Multimodal rail transport for Greener Supply Chain in Automotive Industry

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Starting from the European policies objectives regarding the reduction of CO_2 emissions, especially in the field of transport, the present work analyzes the necessary transformations to ensure sustainable transport in the supply chain in the automotive industry, exploring adaptable and sustainable solutions that contribute to achieving these goals. In this context, the proposed solution is the emissions decrease and the degrading pollution of the environment through the partial reduction of road transport and the integration of multimodal transport, including rail transport.

In an experimental approach, simulations were carried out regarding the integration of the railway system by presenting the constraints and applying the existing solutions for the interested parties, the transport companies that want to implement this type of sustainability. The exploration and adaptation of solutions was done according to the stability of demand and supply, the reconciliation of the parties involved, following the identification of risks and the improvement of the process. The experimental part approaches the decomposition of the lead time, having the role of correctly evaluating the time required to ensure efficient transport, without delays and other associated risks.

Keywords: sustainability, automotive, CO_2, European policies, rail transportation

1. Introduction

In the context of the continuous growth of the car on the road, the concern for motor fuel consumption and environmental pollution is becoming indispensable. According to the BP Global Energy Outlook, global demand for both freight and passenger transport could double by 2040. [1][2]

Transport accounts for a fifth of total EU emissions. Road transport accounts for the largest percentage of transport emissions and in 2021 was responsible for 72% of all EU domestic and international transport greenhouse gas emissions''.[1] Looking at today's EU studies and policies, as the decarbonization process is much slower than other processes in other economic sectors and that emissions from road transport generate the largest weight, an alarm signal is raised. By 2030

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energy consumption from freight transport is expected to grow by almost 60% to 10,850 TBtu, representing 28.6% of total transportation energy use.1 According to the forecasts of the United States Energy Information Administration (EIA), energy use in the freight transportation sector will increase significantly in the future, as a result of the continued growth trends of this sector.[21]

Energy consumption trends in freight transport by different transport modes over the period 2005-2030, highlights that most of this growth will take place in the road and air transport sectors, which are traditionally the most energy-intensive energy and carbon emissions.[2]

In the global context of concerns related to climate change and the reduction of greenhouse gas emissions, the European Union has proposed an ambitious goal through the "Fit for 55" initiative, which aims to reduce net greenhouse gas emissions by just under 55% by 2030. This directive represents a firm commitment by the EU to accelerate the transition to a more sustainable and green economy, having a significant impact on energy policy and long-term development strategies."[3][4]

One strategy to achieve this is to change by 30% of goods transported over distances greater than 300 kilometers or more from road transport to modes of transport with lower CO2 emissions, including the relocation of containers and other freight units from road to railway.[5]

Multimodal transport uses several modes of transport such as rail, road, maritime transport. It is an effective strategy used and a main segment in any industry, especially in the automotive industry and characteristic of the supply chain field. Rail-truck intermodal transportation, which exploits the positive attributes of both trains and trucks, has experienced phenomenal growth since 1980 (AAR, 2010)[6].The Trans-European Transport Network (TEN-T) identifies a “core network” of transport infrastructures, including nine Core Network Corridors, as well as two horizontal priorities (the European Rail Traffic Management System (ERTMS) and “motorways of the sea”). ERTMS ("European Rail Traffic Management System") is a major industrial project being implemented by the European Union, a project which will make rail transport safer and more competitive. According European studies and policies In 2021, the Council adopted conclusions on rail transport as part of smarter and more sustainable mobility in the EU.[7] To decarbonize freight transport, the Rail Freight Forward (RFF) initiative has committed to increase the share of rail transport by 30% by 2030 (CER and RFF. To increase its market share, improve services to customers, and boost economic growth, the rail freight sector should transform its operations by accepting the continued adoption of innovative solutions as part of the digitization of rail transport. In 2014, the Shift2Rail Joint.[8]

Key trends across 2023 are high-speed rail, predictive maintenance, decarbonization, and IoT. TCS, Capgemini, and Accenture are service providers delivering asset management, machine vision-based rolling stock inspection, and intelligent transport systems.[9]

Rail is one of the greenest modes of transport, and operators will capitalize on this. Shipping firm Maersk's solution will save 9,100 tonnes of CO2 annually for 85% of Germany's rail network.[9].

Renault, car manufacturer is increasingly using multimodal transport and improving the fill rate of containers and trucks, as well as the eco-design of packaging and reducing the number of kilometers travelled. The Supply Chain is working with transporters to increase the share of flows by rail compared to transport by truck. For example, the use of trains from Eastern Europe to France has made it possible to avoid 2,600 tonnes of CO2. [10]

Thus, studies show that by combining modes of transport, such as road and rail, CO2 emissions can be reduced compared to using a single mode of transport. For example, the train for the use of goods, over long distances can be much more efficient from an energy point of view and less polluting than road transport used excessively in urban areas.[10]

Starting from this study, the field of logistics for car manufacturing companies is targeted in relation to the large number of carbon emissions and in this sense the main action is firstly to visualize a considerable decrease in carbon emissions: the definitive reduction of diesel/gas cars and road transport.[9][11]

The current paperwork makes an analysis of the current practices and policies for the CO2 reduces in Supply Chain regarding the transport and aims to develop a study to integrate multimodal transport.

In the field of logistics, the most significant contribution is made by transport, namely the logistic process of loading parts, from a company that manufactures and supplies to a manufacturing plant. In a broad sense, logistics is associated with transport, with a significant percentage of pollution for the environment. [12]

Integrating SDGs, sustainability, and circularity into various aspects of policymaking, business strategies, and daily practices is essential for creating a more resilient and equitable society while preserving the planet for future generations. This integration involves aligning objectives, implementing sustainable practices, fostering collaboration across sectors, and promoting awareness and education about the interconnected challenges and opportunities of sustainable development.[13][14]

The focus is on finding sustainable solutions, such as examining as an alternative method the railway route and other means of transport with low carbon emissions compared to road transport. Currently, it starts from data sent by the European Environment Agency, namely the fact that this type of multimodal transport, mostly powered by electricity, is the most sustainable mode of transport. One of the opportunities to reduce pollution generated by vehicles is associated with the development of alternative fuels or energy sources.

Starting from these conclusions, based on studies carried out, the study of the work on finding solutions to reduce CO2 by implementing rail transport in the logistics environment is in accordance with the desire for European sustainability. To minimize the negative impact of transport on the environment, individual countries around the world pursue a policy promoting the use of multimodal transport, with an emphasis on the mechanization and automation of its individual phases. At the same time, great importance is attached to ensuring smoothly functioning supply chains, and thus rational satisfaction of users' needs. Cross-border rail transport faces regulatory challenges, but initiatives like the International Transport Forum's efforts to harmonize standards and regulations are crucial for facilitating seamless rail logistics across different countries [oai_citation:11,Innovation and Technology in Multimodal Supply Chains ITF][39]

The research proposes to offer a comprehensive perspective of sustainable solutions in the logistics and transport industry with the main objective of achieving the objectives set by European policies.

2. Research methodology

The intention of this work is to systematically represent an approach that, although it is used, is not effectively explored, but the pressures on the sustainability of the environment are increasing more and more. Zero pollution or the reduction of significant pollution through various methods means, according to studies, health, sustainability, durability, good life, correct choices, and a cleaner environment. The present work is divided into two parts, namely:

1. Practical research, based on carbon emissions reflected mainly in the current logistics environment from the point of view of transport and the objectives of their reduction through established European policies. So that the research comes from the studies carried out regarding the multimodal transport much more accessible for companies, namely the integration of another type of transport than the road, the most usual one. Transport was the source of around a quarter of all EU CO2 emissions in 2019. Of these, 71.7% came from road transport, according to a report by the European Environment Agency. Road transport accounts for about a fifth of EU emissions.[19]

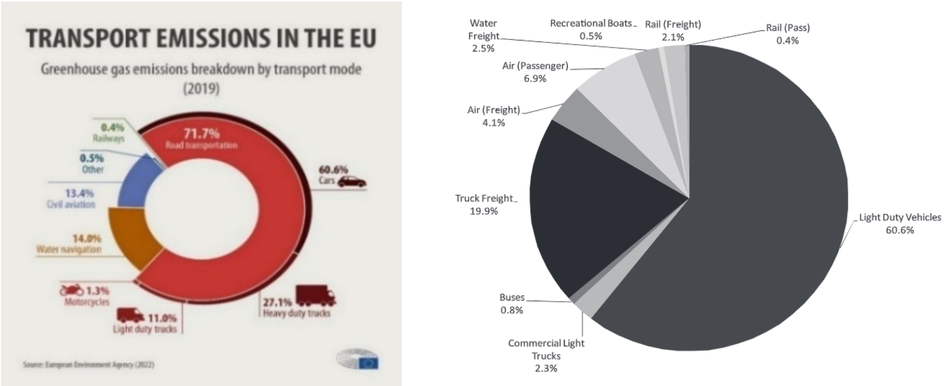


Fig.1 Evolution of CO2 emissions in the EU Energy consumption by transportation sector service, 2030 [2][19]

Energy efficiency, electric motors used in locomotives compared to internal combustion engines. The traffic conditions are also an external factor, unusual for the two transport solutions.[11] Noise pollution is another harmful impact associated with road transport, which remains the main source of environmental noise.[12]

2. Experimental part of the implementation of multimodal transport through tools used, example of calculation, methods, limitations, and future developments that can take place in a car construction company taken as an example and from which certain theoretical data were taken.[18]

3. Material and Methods

Looking at the government or regulatory agency databases that track CO_2 emissions and transport performance through the work, the following objectives are drawn:

a) Evaluating the environmental benefits of using rail in the automotive supply chain by determining the impact of rail use on CO_2 emissions, energy consumption and air pollution compared to other transport methods, road transport.
b) Identifying the main barriers/limitations to the adoption of multimodal rail transport in the automotive industry through identification and categorization of the factors impeding the widespread adoption of rail and multimodal transport in automotive supply chains, including technological, operational, economic and legislative barriers.
c) Identifying and assessing technological and operational solutions to improve rail transport efficiency. Investigate and evaluate technological

and operational solutions that can increase the efficiency and attractiveness of rail transport in automotive supply chains, including automation technologies, digitization solutions, and multimodal integration strategies.

d) Offers established between the carriers that can take part in the project and the logistics operators: incentives and facilities to opt for rail transport instead of road. Implementing intermodal transport practices, such as combining rail to reduce emissions generated by long-haul road transport.

e) Extending the strategy and financing the project under the coordination of European policies and regulations actuals. Thus, more emphasis would be placed on education regarding the awareness of the environmental impact that manufacturing companies have. [6][23]

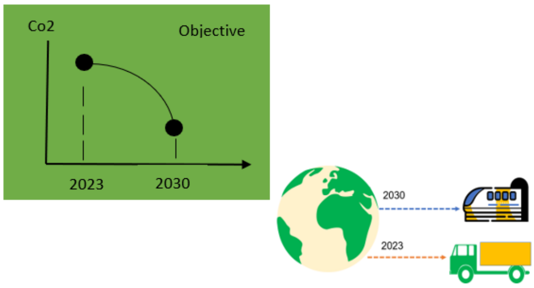


Fig.2 Substantial objective of reducing carbon emissions, beginning from 2020 to 2030

a. Identifying constraints/generating solutions

Analysis of possible solutions for integrating multimodal transport into the activity consisted in identifying the main constraints:

- Punctuality in deliveries to the plant: If there are delays at the factory due to mismanaged transportation, or a lack of follow-up, the automobile production schedule, in the present case, could be caused and the whole process leads to delays in deliveries to customers and additional costs.

b. Request-Offer

The company must provide a clear framework for innovative solutions and ideas, inviting carriers to propose ways of effective integration. On the other hand, carriers will send offers that include details on how they will organize multimodal transportation, highlighting their advantages and resources to meet the specific requirements of the company: Train axis, frequency, terminal, delay.

c. Conciliation of the offer with the initial requests

In the conciliation stage, the company will evaluate the offers received, comparing them with the initial requests. Particular attention will be paid to the solutions proposed by carriers for the efficient integration of multimodal transport.

d. Back-up/ Identifying risks

In the process of choosing carriers risk management is important to consider. The company identified primary carriers and, in parallel, developed a backup plan to manage potential risks or delays.

The backup plan contains:

- Effective Communication System
- Continuous monitoring of the activity.
- Anticipation of product delays at the factory.
- Establish protocols for emergency situations: The risk of coordination failure for the transport of goods.

e. Using tool

The use of tools contributes effectively to transport operations, especially direct communication platforms to facilitate collaboration between all interested parties, suppliers, carriers, customers. The automation and optimization of routes by means of tools, GPS systems will improve the efficiency and profitability of railway transport.

Decomposition of lead time is a useful practice for a company and the carriers. It involves detailing each stage of the transportation process, starting from when the goods leave the supplier to deliver to the customer. By identifying and clarifying each stage, a deeper understanding of the entire logistics route can be achieved. [12]

In order to correctly understand the current situation of the transports used in factories, today we have to list the necessary materials by means of which the actions necessary for the transport of goods from one factory to another are produced. Consequently, a summarized model, from concrete examples used by the Renault Automobile manufacturing company will be presented.

Case study: Implementing rail multimodal transport in the supply chain in the Renault Group company and reducing carbon emissions.

3.1 Route planning

The current situation regarding the means of transporting goods from the supplier to the factory and from the factory to the supplier consists of various types of routes, direct, indirect or through platforms (loading/unloading points).[1]

A direct route describes an optimized scheduled flow from one or more supplier sites to one or more client sites without transit via a cross-dock. Direct routes are specified in operational sheets accessible from the application.

1. Routes are planned by and with the initiative of the Transport Department, which will contact the supplier to set loading times and to provide information on organization and route start up.
2. The Transport Department will also keep the supplier informed about any changes to the route characteristics.
3. The Transport Department defines overall route organization and changeover dates, informing the supplier accordingly.

Fig.3 The main stages for a direct route

The role of the integration of a multimodal transport, in the case of the current study, rail transport, is to adapt sustainability in the supply chain in the current landscape, especially in the automotive industry which involves combining economic success with environmental responsibility.[12]

3.2 Inputs multimodal flow:

The constraints are established between any company that proposes to integrate rail transport, in addition to road transport, in order to deliver the goods and the transport companies that deal with the actual transport, on the route and that are willing to try multimodal transport as well.

Table 1

Constraints	Applied solutions/requirements
Additional train operating costs	The train package must be competitive including additional costs
Punctuality at the factory	Add buffer time at arrival terminal
Punctuality in factory / stocks	High departure frequency (minimum 5 trains/week)
Tracking	GPS on trailer
Exceptional Transport Plan	Train volume flexibility and/or truck reinforcement solution
Reliability and flexibility	Rescue solution for trucks included in the train package

It is essential to find an adapted solution for the implementation of this type of multimodal transport from the carriers, such as addressing specific non-standardized packaging, managing additional train costs, optimizing train tracking, flexibility plant volume fluctuations, development exceptional transportation plans for holidays, and other relevant aspects. While some carriers are ready to adopt this multimodal transport, others require a more extensive persuasion process based on the benefits of adopting these practices.

The data presented below are essential key points to be established, followed, and completed in order to keep track of the time required for the entire railway transport management process and also to take into account possible delays.

These dates are established with the transport company with which the contract is signed after the constraints, the applied solutions and the acceptance of the offers have been presented.

Input data:

- Train axis
- Terminal
- Open hours
- Lead time decomposition
- Loading supplier
- Delivery at the factory
- Closing time in terminal

Table 2

Accelerations and backup plan	Equipment
It is / it is not possible to extract a trailer from train on intermediary stations	Type of trailers (standard, mega etc.), own / rented fleet, with/without GPS,
It is / it is not possible to get out a trailer from departure terminal, before closing time, and to make delivery by road	Type of wagons (platform etc.), own / rented
Once that a trailer it's out from arrival terminal, it is / it is not possible to accelerate the delivery	Rail corridor:electrified/covered by locomotives
If a trailer it's blocked on a train, we can / we cannot initiate an urgent delivery by road from the supplier	Rail KPI punctuality (last 3-6 months): % punctuality % delay < 24 hours % delay > 24 hours

The main tools to use to complete the process:

1. FCC- Operational Sheets
2. Timetables
3. Decomposition of lead time
4. GPS
5. Google Maps
6. Geographic information systems

Rail transport often lacks the flexibility and frequency of road transport. Automotive supply chains, which demand just-in-time (JIT) delivery, may find rail schedules less accommodating, leading to potential delays, that is why it is necessary to calculate the transit times and track them through various work tools.

Transit time represents the total time from origin to destination and is an important determinant for promoting multimodal freight transport solutions. Winebrake et al. indicated that rail transport is often cost-competitive, but it always has a longer transit time than other transport modes. Loading and unloading operations at terminals increase transit time and thus reduce intermodal transport preference.[28][2]

Timetables are very important in this process because the time spent on the road is in direct contact with the time of arrival at the factory, so that the goods arrive in the allotted time after decomposition. Delays that can occur for various

reasons can affect the production of cars, the factory stock, etc. Geographic information systems help to analyze and fix routes according to geographical factors to minimize the impact on the environment.
For real-time tracking of the location of trucks full of goods, GPS maps and computer systems are used that alert potential unpleasant events: snow crises, accidents, etc. The colored dots on the route indicate various external factors that happen on the route, such as: road accidents that could make it difficult to access the route now crises/floods, works on that route, etc.

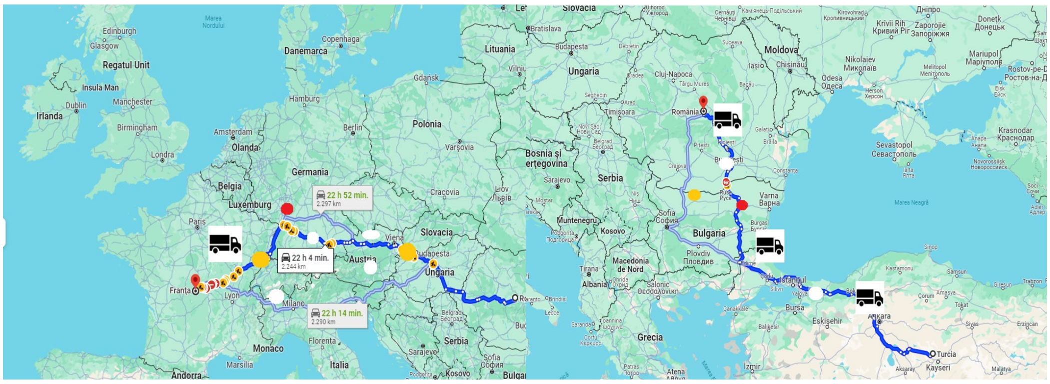


Fig.4 Locating the trucks on the route

4. Results and discussion

In order to illustrate how the integration of multimodal rail transport into the supply chain can influence supply chain processes and performance, this section examines some of the results obtained, including a detailed analysis of the decomposition of lead times and inputs, one of the tools used. In order to achieve the desired result of integrating rail transport into the supply chain, after establishing the necessary methods and tools, concrete examples of routes were used and, in doing so, reducing the number of km traveled on the road route and reducing CO2 from rail transport [5].

Lead time decomposition, one of the tools used, was the main step to calculate the exact transit time, including hours and a detailed route description of the freight transport. This process is based on the specific transportation plan in the company's system, which contains precise data, such as the location of the supplier from where the goods depart, the exact times, the destination of the factory, the exact location, the calculated delivery time and the date of application of the respective flow The route that is taken as an example of the study is Romania-France. The process on the road route is simple: The supplier from Romania sends the parts directly to France through a carrier company that has a certain type of truck provided (with a certain length and mass). At the same time, it is discussed that the respective transport, for example GEFCO has started according to the steps in the previous chapter and the project of integrating the train as a railway route in addition to the road route. Thus using railway terminals, his responsibility being to collaborate directly with both the company and the railway company.

Inputs for GO decision:

- The budget
- Quality
- CO2 reduction
- Transport tests
- Equipment suitability
- Overall communication and reactivity

In the table below, the data related to the country where the goods will be delivered, the customer country where they will receive the goods, the route used to be both train and road, the transport solution with the 2 terminals and the time intervals transmitted by railway line.

Table 3

FCC line	Supplier-Country	Client-Country	Type of route	Proposed solution	Terminal closing time	Terminal Arrival time
2210 -01	Romania	France	Road + Train	Frn RO>Terminal Curtici>Ter KOLN Germany>Dest FR	14:00	10:00

After the adopted railway route, the 2 terminals and the main time intervals have been established, a lead time decomposition will be made that shows how long the respective route. So that the route is represented coded, by means of the colors and the accompanying legend, which is the required travel time both by road and by rail, including the breaks. The lead time decomposition starts from the day established with the supplier and the carrier intended to pick up the goods until the day when these goods arrive at the respective factory without any delay.

- Loading goods: Monday, 12:00
- Unloading goods: Wednesday, 06:00.

Through decomposition, it can also identify critical points or stages that consume the most time in the process, this implies opportunities to focus on some areas.

FCC lane	Exp Country	Dest country	type	Solution	1st Terminal closing time	1st Terminal Departure time	Last Terminal Arrival time
2210-01	Romania	France	Road + Train	Frn RO>Ter Curtici>Ter Koln >Dest FR	23:59		7:00
2210-01	Romania	France	Road + Train	Frn RO>Ter Curtici>Ter Koln >Dest FR	23:59		7:00
2210-01	Romania	France	Road + Train	Frn RO>Ter Curtici>Ter Koln >Dest FR	23:59		7:00
2210-01	Romania	France	Road + Train	Frn RO>Ter Curtici>Ter Koln >Dest FR	23:59		7:00
2210-01	Romania	France	Road + Train	Frn RO>Ter Curtici>Ter Koln >Dest FR	23:59		7:00

Fig.5 Route description

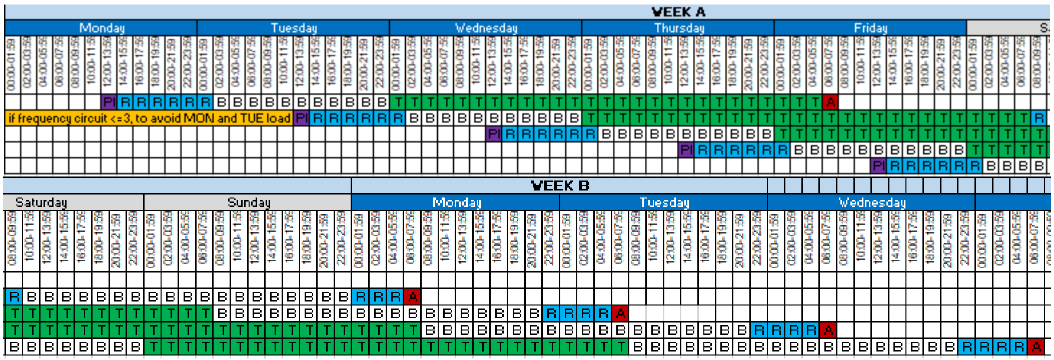
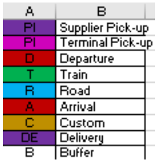


Fig.6 Decomposition of lead time



The color code is represented in the legend

Comparative Analysis: Evaluation of costs per ton-km for each mode of transport
Determining the impact of the use of rail transport on CO_2 and other pollutant emissions, compared to road transport, in the supply chain of the automotive industry.

- CO_2 emissions: Calculation of CO_2 emissions per tonne-kilometre for rail and road transport.
- Energy consumption: Evaluation of energy consumption for both modes of transport.
- Operational costs: Comparison of operational costs per tonne-kilometre for rail and road transport

- Calculating emissions:

- Using specific formulas to calculate emissions of CO_2 and other pollutants for each type of transportation.

- Emissions (kg CO_2) = Distance traveled (km) x Fuel consumption (liters/km) x Emission factor (kg CO_2/liter). (1)

- Example calculation for road transport:

- If a truck transports goods over a distance of 3000 km, consumes 30 liters of fuel per 100 km, and the emission factor is 2.68 kg CO_2/liter, then the total emissions are: The GREET Model indicates an emission factor of 2.68 kg CO_2/litre for diesel fuel used by Euro 6 trucks.[30][40]

Emissions = 3000 { km} x 0.3 { liters/km} x 2.68 kg CO_2/liter} = 2412{ kg CO_2} (2)

- Example calculation for rail transport:

- If a train transports goods over a distance of 3000 km, consumes 5 kWh of energy per km, and the emission factor for electricity is 0.1 kg CO_2/kWh, then the total emissions are:
Emissions = 3000 { km} x 5 { kWh/km} x 0.1 { kg CO_2/kWh} = 1500 \ kg CO_2}
- Rail transport generates 1500 kg CO_2 for a distance of 3000 km, while road transport generates 2412 kg CO_2 for the same distance.
- The difference of 912 kg CO_2 (2412 kg CO_2 - 1500 kg CO_2) indicates that rail is more environmentally friendly.

Table 4

Road transportation	Rail transport
Fuel consumption: 30 liters/100 km	Energy consumption: 5 kWh/km.
Energy efficiency: 10 tonne-kilometers per liter (assuming a truck can carry 10 tons of goods)	Energy efficiency: 500 tonne-kilometers per kWh (assuming a train can carry 500 tons of freight).

Suppose car company Renault Group transports goods over a total annual distance of 1,000,000 km.

- **Road transportation**:
  - Total emissions:
    2412{ kg CO_2/1000 km}\times x 1000 = 2,412,000{ kg CO_2/year}
- **Rail transport:**
  - Total emissions:
    1500{ kg CO_2/1000 km} Times x 1000 = 1,500, 000 { kg CO_2/year
- **Annual difference in emissions**:
2,412,000 kg CO_2/year} - 1,500, 000 { kg CO_2/year} = 912000 { kg CO_2/year}

Interpretation:
- Rail transport is much more energy efficient than road transport. A train consumes 5 kWh to transport 500 tons of goods for 1 km, while a truck consumes 30 liters of fuel to transport 10 tons of goods for 100 km.
- This difference shows that trains can transport much more freight per unit of energy consumed than trucks, which contributes to a significant reduction in total energy consumption and associated emissions.
The European Union's "Fit for 55" policies aim to reduce carbon emissions by 55% by 2030. In terms of transport, measures are proposed to promote low- or zero-emission vehicles, encouraging the use of rail and sea transport. The conclusion of the paper shows how effective rail transport is in reducing CO2 emissions compared to other modes of transport, and this can be directly relevant to the objectives of "Fit for 55". The integration of rail transport into modern logistics can contribute to achieving these objectives by reducing the distances

traveled by road vehicles, which are responsible for a significant part of carbon emissions.[3]

Limitations

The limitations regarding this implementing can be the refusal of certain carriers to implement this type of railway transport.
They can choose not to implement a new type of transport, using only road for several reasons such as:

- Significant initial investments, higher costs, specialized equipment and adaptations to logistic processes, also expensive
- Limited access to certain destinations, because the railway line may not be as accessible as the road routes.
- Managing the implementation of a railway route is much more complex because it requires collaboration and coordination with train operators and compliance with fixed schedules. Complex regulatory frameworks and varying standards between countries can complicate cross-border rail transport. Harmonization of regulations is needed to facilitate smoother operations.
- The adoption of new regulations and including CMR type insurance
- Different regulations and transport standards: different countries may have different regulations, complicating the interaction.

The rail industry needs to adopt new technologies like automation, IoT, and AI to enhance efficiency and reliability. However, the transition to these technologies can be slow and costly. Draup's 2023 Report highlights how digitalization and new technologies are driving advances in rail transport, but also points out the need for significant investment and regulatory alignment to fully realize these benefits.[9]

Efficient rail transport requires well-developed intermodal hubs where goods can be transferred seamlessly between trucks and trains. The lack of such hubs can create bottlenecks and increase handling times.[39]

- These factors contribute to the refusal of certain carriers to adopt rail transport and can highlight certain disadvantages for them, but since it is a challenging project, the opening should be as large as possible.

Future developments

In association with the European Objective of reducing CO_2 emissions by at least 55% by 2030, future developments of this work could include a deeper investigation of technologies in multimodal transport and the revelation of the impact of future regulations and policies on the implementation of sustainable solutions of multimodal transport integration.[26] Also must also be focus identification of innovative strategies for the promotion of efficient and environmentally responsible external logistics at the level of any company.[5][23]

For example, through the digital application in logistics, its integration, due to the technological progress in the production systems worldwide, generated by the 4.0 revolution, from the point of view of transport, the state of traffic can be analyzed in real time, increasing the efficiency of logistics management, Reducing the use of fossil fuels, pollution, noise, traffic congestion, human error and accidents. Accelerate order processing, improve control and real-time knowledge of order delivery status, reduce fuel costs, Increase overall efficiency.[16][17]

During the work, several key points for future follow-up were identified:

- Identifying and implementing effective communication channels between the company and carriers are essential to managing transit and respond quickly to problems changes or issues.
- Implementing a robust carrier performance monitoring system allows prompt identification of any deficiencies and continuous improvement of service quality.
- A detailed evaluation of performance and results at the end of the project provided essential insights into future projects and possible improvements in logistics processes.
- using Ishikawa as a quality tool to highlight the root cause of an affected area. [29]
- Establishing relevant aspects related to feedback (open communication between all interested parties), regular meetings, both from the clients and from the other parties to identify improvement methods, problems, strategies in logistics. Being a new concept, which some carriers do not adopt for several reasons, this must be strictly monitored.
- According to the studies in *Artificial intelligence in railway infrastructure: current research, challenges, and future chances* digitization in railway infrastructures generates a large volume of real-time data, because many devices and sensors are used to actively monitor. This data can provide insights into health the conditions of the monitored assets, and this enables prediction maintenance. To get useful information in real time, cloud infrastructures must be invested and exploited. With that big data, communication network and 5G adoption technology is needed.[31]

5. Conclusions

In conclusion, the promotion of railway transport contributes to the reduction of carbon emissions and to the improvement of air quality and life. The railway transport implementation project has a positive impact on sustainability for the

local community, for the economy, contributing to the achievement of European objectives and alignment with them.
So that the work came to fruition by defining the existing types of transport and finding some constraints and solutions applied and sent to all road transport companies in collaboration to expand these types with a durable and sustainable with railway transport.

After these applied solutions were confirmed with the carriers, the process started by finding input data to help the implementation of the project.

Useful tools were also presented that facilitate quick management, being the supply chain where the time required for delivery and the absence of delays at the client's factories are key points of production efficiency.

Presentation of some advantages obtained following the conclusions drawn:

- Lower transport costs for long distances due to the high loading capacity of trains and lower fuel consumption per ton-kilometer.
- Reduction of CO_2 emissions and environmental impact, as trains have a much lower carbon footprint compared to trucks and road vehicles.
- Reducing the risk of road accidents and traffic jams, contributing to safer and more reliable distribution of goods.
- The lack of adequate infrastructure for the implementation of rail transport and inefficient investments can represent obstacles for this type of project, but this type of project is a starting step to better visualize the changes that may appear in transport logistics.

The study presents, in broad terms, the essential steps for the preparation of the land, in order to implement multimodal transport, what are the constraints that can make the project not work, what are the improvement solutions or the future key points to be reached to use multimodal, rail transport in as many factories as possible. Current research highlight the potential for substantial emission reductions and efficiency improvements, driven by advancements in digitalization and sustainable technologies.

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R E F E R E N C E S

[1].https://www.europarl.europa.eu/news/en/headlines/society/20180305STO99003/reducing-carbon-emissions-eu-targets-and-policies

[2]. *Winebrake, J. J., Corbett, J. J., Falzarano,* A., et al. (2012). Assessing Energy, Environmental, and Economic tradeoffs in Intermodal Freight Transportation. J Air Waste Manage Assoc, 58, 1004–1013. https://doi. org/10.3155/1047-3289.58.8.1004.

[3].Fit for 55: reform of the EU emissions trading system, Last review: 27 January 2024: https://www.consilium.europa.eu/en/policies/green-deal/fit-for-55

[4]. *Zakharov D., Magaril E., Rada E.C.*, Sustainability of the urban transport system under changes in weather and road conditions affecting vehicle operation, SUSTAINABILITY, v. 10, n. 6 (2018), 2052

[5] *Ilie Nae, Irina Severin*, Performance Management model for third part logistics companies. January 2018, UPB Scientific Bulletin Series D. Mechanical Engineering 80(4):279-286

[6]. *Alexandru Burda*, Logistics and distribution of goods - course support. 5th edition

[7]. Transport and environment report 2020, EEA Report No 19/2020, Luxembourg: Publications Office of the European Union, 2021

[8]. *Boban Djordjevic´ 1 • Oskar Fro¨idh1 • Evelin Krmac2* Determinants of autonomous train operation adoption in rail freight: knowledge-based assessment with Delphi-ANP approach

[9]. Digitalization December 9, 2022 How Digitalization and New Tech Drives the Rail Transport Beyond 2023

[10].Communiqué de presse: https://media.renaultgroup.com/renault-group-exceeds-its-decarbonisation-target-for-its-freight-transport-activities/

[11]. *Ghazal Assadipour Ginger Y. Ke Manish Verma* : Planning and managing intermodal transportation of hazardous materials with capacity selection and congestion, April 2015 Transportation Research Ghazal Assadipour

[12] Intermodal freight transport EU still far from getting freight off the road, 08.2023 https://op.europa.eu/webpub/eca/special-reports/intermodal-freight-transport-08-2023/en/

[13] Circular Economy & SDGs https://circulareconomy.europa.eu/platform/sites/default/files/3228_brochure_sdg__hch_cmyk_a4portrait_-_0520-012.pdf

[14] *Cris Garcia-Saravia Ortiz-de-Montellano, Pouya Samani, Yvonne van der Meer*, How can the circular economy support the advancement of the Sustainable Development Goals (SDGs)? A comprehensive analysis

[15] ISO 14001: Energy and waste

[16] *Camila Patricia Malagón-Suárez Javier Arturo Orjuela-Cast*ro Challenges and Trends in Logistics 4.0 Ing, vol. 28,no. suppl, 2023.e18492:

[17] *Zuzana Gerhátová, Vladislav Zitrický, Vladimír Klapita*, Industry 4.0 Implementation Options in Railway Transport

[18] *Praven Kumar Chanda* Modeling intermodal freight flows using GIS, The University of Toledo May

[19] CO_2 emissions from cars: facts and figures (infographics) Published: 22-03-2019 Last updated: 14-02-2023 https://www.europarl.europa.eu/topics/en/article/20190313STO31218/co2-emissions-from-cars-facts-and-figures-infographics

[20] *Aiman Albataynehi, Mohammad N.Assaf, Dariusz Alterman, Mustafa Jaradat*, Comparison of the Overall Energy Efficiency for Internal Combustion Engine Vehicles and Electric Vehicles 2020, vol. 24, no. 1

[21]Source: European Parliament (EP) i, published on Monday, October 30 2023: https://www.eumonitor.eu/9353000/1/j9vvik7m1c3gyxp/vkqp9dzgriys?ctx=vg9hjjllgxmz,

[22] *Ilie Nae, Irina Severin, Gheorghe Solomon* Performance Management Evaluation Model for Third-party Logistics Companies, September 2016, Conference: Proceedings of the 28th International Business Information Management Association Conference, Seville, Volume: Vision 2020: Innovation Management, Development Sustainability, and Competitive Economic Growth

[23] *Elena Magaril, Romen Magaril, Hussain H. Al-Kayiem, Elena Skvortsova, Ilya Anisimovand Elena Cristina Rada*, Investigation on the Possibility of Increasing the Environmental Safety and Fuel Efficiency of Vehicles by Means of Gasoline Nano-Additive

[24] https://transport.ec.europa.eu/transport-modes/rail/ertms_en Directorate General for Mobility and Transport

[25] Environmental Sustainability in Freight Transportation: A Systematic Literature Review and Agenda for Future Research, Transportation Journal 56(3):263, July 2017

[26] European Environment Agency Greenhouse gas emissions from transport in Europe: Published 24 Oct 2023

[27] https://www.ecotransit.org/en/news/

[28] *Ahmed Karam1,2,3*, Anders Julius Klejs Jensen1 and Mohamed Hussein4* Analysis of the barriers to multimodal freight transport and their mitigation strategies

[29] *Irina Severin, Mihai Voicu* Quality Engineering 2003, Ed. Printech

[30] *Rui Ren 1 , Wanjie Hu 2,* , Jianjun Dong 2,*, Bo Sun 2 , Yicun Chen 3 and Zhilong Chen 1A* Systematic Literature Review of Green and Sustainable Logistics: Bibliometric Analysis, Research Trend and Knowledge Taxonomy

[31] https://www.energy.gov/eere/greet

[32] *Xuezong Tao, Qin Wu Energy* consumption and CO_2 emissions in hinterland container transport

[33] Artificial intelligence in railway infrastructure: current research, challenges, and future opportunities

[34] *Ilie Nae, Irina Severin*, Performance Management model for third part logistics companies. January 2018, UPB Scientific Bulletin Series D. Mechanical Engineering 80(4):279-286

[35] Sustainable Railway Future Issues and Challenges, Edited By *Becky P.Y. Loo, Claude Comtois*, 2015

[36] *Tan Miller* Logistics Management: An Analytics-Based Approach, Business Expert Press 30 avril 2020

[37] How the automotive industry is gearing up into sustainability's fast lane, Jan 19, 2023

[38] https://tcc-gsr.com/global-overview/global-transport-and-climate-change/

[39] *Lóránt Tavasszy Delft* University of Technology Innovation and Technology in Multimodal Supply Chains Discussion Paper

[40] https://www.energy.gov/eere/greet