenhouse gas emitted by human activities, measured by the amount released and the overall impact on global warming. Burning a litre of gasoline emits 2.39 kg of CO_2 and 2.62 kg of CO_2 in the atmosphere for diesel (the vast majority of trucks having diesel engines) [39]. As the density of the fuel is sub-unitary, it becomes interesting to see how the weight of the emissions is multiplied by the combination of oxygen. The following formula for calculating CO_2 emissions is therefore deduced:

$$E = d * C_m * I_C$$

in which:

- E – CO_2 emissions measured in tonnes.
- d – the distance measured in kilometres.
- C_m – the average consumption expressed in litres / 100 km (approx. 29 l / 100 km for Euro 6 engines, 20 TO – 24 TO trucks).
- I_c – the fuel index (2.39 kg CO_2 for petrol and 2.62 kg CO_2 for diesel respectively).

The emission level is automatically calculated and displayed in the reports of the application that implements the transport optimization algorithm. Thus, application operators have access to this data in a much shorter time than their conventional evaluation. By analysing the results obtained and the experience of previous research, we can see that the degree of optimization of the distribution is between 10% - 20% economy of kilometres. The RNM Alliance estimates that 40,000 kilometres will be covered each week for the transport of goods in 20-ton trucks. At the same time, in order to determine the financial savings, we can take into account an average fuel cost of 1.65 Euro / litre (no taxes). Thus, we can consider two scenarios, a pessimistic one, in which the level of optimization is 10%, and an optimistic one, in which the level of optimization reaches 20%. The obtained results are presented in table no. 2.

Table 2. Savings generated by the transport optimization algorithm

	Scenario 1 10% cost reduction	**Scenario 2 20% cost reduction**
Distance (km)	4.000	8.000
Fuel (litres)	1.160	2.320
Fuel cost (Euro)	1.909	3.818
CO_2 emissions (tons)	3.039	6.078

As can be seen, even in the pessimistic scenario, fuel-only savings, without considering the reduction of labour time, are substantial.

6 Conclusions

The existential perspective on modern society places the transport sector, along with that of information and communication technology, at the foundation of its development. Transport connects people, cities, countries, and economies, significantly stimulating growth and employment. The larger the quantities to be transported and the longer the distances travelled, the more challenging. At the same time, transport remains a major source of environmental pressure, generating more than a fifth of global greenhouse gas emissions, most of which are from road transport. The technological progress today offers, more than ever, the possibility of adopting environmentally friendly solutions for transport management.

The software tool elaborated and developed by authors and based on a transport optimization algorithm covers a wide range of specific activities, with a financial, competitive, and environmental impact. It contributes to significantly saving resources by streamlining the activities involved in specific processes. Thus, the economic impact materializes in the reduction of resource consumption, be it fuel, vehicles, or human capital. At the same time, the full monitoring of the transport stages provides a complete view of the activity and allows the generation of complete and detailed reports. The impact on the environment is measured by the level of carbon dioxide emissions using the specific methods presented. The implementation of the transport optimization algorithm and the financial and environmental advantages obtained makes the RNM alliance the beneficiary of a strategic advantage in the increasingly fierce competition of the global road transport sector.

Last but not least, the fields of information and communication technology and the implications that the outputs of their exponential development have as vectors of influence in all spheres of human existence must be considered as future directions of research. At the same time, we cannot fail to notice some limitations of the EGD regarding energy-intensive industries such as those mentioned. The adoption and implementation of solutions built on artificial intelligence, virtual machine learning, augmented reality, robotic process automation or other modern technological paradigms in various sectors of activity (including transport) will have a significant impact on the environment. The new technological discoveries, once materialized on the broad consumer market, will become just as many sources of conflict situations, demanding new specific agreements or pacts. Such examples may include, in the extremely near future, the sharing of urban airspace for flying machines or thresholds for international virtual currency transactions (national shares of private virtual space for data mining in the digital currency blockchain, similar to the EU ETS).

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