Politecnico di Torino

Master of Science in Engineering and Management

ANALYSIS OF DECARBONIZATION IN TRANSPORT LOGISTICS

Supervisor:

Rafele Carlo,

DIGEP – Politecnico di Torino

Candidate:

Natallia Yarashuk

Academic year 2023 – 2024

TABLE OF CONTENTS

ABSTRACT

This paper analyzes the decarbonization process and progress in the logistics industry.

The first chapter provides an overview of the decarbonization strategy in the logistics sector. It also describes international standards and the main principles used during the evaluation of CO_2 reduction processes.

The second chapter takes into consideration the influence of key drivers on the carbon footprint in the logistics industry. It describes and analyzes how regulatory policies, investors, customers, and companies in the industry influence the decarbonization process worldwide.

The third chapter focuses on analyzing the advantages of multimodal logistics in the supply chain and the measurement of CO_2 emissions, using the GLEC methodology and Greenrouter tool calculation. It introduces Tailormade logistics, its practices, and future opportunities related to reducing carbon emissions.

Lastly, it illustrates the CO_2 emissions for different transport solutions and various green implementations. All calculations were based on the data provided by Tailormade Logistics (Italian branch) for their most common routes.

1. DECARBONIZATION STRATEGY IN LOGISTICS OVERVIEW, INTERNATIONAL STANDARDS AND MAIN PRINCIPLES

1.1 IMPACT OF CLIMATE RISKS ON LOGISTICS WITH A FOCUS ON THE EUROPEAN TERRITORY

Events related to climate change directly affect the efficiency of modern supply chains. According to Research Center for Epidemiology average annual number of natural disasters increased from 195 to 365 per year (respectively, in the period 1987-1998. and in 2000 and 2006). At the same time, the greatest impacts of climate change are felt in developing countries that are more vulnerable to economic and social factors. The drastic influence of global warming can be seen (Figure 1) by comparing extreme temperatures in the 1951-1980 and 1980-2019 periods. [1]

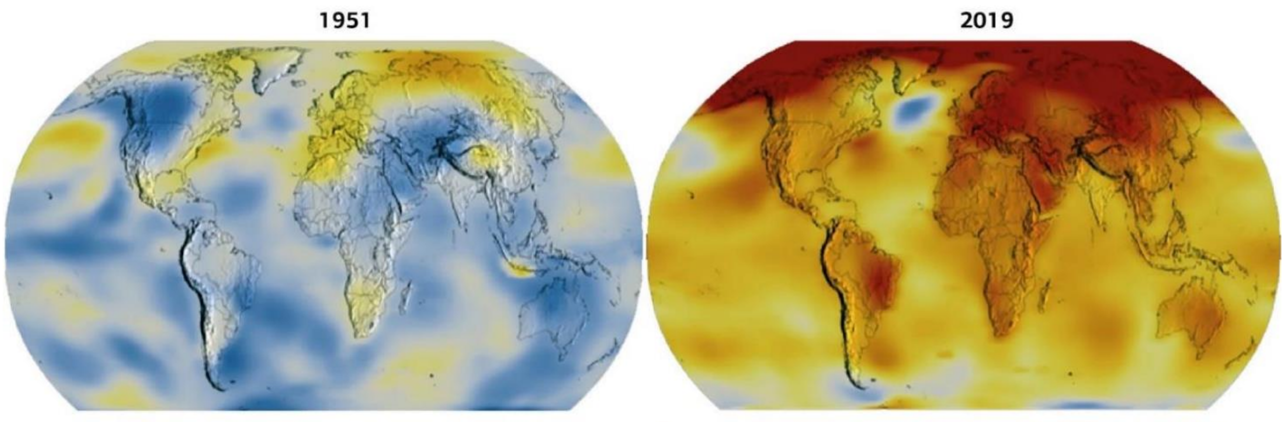


Figure 1 - Climate change in 1951-1980 and 1980-2019

Regardless of the warming scenario, the temperature in Europe will rise at a rate exceeding the global average. The last decades of observation recorded an increased frequency and intensity of extreme temperatures that include marine heat waves. Critical thresholds for ecosystems and people are projected to be exceeded with a high probability in all scenarios at warming levels of 2 C and above. At the same time, in all scenarios, the frequency of cold periods and frosty days decreases. Relative sea level rise in all European areas except the Baltic Sea is approaching to or above the world average.

Changes are projected to continue beyond 2100. Extreme maritime events will become more frequent and intense, leading to more frequent coastal floods.

The impacts of climate change on the transport sector are associated with extreme weather and hydrological events, including heavy rains, storms and extreme winds, sea tides, floods, heat waves. These manifestations of climate change have a particular impact on the transport infrastructure and, consequently, on the transport itself, its reliability and safety. The main

[1] *NASA, World Radiation Centre, Krivova, Global Carbon Project (GCP), Carbon Dioxide Information Analysis Center (CDIAC); Annual climate report of Roshydromet, 2021*

impacts of the climate change for Railway and Marine transportation described in details in Table 1. [2]

Table 1 - Key impacts of climate change on rail and maritime transport

Railway	Marine Transport
INCREASED PRECIPITATION AMPLITUDE, SEA LEVEL RISE	
• landslides/washing out of embankments, destruction of the roadway	• some ports are affected by floods (frequent and intensified)
• periods of high and low water can affect rail traffic	• storm surges, sea level rise, severe flooding, extreme cold and freezing
• risk of flooding of railway equipment, especially in those places where the difference in the level of railway tracks and water surfaces is insignificant	• flooding of port infrastructure
• washout of railway bridges, weakening of pillars	• development of arctic routes adaptation to the decrease in the depth of sea routes for a number of sea routes
• risk of deterioration in the operation of traffic signal systems and power lines (in case of flooding)	
• risk of flooding or derailment of railway trains on the coast	
HURRICANES, INCREASING WIND SPEED	
• physical blocking of roads and railways, damage to power lines, lateral displacement of the contact wire of the network	• increased storminess, heavy seas affect the safety and speed of maritime navigation
• surge waves that can damage or affect trains	
HEAT WAVES, EXTREME TEMPERATURES	
• reduced comfort for passengers and workers, increased demand for air conditioning	•heavy seas
• an increase in accidents due to a decrease in the concentration of personnel	• changes in sea currents
• the question of how high temperatures require new maintenance technologies and air conditioning systems for vehicles and buildings is not well understood	• reduced comfort for passengers and workers, increased demand for air conditioning
• overheating of the rails, possible bending - reduces the permissible speed of movement and increases the risk of derailment	• an increase in accidents due to a decrease in the concentration of personnel
• a threat to the vehicle equipment and infrastructure, signaling and communication services (reduces the reliability of auto-lock devices, software and hardware components)	

[2] *Consequences of climate change for international transport networks and adaptation to them / European UN Economic Commission, 2013 // URL.https://unece.org/fileadmin/DAM/trans/main/wp5/publications/climate_change_2014r.pdf*

INCREASING THE RISK OF FOREST FIRES	
• risks of physical blocking of the roadway, as well as other transport infrastructure, including storage	• Risk to land-based storage and port infrastructure, supply chain disruptions
• Forest fires, embankment fires and fires in close proximity to railway facilities may require changes in vegetation cover to accommodate climate change	

Climate regulation and the energy transition are the biggest drivers of change in commodity flows, creating new growth opportunities for low-carbon logistics. A systematic study of these trends is just beginning and should be updated in the light of the changes taking place in the world.

1.2 GREENHOUSE GAS EMISSIONS IN LOGISTICS

Every year, trucks, planes, ships and trains transport billions of tons of cargo around the world. According to ITF (International Transport Forum) estimates, CO2 emissions in 2020 amounted to 3,233 million tons[3].15 The share of GHG emissions from road transport was the largest at 68% in 2020 (52% of total emissions including logistics buildings).

Maritime transport dominates freight transport with more than 70% of all tonne-kilometres driven, while emissions from this segment account for only about 17% of all transport freight emissions (and 13% of total emissions including logistics buildings). This result is achieved due to its high throughput and low carbon intensity. According to the UN, maritime transport provides 80% of world trade by volume and more than 70% of world trade by value. However, marine shipping is the third largest source of emissions after road transport (Figure 2). The global maritime transport sector accounts for about 3% of global anthropogenic GHG emissions. Emissions between other segments are distributed as follows: 24% - logistics buildings, aviation and railway - 4% each and inland water transport - 3%.

[3] *ITF Transport Outlook 2021 / International Transport Forum, May 2021 // URL. https://www.itf-oecd.org/itf-transport-outlook-2021*

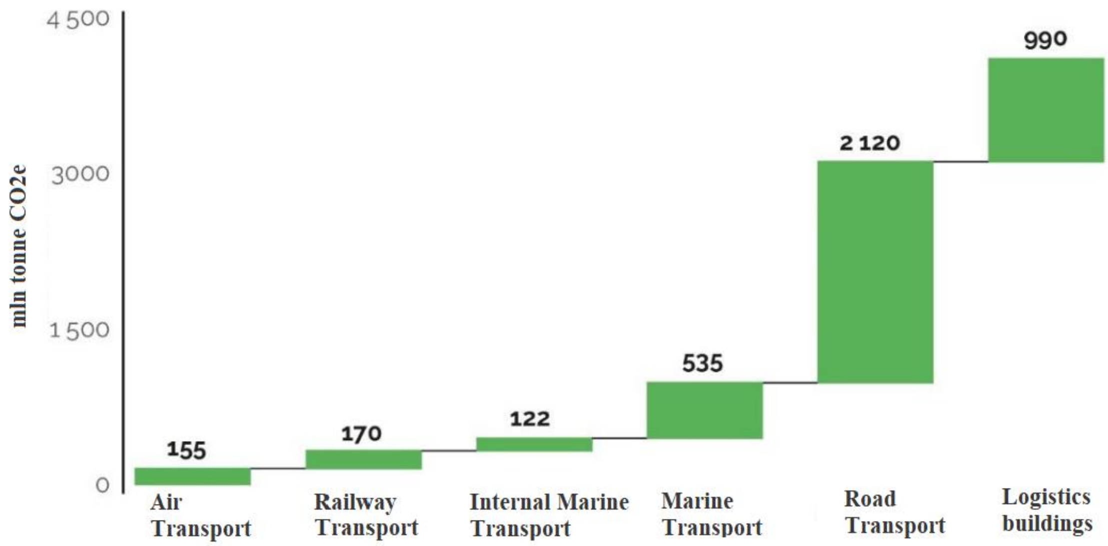


Figure 2 - CO2eq emissions from freight transport by mode of transport in 2020 (emissions from tank to wheels), as well as logistics buildings

Specific indicators of GHG emissions from various modes of transport show that the highest level of emissions from wells to wheels falls on aviation and road transport (Figure 3)[4]. Rail and maritime transport emit an order of magnitude less GHG than road transport and aviation, and can themselves be a low-carbon alternative. However, this segment also has great potential for reducing emissions.

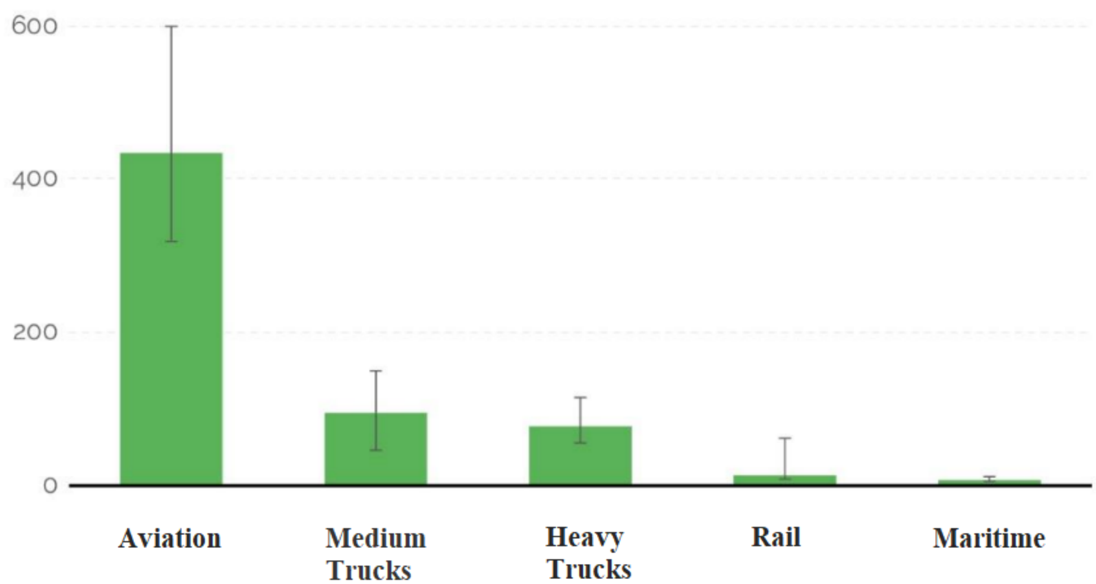


Figure 3 - Average CO2 emissions by mode of freight transport (gCO2 per t/km)

---

[4] *Average CO2 Emissions by Passenger and Freight Transport Mode / IEA, 2019 // URL:* *https://transportgeography.org/contents/chapter4/transportation-and-environment/co2-emissions-passenger-freight-transport-mode/*

1.3 FUEL LIFE CYCLE

When calculating GHG emissions from fuel combustion, it is important consider emissions throughout the lifetime fuel cycle (well-to-wheel or well-to-wheel (WTW))[5].

Emissions over the entire life cycle of a fuel consist of two component:

1. production and distribution (from well to gas station)

2. fuel combustion (from refueling to wheels)

Accounting for both components is an extremely important element control over the company's carbon footprint, as calculation of the full life cycle of fuel for some fuels, the picture changes radically. So, for example, when burning biodiesel and bioethanol no greenhouse emissions gases, but at the stages of its production and transportation before refueling, they are (Figure 4).

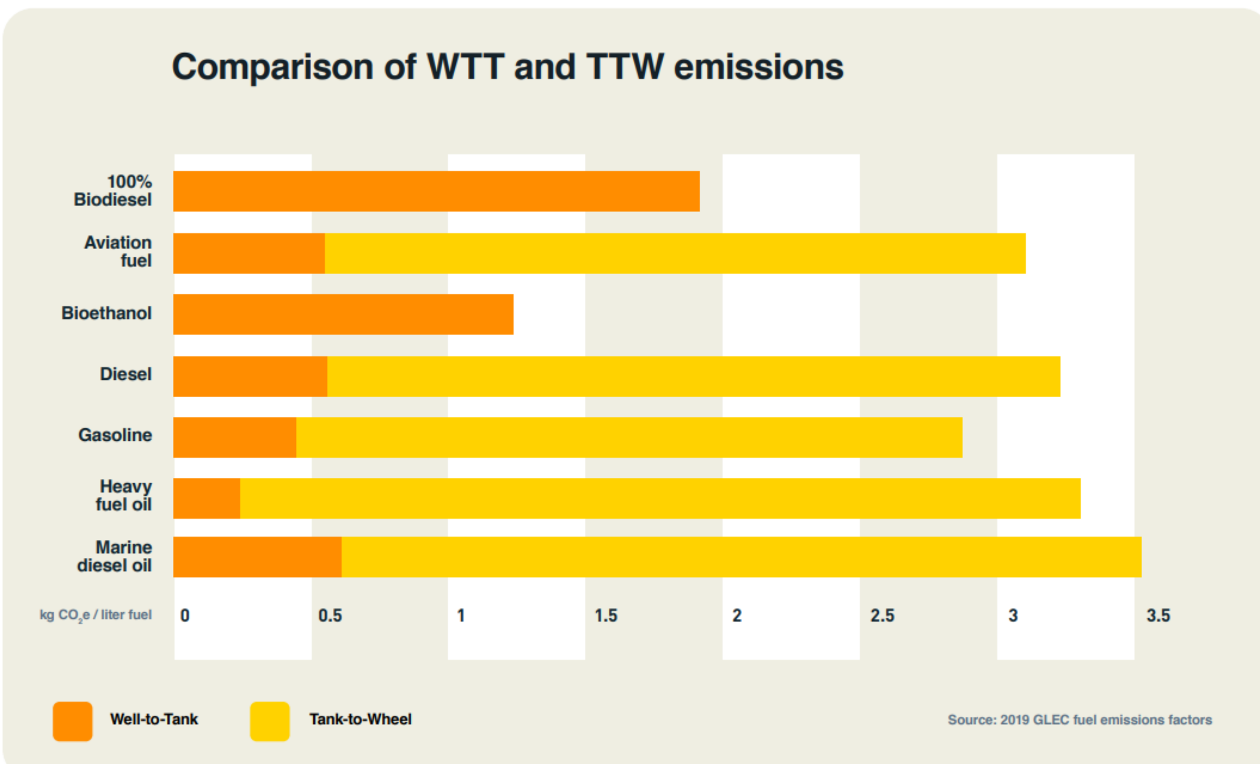


Figure 4 - Comparison of emissions "Well-to-Tank" and "Tank-to-Wheel"

[5] *Global Logistics Emissions Council Framework for Logistics Emissions Accounting and Reporting Version 2.0 / Smart Freight Centre, GLEG, 2019 // URL.* https://www.feport.eu/images/downloads/glec-framework20.pdf

1.4 RELATIONSHIP BETWEEN THE LOGISTICS INDUSTRY AND SUPPLY CHAIN EMISSIONS

Logistics plays an important role in the modern supply chain. The figure below shows the supply chain and distribution of the GHG Emissions Scopes from the perspective of a logistics company.

From the point of view of the logistics industry, supply chain emissions scope consists of stages from the procurement of raw materials for logistics services to the provision of logistics services by the logistics company[6]. After the provision of services it also includes the use and disposal of packaging materials added by the logistics company (Figure 5).

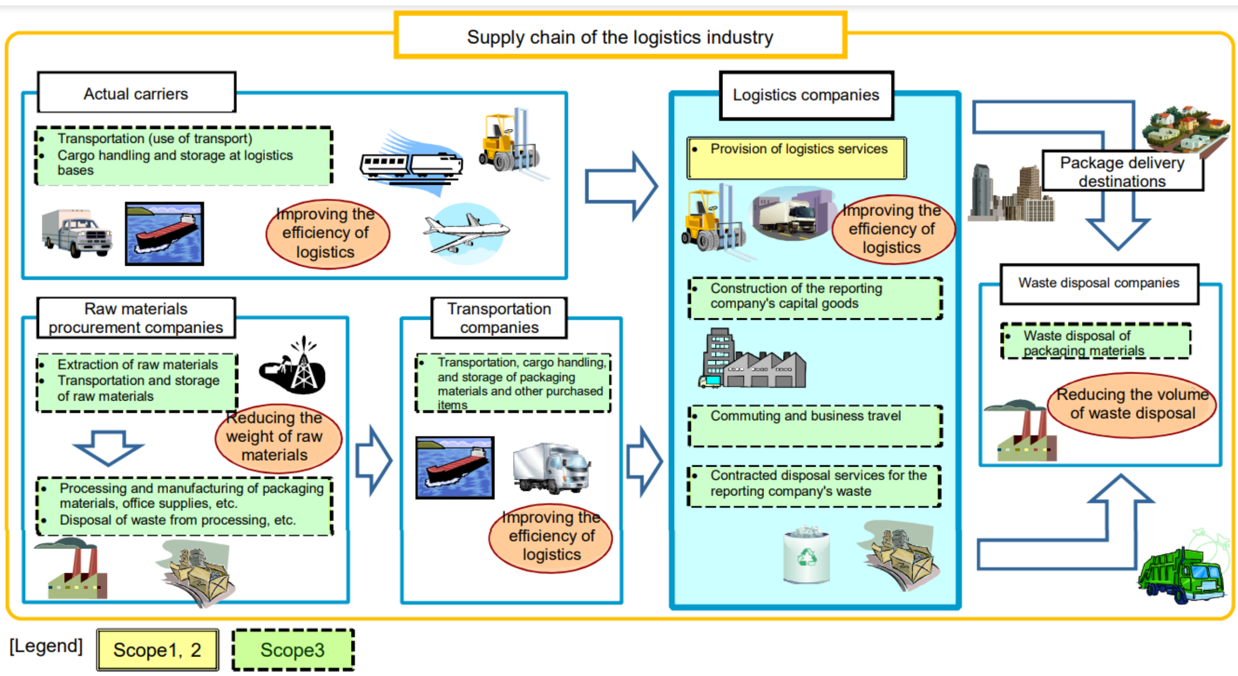


Figure 5 - Supply chain emissions from the logistics industry

It is important to understand the full range of what is required to measure emissions and sustainable logistics initiatives. But one of the challenges of accounting for emissions in green logistics is ensuring that indirect emissions are accounted for throughout the supply chain. To standardize understanding of the various categories of emissions, there is a global set of standards and requirements established by the Greenhouse Gas Protocol[7].

According to the Protocol, the company's greenhouse gas emissions divided into direct and indirect and classified in three categories (Scope 1-3).

[6] *Explanations by Industry (Logistics Industry) for the Basic Guidelines on Accounting for Greenhouse Gas Emissions Throughout the Supply Chain, Ver. 1.0 (Draft), Ministry of the Environment, Japan 2013*

[7] *Greenhouse Gas Protocol // URL. https://ghgprotocol.org/*

According to the Protocol, a company's greenhouse gas emissions are divided into direct and indirect and are classified into three categories (Scope 1-3).

- Direct emissions are greenhouse gas emissions from sources owned and/or operated by the reporting company (Scope 1, or Scope 1).

Scope 1 - direct emissions: GHG emissions from sources owned or operated by the company. These include, for example, emissions from fuel combustion or non-combustion process emissions.

- Indirect (indirect) emissions are emissions that result from the activities of the reporting company, but are emitted to the atmosphere from sources owned and/or controlled by another company (Scope 2,3 or Scope 2 and 3).

Scope 2 - indirect energy emissions: emissions from the production of electricity or heat used in the company's production processes and supplied from outside.

Scope 3 - Other indirect emissions: These are emissions associated with the activities of the company, but come from sources owned or controlled by other organizations. Such sources of emissions include, for example, the production of consumed raw materials and fuels, the transport of goods and the use of manufactured products by consumers. In other words, GHG emissions from Scope 3 include indirect emissions from the value chain that are not included in Scope 1 and 2.

The adjusted Scope breakdown for the logistics company is as follows (Table 2):

Table 2 – Categories of emissions

Division	Category	Activities subject to accounting
	Emissions of reporting company	
	Direct emissions (Scope 1)	Direct emissions from the use of fuel in the reporting company's vehicles and logistics bases and coolant leakage at warehouses
	Energy-derived indirect emissions (Scope 2)	Indirect emissions from the use of electricity and heat purchased at the reporting company's logistics bases and offices
	Other indirect emissions (Scope 3)	
1	Purchased goods and services	Emissions from activities up to the provision of services such as contracted transportation with freight carrier services purchased by the reporting company or manufacturing of goods such as packaging materials and office supplies
2	Capital goods	Emissions from construction and manufacturing of the reporting company's capital goods (vehicles, logistics bases, and facilities and equipment therein)
3	Fuel and energy related activities not included in Scope 1 or 2	Emissions from procurement of fuel used in power generation, etc., for electricity and heat procured from other companies (excluding indirect fuel emissions included in Scopes 1 and 2 and indirect fuel emissions at

		power plants due to the use of electricity)
4	Transportation and delivery (upstream)	Emissions from distribution of packaging materials, office supplies, etc., up to delivery to the reporting company
5	Waste generated in operations	Emissions from transportation and processing of waste generated by the reporting company's logistics bases, etc.
6	Business travel	Emissions from business travel by employees
7	Employee commuting	Emissions from transportation of employees when commuting to and from the place of business
8	Leased assets (upstream)	Emissions from operation of assets (such as vehicles and forklifts) leased to the reporting company (excluded if calculated under Scope 1 or 2)
9	Transportation and delivery (downstream)	(Emissions from transport, storage, cargo handling, and retail sales of sold products (excluding cases where transportation, etc., of such products is performed by the reporting company))
10	Processing of sold products	(Emissions from processing of intermediate products by companies to whom such products are sold)
11	Use of sold products	(Emissions from use of services by users [consumers])
12	End-of-life treatment of sold products	Emissions when parties who have received deliveries perform transportation and processing of packaging materials purchased by the reporting company
13	Leased assets (downstream)	(Emissions from operation of assets leased to others)
14	Franchises	(Scope 1 and 2 emissions from franchise members [e.g., freight handling establishments operated in franchise chains])
15	Investments	(Emissions from operation of investments)
	Other	Emissions from use of cargo handling equipment owned by other parties in harbor freight transportation business, etc.

For a logistics company, its main controlled GHG emission sources that fall within Scope 1 and 2 will be:

• Direct emissions from fuel use in vehicles and logistics buildings, owned by the company;

• Indirect emissions from electricity use and heat purchased for logistics buildings and offices of the reporting company, as well as leakage coolant in the premises.

Scope 3 is the easiest to overlook and the hardest to measure. This is because it includes all indirect emissions generated by resources not owned or controlled by the company, but which the company indirectly influences in its value chain. However, a company can also influence emissions in Scope 3, but to a different degree. For example, the company has the highest degree of influence in the category "Emissions from activities before the provision of services, such as contractual transportation with the services of a freight carrier purchased by the reporting company, or the production of goods, such as packaging materials and stationery".

Emissions from contractors and suppliers can be reduced by the reporting company by selecting contractors with lower emissions.

The situation is similar in the Capital Means of Production and Upstream Transportation and Distribution categories, where a logistics company can, for example, choose a greener mode of transport as a means of production, or a company can optimize the methods of ordering packaging material, as well as choose suitable transport company, etc. However, due to the high costs in this category, the company has less flexibility in choosing a decarbonization solution.

In other words, a company can influence emissions in Scope 3 where it can choose suppliers or businesses that provide other services (e.g. recycling).

1.5 DECARBONIZATION TECHNOLOGIES

As in many other sectors of the world economy, various technological methods of decarbonization can be applied in logistics. These methods differ in the degree of technological readiness, in their cost and efficiency of application. However, the following key areas in this area can be identified: energy efficiency (including through design and operational changes), electrification, the transition to renewable energy sources in energy supply, the use of alternative fuels with a lower carbon footprint, and digitalization.

1.5.1 ELECTRIFICATION

ELECTRIFICATION IN ROAD TRANSPORT

Electric vehicles powered by batteries do not produce harmful emissions and are quiet in use. In urban environments, they generally improve air quality and reduce unwanted noise for the locals. Relatively high cost of e-mode transport is easily offset by low maintenance and operation costs due to its high efficiency.[8]

As for the logistics industry, battery vehicles are still far behind vehicles powered by conventional internal combustion engines. The reasons for this gap are short range, long charging time, insufficient infrastructure for recharging and limited payload. As a consequence, electrification is currently limited to short-haul transportation and delivery to urban areas.

At the same time, the largest part of greenhouse gas emissions comes from heavy and long-haul transportation. The main difficulty for the transition to electric vehicles in freight

[8] *Electric Vehicles: Benefits, Challenges, and Potential Solutions for Widespread Adaptation // URL.* *https://www.mdpi.com/2076-3417/13/10/6016*

transport is the development of batteries with higher performance and the expansion of cross-border charging infrastructure.

The combination of zero emission vehicles in logistics and transportation requires some additional challenges from an organizational and operational point of view. The integration of electric vehicles into logistics operations is currently being researched, as well as the development of vehicle types with features not yet on the market and which are of particular importance for sustainable logistics.

Existing logistics and transportation systems include a diverse fleet of vehicles with conventional internal combustion engines, as well as other types of vehicles using green technologies, such as plug-in hybrid electric vehicles and other electric vehicles tupes.

However, the inclusion of electric vehicles in logistics and transport activities also creates some additional challenges from a strategic, planning and operational point of view. For example, smart cities must provide charging stations for electric vehicles, which means that investment decisions must be made regarding the number, location and capacity of these stations.

Speaking of **"cargo electric vehicles",** three types of vehicles should be distinguished[9]:

1) Battery Electric (Full EVs or BEV)
2) Plug-in Hybrid Electric Vehicles (PHEV)
3) Hybrid Electric Vehicles (HEV, or "Hybrids") - hybrid designs that combine a traditional internal combustion engine and an electric motor.

Extensive experimentation with electric trucks for commercial use began in different countries more than 20 years ago. Around 2010, the first production models began to appear on the market, and at present, experimental activities are accompanied by mass production and actual operation of various types of electric trucks. First of all it concerns cars of small and average loading capacity. Electric vehicles are used in urban logistics systems in London, Stockholm, Lisbon, Madrid, Rotterdam, Amsterdam and other cities around the world.

Comparison of an electric car with a car equipped with an internal combustion engine shows that **its main advantages are:**

- high environmental friendliness. The electric motor has a zero level of harmful emissions. At the same time, it is obvious that during the production of energy used by an electric vehicle at a power plant, harmful emissions are likely to occur, and in fairly large volumes. Therefore, electric vehicles in the literature are sometimes called not "zero emission vehicles", but "displaced emission vehicles". Nevertheless, for a modern city, especially for its central part, where the concentration of harmful emissions in the air often many times exceeds the

[9] *Different kinds of EVs // URL.* https://www.ev-resource.com/ev-types.html#/

permissible values, such “relocation” is quite justified. In addition, electric vehicles have a low noise level;

- lower fuel cost;

– lower frequency of maintenance and related costs, since the electric vehicle has fewer moving parts, no need to change engine oil, less brake wear due to the presence of electroregenerative braking;

— in the presence of environmental restrictions/preferences in the transportation area (emission restrictions, “delivery windows” for ordinary cars, free parking for environmentally friendly vehicles, etc.) — greater flexibility and efficiency of transportation;

— “environmental image” of the operating company.

The disadvantages of an electric vehicle compared to "conventional" vehicles include:

- the price, which is still significantly higher than the cost of a car with an internal combustion engine comparable in terms of characteristics. A higher indicator is also such an indicator as the total cost of owning a vehicle;

- low daily mileage and, as a result, a small radius of action. The mileage of commercial electric vehicles on a single charge is 100-150 km, and at the same time it varies greatly at the beginning and end of the battery life. In addition, it is highly dependent on vehicle load, air temperature, traffic conditions and driving style. The unpredictability of battery capacity changes prevents EV fleet owners from planning for stable cycles of operation and fleet renewal, which deters many potential users;

— variability in the performance of electric vehicles of approximately the same class from one manufacturer to another; at the same time, the parameters declared by the plant are often not confirmed in operation (this happens much less often with “ordinary” cars);

- charging time, measured in hours. For this reason, charging electric vehicles is practically feasible only at night (between shifts);

- lack of a network of charging stations and a single standard for charging equipment (currently, work on the corresponding standard is underway in the EU). An important factor is the dependence of the development of a network of charging points on the distribution of cars for the personal use of citizens, since the creation of such a network only for trucks looks obviously unprofitable at present. In addition, many experts point out that with an increase in the fleet of electric vehicles, there will be a problem of limited power grid capacity while charging a large number of vehicles at the same time;

- limited availability of technical assistance and (or) long waiting times for service, shortage of some spare parts. As electric vehicles themselves improved, it was this shortcoming that began to come to the fore among the reasons hindering their commercial use;

- the practical absence of a secondary market;

- the need for retraining of drivers and technical personnel.

These features of cargo electric vehicles quite clearly outlined the scope of their application: this is work in the distribution area from terminals located within the city, with the primary service of territories to which access to vehicles with internal combustion engines is somehow limited.

ELECTRIFICATION IN RAIL TRANSPORT

Freight transport by road alone will grow by 71% from 2004 to 2025, according to the German Federal Ministry of Transport, Building and Urban Affairs.[10] Long-term studies show that the increase in traffic more than outweighs the decline in individual truck consumption. Against this backdrop, the potential relief offered by combined transport is becoming increasingly important. This is because the movement of goods by rail dramatically reduces the emissions of pollutants from transportation.

A neutral comparison of pollutant emissions from different modes of transport in freight transport demonstrates the clear environmental benefits of combined transport. The IFEU institute has demonstrated a model whereby rail transport saves only 57 grams of CO2 greenhouse gases per tonne-kilometre compared to freight transport by road alone. The transfer of transport from road to rail is the most environmentally friendly mode of transport compared to all other modes of transport.

The freight electric trains obtain the increasing interest. They play a significant role in modern transport logistics. Among the main advantages of freight electric trains in transport logistics:

- Environmental sustainability: Electric freight trains run on electricity, which means that they do not emit harmful gases into the atmosphere, such as carbon dioxide and nitrogen oxides. This reduces the environmental impact and contributes to a cleaner logistics system.
- Efficiency and fuel economy: Electric trains have a high energy utilization rate and excellent efficiency in moving goods. This allows you to reduce fuel costs and provide more economical transportation of goods.
- Large capacity: Electric freight trains are capable of carrying significant volumes of cargo in one run, making them ideal for long-distance mass transportation.
- Long service life: Electric trains usually have a long service life, which ensures stability in transport logistics and reduces the need for frequent vehicle replacement.

[10] *Freight Transport and Logistics Masterplan, German Federal Ministry of Transport, Building and Urban Affairs, 2019 // URL. https://bmdv.bund.de/SharedDocs/EN/Documents/masterplan-freight-transport-and-logistics-publication.pdf?__blob=publicationFile*

- Railway electrification: The introduction of electric freight trains contributes to the electrification of the railway infrastructure, which can improve the efficiency of the entire system and reduce dependence on oil products.
- Infrastructure Improvement: Efficient operation of electric freight trains requires modern infrastructure such as electrical substations and recharging networks. This contributes to the development and improvement of the railway infrastructure as a whole.
- Reducing car traffic: The use of electric freight trains to transport goods can reduce dependence on road transport, which can help reduce traffic congestion and reduce traffic congestion on highways.

However, it is worth noting that the introduction of electric freight trains may face certain challenges, such as

- high initial investment in infrastructure and electrification
- limited opportunities to transport goods to remote or non-electrified regions

But overall, these trains represent a promising means of transportation for sustainable and efficient logistics.

ELECTRIFICATION IN MARITIME SHIPPING

The International Maritime Organization (IMO) is taking steps to cut shipping emissions by adopting the Revised Greenhouse Gas (GHG) Strategy that sets a sectoral target of net-zero emissions by 2050.[11] Electrification promises to be a key technology for reducing marine emissions, but marine battery technology is still underdeveloped.

Currently, some types of boats are more suitable for battery conversion than others. These include ferries that operate on predetermined routes and small container ships that operate on fixed routes.

Their flights are very predictable and have reliable operating patterns. This makes it easy to analyze energy consumption and calculate the cost of electrification to see if it is economically viable.

On the other hand, ocean-going container and cargo liners making intercontinental flights are difficult to electrify due to the volatility of conditions. To cope with such uncertainty is a very large battery.

[11] *Net-zero by 2050: Achieving shipping decarbonization through industry momentum and the new ambition at IMO// URL. https://unctad.org/news/transport-newsletter-article-no-108-net-zero-by-2050#:~:text=In%20July%2C%20Member%20States%20of,emissions%20by%20or%20around%202050.*

Electric-powered ships are a costly solution, primarily because batteries that are developed for marine use are usually custom-made for a particular ship design. This makes them unique and therefore expensive.

According to Maritime Battery Forum data[12] use of batteries is gaining more recognition in the shipping industry. Among the electrified ships these are pure electric, plug-in hybrids and hybrids(52%). Interestingly, 34% of these operating ships are based in Norway (Figure 6).

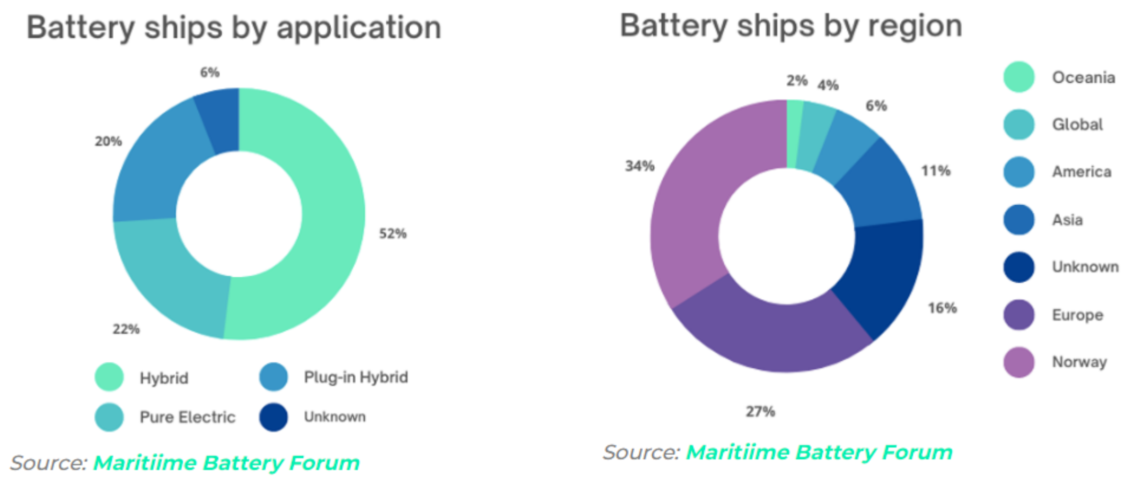


Figure 6 – Battery ships application

1.5.2 SUSTAINABLE FUEL ALTERNATIVES FOR LOGISTICS OPERATIONS

Until the transport industry reaches the point where it can become fully electric, other solutions will be needed to reduce greenhouse gas emissions. Therefore, the development and improvement of sustainable fuels such as biofuels, e-fuels (electricity-based fuels or energy fuels) are essential.

Alternative fuels are playing an increasingly important role in the quest to reduce dependence on oil and reduce the negative impact on the environment. They are one of the key elements in the fight against climate change and the reduction of greenhouse gas emissions such as carbon dioxide.

[12] *The opportunities, challenges, and the latest developments of electrification in the shipping industry // URL.* https://platformzero.co/the-opportunities-challenges-and-the-latest-developments-of-electrification-in-the-shipping-industry/

ROAD FREIGHT

Diesel fuel is the main fuel, although there are a number of other fossil fuels that can be used to protect the environment. Some of the most promising alternative fuels in transport logistics include:

1. Biofuel: This type of fuel is produced from plant or animal sources and can be used in cars, aircraft and ships. Biofuels have the potential to reduce greenhouse gas emissions because they are carbon neutral, which means that the level of CO2 emissions when they are burned corresponds to the level of CO2 that was taken up by plants or animals during the growth process.[13]

Biofuels are a sustainable alternative to diesel fuel. They are considered sustainable because the carbon dioxide emissions from use are partly offset by carbon dioxide uptake when new crops are grown. However, there are concerns about the loss of land for growing food where land is already used for agriculture, and about the release of carbon gases contained in the soil when there is a change in land use compared to the untouched landscape.

Another form of biofuel is biodiesel, which is usually a mixture of diesel fuel and refined vegetable oils from plants such as soybeans, palms, and canola. Fossil fuel blends containing 5 to 20% biofuels are quite common. a similar option is bioethanol, which is produced by the fermentation of crops such as sugar cane or corn. Another alternative is biomethane, which is produced by the anaerobic digestion of organic matter. Biomethane can be obtained from crops, but often from waste (sewage, agricultural waste, food waste, and landfills). Methane is burned in use rather than escaping from landfills as methane gas, which is actually far more effective in terms of global warming than carbon dioxide.

Synthetic fuels, on the other hand, are chemically produced from coal, gas, or organic matter. The problems associated with their use and characteristics are similar in many ways to biofuels, and therefore the source of the feedstock (crops or used cooking oil) is important.

Hydrotreated vegetable oil (HVO) is one such fuel and is produced by saturating feedstock at high temperatures and then "cracking" to remove impurities. This process avoids some of the harmful emissions associated with conventional diesel fuel.

Another option is to use dimethyl ether (DME), which is made from coal, natural gas, black liquor (a by-product of paper pulp production), or biomass. It can be replaced with diesel or LPG or used as a hydrogen-rich source for fuel cells.

2. Li-ion batteries: These batteries are widely used in electric vehicles and play an important role in today's hybrid and all-electric vehicles.

---

[13] *What are the Sustainable Fuel Alternatives for Logistics Operations? // URL.* https://www.koganpage.com/logistics-supplychain-operations/what-are-the-sustainable-fuel-alternatives-for-logistics-operations

Lithium-ion batteries are currently popular for light commercial vehicles. The use of batteries avoids the emission of carbon dioxide and harmful particles from vehicles, but their environmental performance is largely dependent on the source of electricity. If electricity is produced from renewable sources (for example, wind or solar), they can be considered as “green” as possible.

3. Hydrogen: Another option is to use a hydrogen fuel cell, which uses a chemical reaction to generate electricity to the vehicle. Hydrogen is delivered to the battery's cathode and oxygen is delivered to the battery's anode. That creates an electrical current without any other outlet. However, hydrogen production requires energy, and there are currently two main options that can be seen as having a limited impact on global warming. One is "green" hydrogen, produced by electrolysis using electricity from renewable sources, and the other is "blue" hydrogen, which is produced from natural gas with carbon capture and storage (e.g. underground). Due to their relatively high energy density, hydrogen fuel cells are considered a strong contender as truck fuel.

4. Electricity: Electric vehicles (EVs) are becoming increasingly popular in freight and passenger logistics. Electric-powered buses, trucks and cars can reduce carbon dioxide and pollutant emissions on the roads.

Electric road systems compensate for energy losses associated with hydrogen conversion processes. They provide electricity directly to vehicles using overhead contact wires - just like overhead electrical wires for traction rails and trolleybuses. The main problem is infrastructure costs. This type of system may be limited to the main road network, with other technologies (such as batteries or hydrogen fuel cells) used on shorter track sections.

5. Methane: Natural gas (CNG) and liquefied natural gas (LNG) vehicles are other alternatives for buses, trucks and cars. This can reduce emissions of greenhouse gases and other pollutants compared to traditional gasoline and diesel engines.

The introduction of alternative fuels in transport logistics still faces some challenges, such as limited charging or refueling infrastructure, high equipment costs, and the limited energy density of some alternative fuel sources. However, with the development of technology and the support of governments and businesses, alternative fuels continue to develop and make a significant contribution to the sustainable development of transport logistics.

2. INFLUENCE OF KEY DRIVERS ON DECARBONIZATION OF THE INDUSTRY. INTERNATIONAL PRACTICE

Public and private actors are advancing efforts to decarbonize Maritime and rail transport through various initiatives and mechanisms. There are four key drivers that stimulate the decarbonization of maritime and rail transport - regulatory policy, pressure from investors, consumer expectations (from end consumers to cargo owners) and initiative from the industry companies themselves (Figure 7).

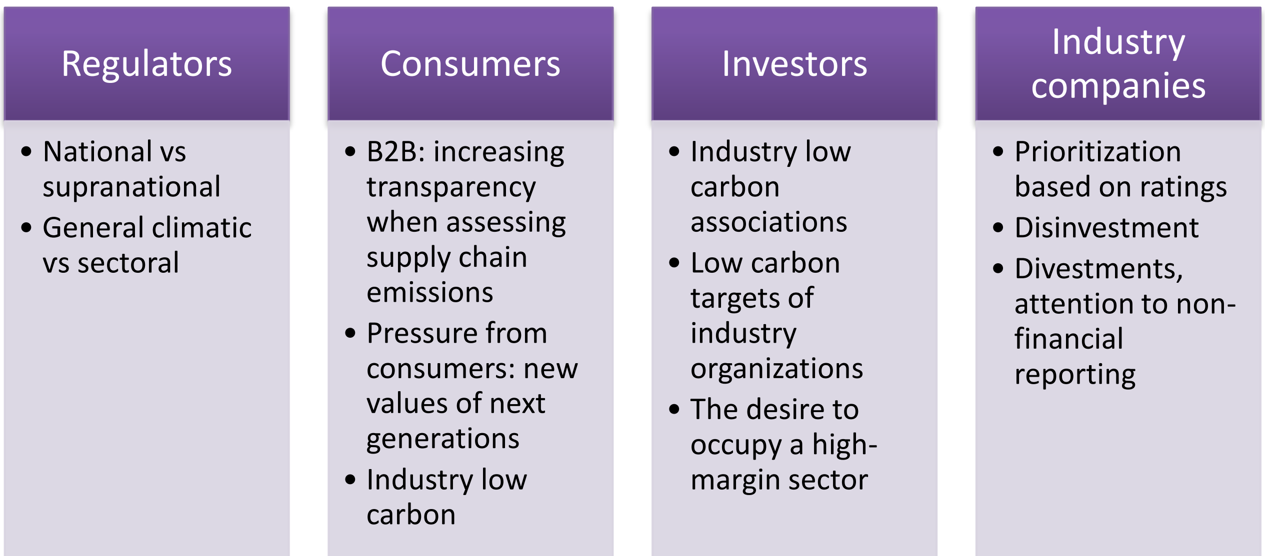


Figure 7 - Key drivers that stimulate the decarbonization

2.1 REGULATORY POLICY

Regulation in the field of GHG emissions in maritime and railway transport can be divided by area of influence into national and supranational.

The basis of supranational methodological approaches to assessing direct and indirect GHG emissions of all types of transport in international methodologies are the requirements of the guidelines and instructions established by the Intergovernmental Panel on Climate Change (IPCC), as well as recommendations of the World Meteorological Organization and the United Nations Environment Program and Global Greenhouse Gas Inventory Protocol (GNG Protocol).

These approaches are translated into national methodologies for estimating emissions, as well as into methods adopted by organizations and initiatives that develop issues of accounting for GHG emissions and contribute to their reduction. Among them, in turn, we can distinguish intersectoral and sectoral (international) approaches.

Among the cross-industry ones:

- SBTi
- GHG Protocol
- ISO standards
- voluntary certification systems (important for the industry)

SBTi Initiative[14]. Many companies use SBTi to communicate and measure decarbonization goals. This is an effective method for drawing up corporate decarbonization goals and aligning them with the goals of the Paris Agreement. The initiative's methodology makes it possible to set science-based emissions reduction targets. By 2022, more than 2,000 companies around the world had joined the initiative (Figure 8). SBTi has a particular102 focus on the freight transport sector and provides tools for setting science-based targets for rail transport (SDA Transport Tool). For maritime transport, recommendations are under development (SDA Maritime Tool), and therefore a common tool for different modes of transport (SDA Transport Tool) is used.

SBTi History. SBTi Initiative was created in collaboration between CDP, the United Nations Global Compact, World Resources Institute (WRI), the World Wide Fund for Nature (WWF), and the We Mean Business Coalition. The goal of the methodology is to make companies more effective in achieving the climate science requirements of the global economy: to reduce in half the emissions by 2030, and achieve net-zero before 2050. The developed criteria provide tools and guidance to help agencies, businesses, institutions to set GHG emissions reduction targets in line with the science demands, which are needed to keep global heating below 1.5°C. After companies and institutions set the targets, SBTi validates them against these criteria and pieces of guidance. First of all, the companies must have all of their targets to be in line with SBTi requirements. Secondly, the company will be considered to have a validated by SBTi science-based target and can communicate as such.

The SBTi was founded in 2014 with the idea to encourage 100 companies to commit their GHG emissions reduction targets and set them in line with climate science. Since then, the impact and scale have grown throughout the years. In 2022 SBTi started the process of legalization themselves as an entity to further strengthen their governance and grow to satisfy increasing demand for science-based targets.

The goals of SBTi's incorporated the diffusion of innovation theory. The work is based on the assumption that 20% of businesses in a particular territory or sector equals critical mass, so the goals are to reach this 20% threshold by 2025.

This means:

• $20 trillion of the global economy covered by approved 1.5°C targets.

• 5GT of corporate emissions covered with science-based targets or commitments.

[14] Ambitious Corporate Climate Action / Science Based Targets // URL. https://sciencebasedtargets.org/

• 10,000 companies commit to or set science based targets.

Their main priority maximizing of the emissions reduction. Therefore, SBTi's sector-specific guidance focuses on the highest-emitting sectors and enabling sectors like maritime and aviation. The target related to coverage of the global economy is supposed to promote science based targets into large corporations in all main sectors, mainstreaming corporate climate actions.

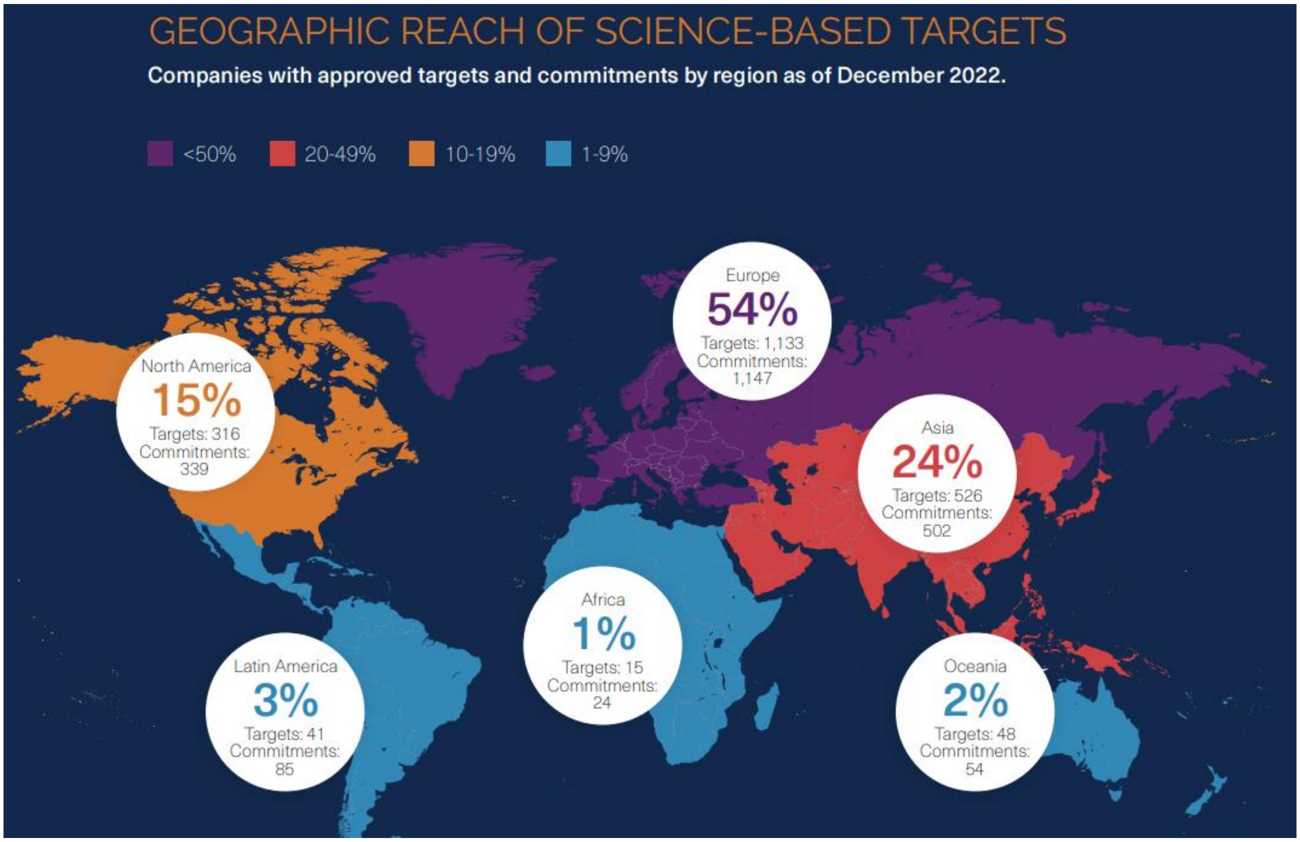


Figure 8 - Geographic reach of Science-based targets

GHG Protocol[15] does not identify logistics as a separate industry, but does provide a methodology for calculating GHG emissions from transport. The GHG Protocol also provides guidance for calculating GHG emissions from buildings, which can be applied to warehouses, terminals, ports, etc. At the same time, methods for assessing, monitoring and managing GHG emissions in warehouses or terminals are an important point for further research and a subject for standardization. However, this approach to estimating GHG emissions has not yet become widespread in the transport industry.

15 Greenhouse Gas Protocol // URL. https://ghgprotocol.org/

History of GHG Protocol.

GHG Protocol establishes comprehensive global standardized frameworks to measure and manage greenhouse gas (GHG) emissions from private and public sector operations, value chains and mitigation actions.

GHG Protocol was created on a 20-year partnership between World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD), GHG Protocol works with governments, industry associations, NGOs, businesses and other organizations.

GHG Protocol supplies the world's most widely used greenhouse gas accounting standards. The Corporate Accounting and Reporting Standard provides the accounting platform for virtually every corporate GHG reporting program in the world.

GHG Protocol was created when WRI and WBCSD recognized the need for an international standard for corporate GHG accounting and reporting in the late 1990s. Together with large corporate partners such as BP and General Motors, in 1998 WRI worked together on a report called "Safe Climate, Sound Business." It was identified as an action guide towards the climate change and the need for standardized measurement of GHG emissions in particular.

The first edition of the Corporate Standard was published in 2001 with the following updates that clarifie how companies can measure emissions from electricity and other energy purchases, and account for emissions from throughout their value chains. GHG Protocol also developed a suite of calculation tools to assist companies in calculating their greenhouse gas emissions and measure the benefits of climate change mitigation projects.

There are different resources for navigating GHG Protocol tools (Table 3):

- Cross-sector tools: Applicable to many industries and businesses regardless of sector.
- Country-specific tools: Customized for particular developing countries.
- Sector-specific tools: Principally designed for the specific sector or industry listed, though they may be applicable to other situations.
- Tools for countries and cities: These tools help countries and cities track progress toward their climate goals.

Table 3 - Overview of GHG calculation tools available on the GHG Protocol website

	CALCULATION TOOLS	MAIN FEATURES
CROSS-SECTOR TOOLS	Stationary Combustion	• Calculates direct and indirect CO_2 emissions from fuel combustion in stationary equipment • Provides two options for allocating GHG emissions from a co-generation facility • Provides default fuel and national average electricity emission factors
	Mobile Combustion	• Calculates direct and indirect CO_2 emissions from fuel combustion in mobile sources • Provides calculations and emission factors for road, air, water, and rail transport
	HFC from Air Conditioning and Refrigeration Use	• Calculates direct HFC emissions during manufacture, use and disposal of refrigeration and air-conditioning equipment in commercial applications • Provides three calculation methodologies: a sales-based approach, a life cycle stage based approach, and an emission factor based approach
	Measurement and Estimation Uncertainty for GHG Emissions	• Introduces the fundamentals of uncertainty analysis and quantification • Calculates statistical parameter uncertainties due to random errors related to calculation of GHG emissions • Automates the aggregation steps involved in developing a basic uncertainty assessment for GHG inventory data
SECTOR-SPECIFIC TOOLS	Aluminum and other non-Ferrous Metals Production	• Calculates direct GHG emissions from aluminum production (CO_2 from anode oxidation, PFC emissions from the "anode effect," and SF_6 used in non-ferrous metals production as a cover gas)
	Iron and Steel	• Calculates direct GHG emissions (CO_2) from oxidation of the reducing agent, from the calcination of the flux used in steel production, and from the removal of carbon from the iron ore and scrap steel used
	Nitric Acid Manufacture	• Calculates direct GHG emissions (N_2O) from the production of nitric acid
	Ammonia Manufacture	• Calculates direct GHG emissions (CO_2) from ammonia production. This is for the removal of carbon from the feedstock stream only; combustion emissions are calculated with the stationary combustion module
	Adipic Acid Manufacture	• Calculates direct GHG emissions (N_2O) from adipic acid production
	Cement	• Calculates direct CO_2 emissions from the calcination process in cement manufacturing (WBCSD tool also calculates combustion emissions) • Provides two calculation methodologies: the cement-based approach and the clinker-based approach
	Lime	• Calculates direct GHG emissions from lime manufacturing (CO_2 from the calcination process)
	HFC-23 from HCFC-22 Production	• Calculates direct HFC-23 emissions from production of HCFC-22
	Pulp and Paper	• Calculates direct CO_2, CH_4, and N_2O emissions from production of pulp and paper. This includes calculation of direct and indirect CO_2 emissions from combustion of fossil fuels, bio-fuels, and waste products in stationary equipment
	Semi-Conductor Wafer Production	• Calculates PFC emission from the production of semi-conductor wafers
	Guide for Small Office-Based Organizations	• Calculates direct CO_2 emissions from fuel use, indirect CO_2 emissions from electricity consumption, and other indirect CO_2 emissions from business travel and commuting

GHG Protocol is developing standards; tools and online training that helps countries and cities track progress towards their climate goals.

Other methods.

Quite often, companies use specialized calculators that allow them to estimate the carbon footprint of a specific route using specific modes of transport. The calculators EcoTransIT, SmartWay Rail Carrier Tool, NTMCalc Freight[16] (Figure 9), Climate care[17], LOG-NET106[18], etc. are widely used.

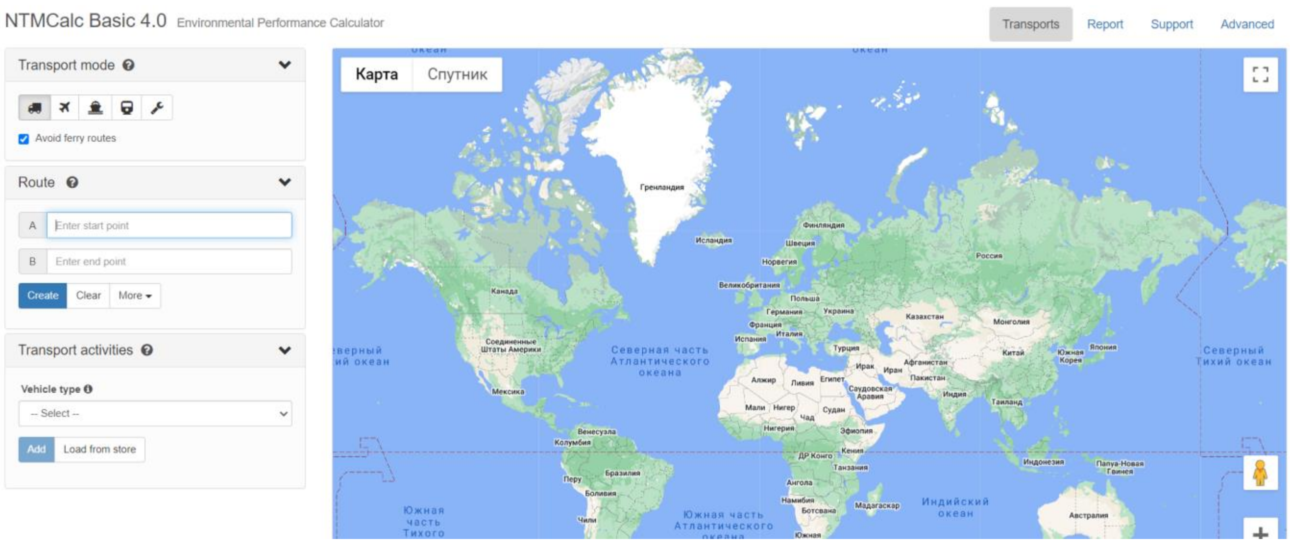


Figure 9 - NTMCalc Freight

There is a large set of approaches, methodologies (national and sectoral) and computer programs that are used to estimate direct GHG emissions from vehicles and infrastructure. They are based on the IPCC methodology. Methods for assessing GHG emissions from railway and maritime transport are based on similar principles. These approaches are fixed in relation to specific industries by supranational and national regulators.

2.2. INVESTORS

Another important driver of change is investors. On the one hand, all groups of investors are sensitive to climate risks and consider them, to one degree or another, as investment ones. Some investors are moving on, becoming actively involved in the ESG agenda (Environmental, social and governance), joining the principles of sustainable finance and exiting projects with high climate risks.

[16] NTMCalc 4.0 - Network for Transport Measures // URL. https://ntmcalc-fb.transportmeasures.org
[17] Small business carbon calculator / Climate Impact Partners // URL. https://climatecare.org/calculator/
[18] LOG-NET Carbon Calculator // URL. http://sustainability.lognet.com/

The potential damage from climate change is expected to increase from 2% of GDP to 4% by 2050[19]. Risks cause non-linear effects and are unevenly distributed ("butterfly effect", high vulnerability of certain population groups). At the same time, risk models based on historical events become irrelevant, and consequences become poorly predictable. This is causing insurance companies' historically stable premium and profit pools to shrink and potentially disappear in more climate-risky locations and industries. This will make some climate-exposed assets more difficult to insure.

Some investors assume divestment obligations and carry out so-called "divestments". These include projects that are indirectly or directly related to the extraction of fossil fuels. According to the public divestment database134, more than 1,500 organizations worldwide have made such commitments, with a total of $40.43 trillion in assets under management[20]. Investors are increasingly paying attention to non-financial reporting, a company's sustainability performance and associated risks, and integrating these assessments into their investment decisions.

Among the latest steps to include the financial sector in the decarbonization agenda are the so-called Katowice Commitments under the Conference of the Parties (COP24), signed in December 2018 by BBVA, BNP Paribas, Société Générale and Standard Chartered[21]. Thus, the banks, with a combined loan portfolio of 2.4 trillion euros, indicated their intention to use them to achieve the goals of the Paris Agreement. In addition, the banks recorded their intentions to work together to further improve the indicators and tools necessary to achieve their goals.

The Katowice agreement became the basis for the formation of the Collective Commitment to Climate Action, which has already included 30 banks representing portfolios worth $13 trillion. Further steps were consolidated through the work of the Net-Zero Banking Alliance (initiated by the UN Environment Program Finance Initiative and accredited by Race to Zero136), which brought together 40% of global banking assets committed to bringing their loan and investment portfolios to net zero emissions by 2050 d. They also set interim targets for 2030 and commit to using science-based climate targets to reduce the risks of miscalculation. The Alliance aims to strengthen, accelerate and support low-carbon strategies.

At the Conference of the Parties in Glasgow, The Glasgow Finance Alliance for Net Zero expanded the responsible finance framework to include more than 450 organizations as of November 2021, with financial assets of more than $130 trillion.[22]

The key principles of sustainable and responsible financing are embedded in the following initiatives:

---

[19] *Climate change and P&C insurance: The threat and opportunity / McKinsey & Company, November 2020 // URL. https://www.mckinsey.com/industries/financialservices/our-insights/climate-change-and-p-and-cinsurance-the-threat-and-opportunity*

[20] *The database of fossil fuel divestment commitments made by institutions worldwide / Global Fossil Fuel Divestment // URL. https://divestmentdatabase.org*

[21] *Green finance conference, November 2019 // URL. https://www.mnb.hu/letoltes/07- cecile-moitry-bnp-paribas-slides.pdf*

[22] *Glasgow Financial Alliance for Net Zero (GFANZ) // URL. https://www.gfanzero.com/*

• The Poseidon Principles (a framework for assessing and disclosing the climate alignment of ship finance portfolios. They set a benchmark for what it means to be a responsible bank in the maritime sector and provide actionable guidance on how to achieve this);

• The UN Principles for Responsible Investment (PRI) (270 banks representing more than 45% of banking assets);

• Principles for Sustainable Insurance;

• Carbon Disclosure Project (CDP);

• Working Group on Climate-Related Financial Disclosures;

• Climate Finance Partnership.

Institutional investors use "green" or "sustainable" financing instruments. Their market is actively growing. Bonds are the most popular type of green and sustainable debt. Green financing aims to provide positive environmental externalities that are quantifiable and verifiable and complementary to business as usual. These positive environmental externalities make it possible to use transferable property rights recognized by international, regional, national and subnational legal systems (Figure 10).

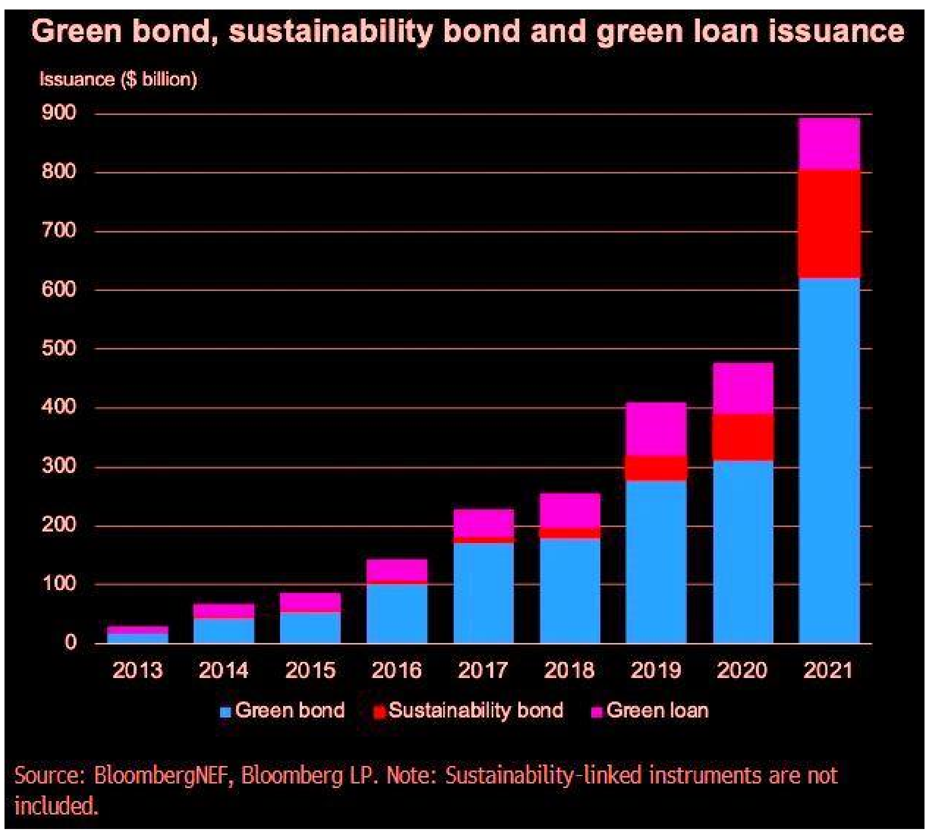


Figure 10 - Green bond, sustainability bond and green loan issuance

Europe is the dominant region for issuing green debt in 2020. In general, developed countries accounted for the largest amount of green debt: 80% of the total in 2020. In the overall structure, the share of emerging markets decreased from 22% to 16% for the year since 2019. Unlike the APR countries, during the pandemic, European investors only increased the volume of "green" financing, adhering to the "green recovery" policy.

Transport, along with energy and buildings, is one of the largest categories that also grew in the post-pandemic 2020. The growth of investment in transport was provided by sovereign bonds and bonds of government organizations: 8 out of 9 sovereign bonds included allocations for transport.

USE OF PROCEEDS

• Energy, Buildings, and Transport were the three largest categories, collectively contributing 81% to the 2021 total (Figure 11).

• All categories exhibited growth, ranging from 24% in Industry to 31% in Transport.

• Non-financial corporate issuers were the strongest supporters of Energy and Transport providing 40% and 27% of the total capital, respectively, while Buildings received most support from financial corporates (37.5%).

• Allocations to Industry increased from just USD1bn in 2020, to USD9.1bn in 2021. Industry was earmarked as a UoP category in 32 deals including sovereign deals from the UK, Serbia, and Hong Kong, and the EU green bond.

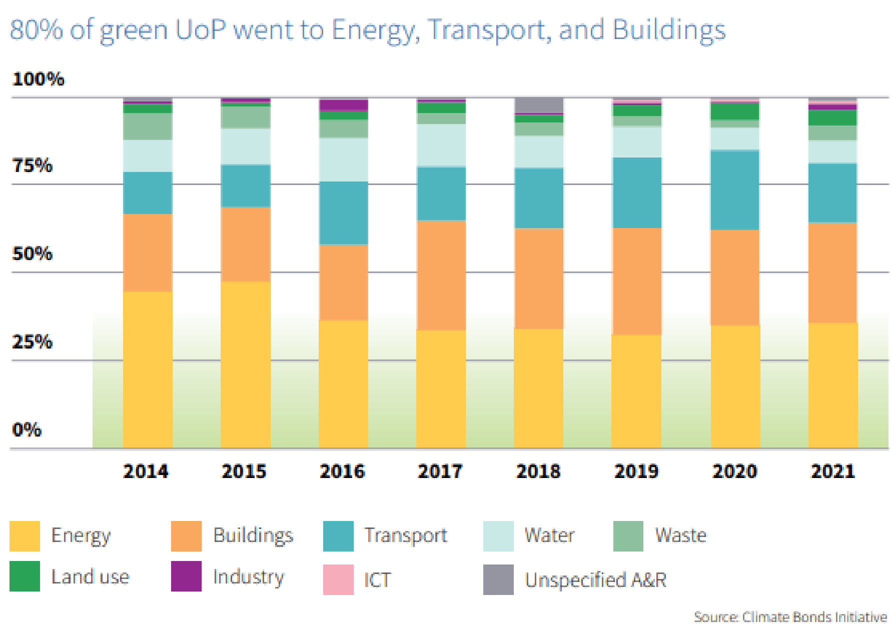


Figure 11 - Distribution of green UoP

Green bonds are the most prominent fixed income financing instrument designed to raise funds for climate and environmental projects. Bonds are labeled "green" or sustainable if they comply with national Taxonomies or industry Green Bond Principles (e.g. Green Bond Principles (GBP)[23], Sustainability-Linked Bond Principles (SLBP), etc.).

At the same time, in general, investors are willing to pay more for “green” bonds. The formation of green bond principles and standards has become an important driver for the development of green finance: the introduction of green labeling based on the ICMA green bond principles in 2014 has allowed a wide group of investors to diversify their portfolios.

Investors place value on green labeling when issuing bonds, even though subsequent financial performance after issuance is comparable to conventional bonds.

Typically, yields on green and conventional bonds of comparable credit quality converge in the secondary market. Special green credit lines are usually tied to meeting specified criteria. Such criteria could be the use of funds to finance technologies and products that are classified as “green”, which can be considered environmentally friendly without additional assessment, increasing the assessment of accredited agencies and ratings, or meeting assigned KPIs tied to the environmental performance of the company.

The choice of rating depends on the lending institution and the investor. The table below (Table 4) presents the key ratings used by the logistics companies that were examined in the study. It is worth noting the fact that ratings often have little correlation for specific positions. In addition, there are concerns that the ratings do not adequately measure the real effects of declared efforts, including those aimed at reducing GHG emissions. In this regard, the choice of a specific rating for participation should be related to the preferences of the credit institution providing financing.

The Company is committed to improving its Environmental, social, and governance Risk Rating, which reflects progress in ESG metrics (Figure 12)[24].

[23] *Green Bond Principles // URL. https://www.icmagroup.org/sustainable-finance/the-principles-guidelines-and-handbooks/green-bond-principles-gbp/*

[24] *European corporate governance institute, «ESG rating disagreement and stock returns», Cristensen, Serafeim, Sikochi «Why is Corporate Virtue in the Eye of The Beholder? The Case of ESG Ratings» 2021*

Table 4 - Use of ESG ratings by railway and maritime transport companies

Компания	S&P ESG	MSCI ESG Research	Sustainalytics	ISS ESG	CDP
DB	○	●	●	●	●
SNCF	○	○	●	○	●
JSCo RZD	○	●	●	○	○
Indian Railways	○	●	●	●	○
Central Japan Railway	○	●	●	●	●
Mass Transit Railway	○	●	○	○	○
MAERSK	●	●	●	●	●
MSC (Mediterranean Shipping Company)	○	○	○	○	○
Cosco Shipping Int	○	●	●	●	●
CMA CGM	●	○	●	○	○
Hapag-Lloyd	●	○	●	●	●
One (Ocean network Express)	○	○	○	○	○
Evergreen International	○	●	●	○	●
HMM	○	●	●	○	●
Yang Ming Marine transport corporation	●	●	●	○	●

● there is an estimate ○ not available

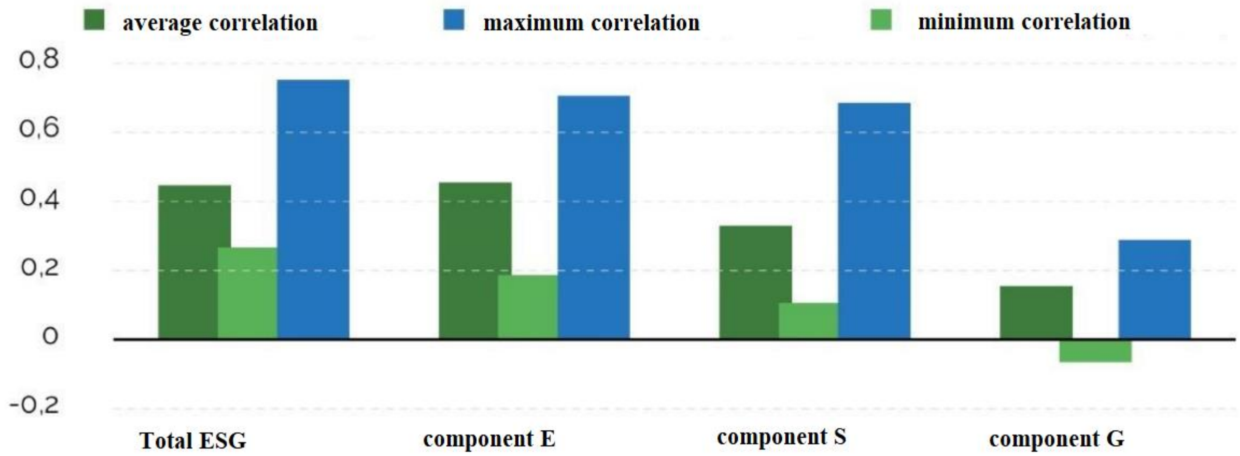


Figure 12 - Correlation of leading ESG ratings

2.3. CUSTOMER AND END USER EXPECTATIONS

There has been a significant increase in the number of public commitments to decarbonize major companies (and consumers of logistics services). Consumers play an important role toward public climate commitments from corporations. So, More than 3850 companies have set their goals within SBTi and institutes, with 2586 companies of them announcing their goals Net Zero[25].

Consumer companies are increasingly concerned about Scope 3 tracking. According to CDP[26], Scope 3 is on average 11.4 times higher than the emissions of a company's operations and therefore has a significant impact on the overall carbon footprint of a company and its products (Figure 13).

[25] *Science Based Targets // URL.* https://sciencebasedtargets.org/
[26] *CDP Global Supply Chain Report 2021 // URL .* https://cdn.cdp.net/cdp-production/cms/reports/documents/000/006/106/original/CDP_SC_Report_2021.pdf

Figure 13 - Supply chain emissions

A total of 11,457 CDP providers out of 23,487 requested disclosed emissions data, but their number is growing steadily, as is number of companies requiring climate disclosure information from suppliers (Figure 14). At the same time with this, consumer demand for environmentally friendly products is steadily growing.

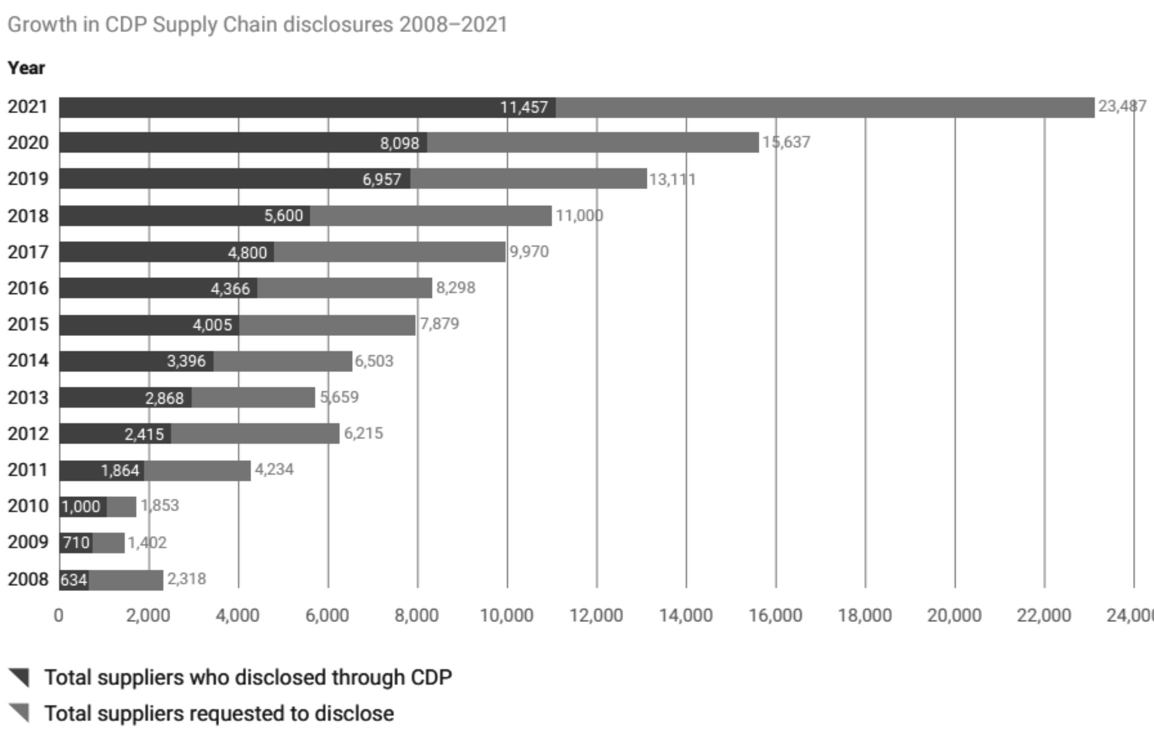


Figure 14 - Growth in CDP Supply chain disclosures

According to Maersk, 2/3 of TOP clients companies have set net-zero targets or adopted scientifically reasonable goals SBTi[27].

Not only are end consumers becoming more selective, but they are also willing to pay more for a similar product or service offered by environmentally responsible and sustainable brands. According to Nielsen (2015)[28], sales of products made by companies with a demonstrated commitment to sustainability grew 4 times faster than competitors' sales. At the same time, 66% of consumers said they were willing to pay more to companies that are socially and environmentally responsible, and among millennials this was even higher at 72%.

The powerful player in the ecosystem surrounding is the one who pays for the shipping services, in most cases the cargo owner. Cargo owners themselves are subject to the expectations of their customers throughout the supply chain, which ultimately ends with consumers, as well as financial institutions and investors. This has led to major cargo owners announcing very ambitious decarbonization targets, with some aiming to be carbon neutral or carbon positive by 2040 or even 2030.

These efforts are institutionalized through The Sea Cargo Charter (charterers), Clean Cargo Working Group, Global Logistics Emissions Council (GLEC) - GLEC Framework (2016, 2019), the Sustainable Shipping Initiative (cargo owners), as well as associations, organizations and platforms: Cargo Owners for Zero Emission Vessels[29] (a platform for cooperation between cargo owners), The Smart Freight Shippers Alliance (SFSA) China, Clean Cargo, Getting to Zero Coalition.

Cargo owners and other market participants rely on the Environmental Ship Index, IMO's Carbon Intensity Indicator rating, RightShip, and Clean Ship Index. As demand for environmentally friendly products and services grows, investors and consumers are demanding greater transparency and accountability, which is provided by, on the one hand, rating systems and independent assessments, or certification systems and ISO standards.

- Environmental Ship Index (ESI) - identifies seagoing ships that perform better in reducing air emissions than required by the current emission standards of the International Maritime Organization (IMO).
- IMO's Carbon Intensity Indicator rating. The rating is part of the IMO's new set of mandatory carbon reporting and rating measures.

1) Ships must report their Energy Efficiency eXisting Ship Index (EEXI) and their annual Carbon Intensity Indicator (CII).

2) The IMO will assign a CII score (from A-E) (Figure 15). . Low performing ships will have to prepare a corrective action plan;

3) Each year it will become harder for a ship to improve its rating

[27] *Annual Sustainability Report Maersk 2021 calendar year*

[28] *The sustainability imperative /Nielsen Consumer LLC, October 2015 // URL. https://nielseniq.com/global/en/insights/analysis/2015/the -sustainability-imperative-2*

[29] *Cargo Owners for Zero Emission Vessels // URL. https://www.cozev.org*

These new measures are part of the IMO's commitment to reduce the carbon intensity from all ships by 40% by 2030.

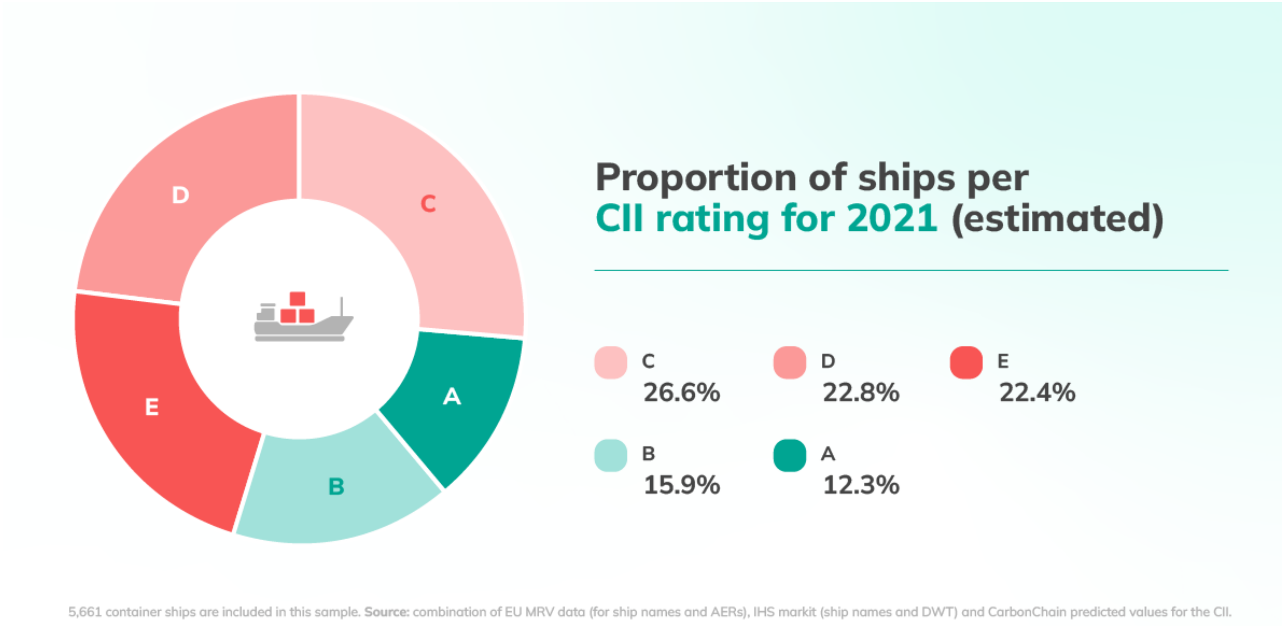


Figure 15 - Proportion of ships per CII rating

- RightShip - RightShip Qi (Quality Index), is a numerical rating that assesses the safety and environmental performance of a vessel.
- Clean Ship Index - an independent and holistic labelling system of vessels' environmental performance; a practical tool for differentiating port- and fairway fees or choosing more sustainable shipping alternatives.

Whether decarbonization happens, weather the resulting capacity cuts and tariff increases—it will really depend on who has to pay for it. If zero-emission ship designs are approved worldwide, either shippers will have to pay the cost of switching to the design through higher freight rates, or shipowners will go bankrupt (assuming no low-cost technology solution is available). If costs cannot be directly passed on to cargo owners, ship capacity will decline due to insolvency, and cargo owners will still end up paying for decarbonization according to the law of supply and demand.

Meanwhile, countries (especially in Asia) if they want to avoid the future costs of decarbonizing shipping could theoretically block global IMO rules and use their financial institutions to finance the construction of ships that are using fleet oil.

2.4. COMPANIES IN THE INDUSTRY: DECARBONIZATION STRATEGIES IN THE LOGISTICS SECTOR

Companies in the industry find themselves in tougher conditions environmental standards from supranational and national regulators, requirements from clients about increasing transparency, reporting on GHG emissions and emissions reduction. In addition, financial institutions and institutional investors are showing increased focus on environmentally friendly and sustainable activities of companies. Green Agenda and projects allow access to additional financing/lending that is linked to environmental performance and decarbonization of activities companies (Table 5).

Table 5 - Impact of the decarbonization agenda on key industry players

Stakeholders	Climate risks	Regular risks	Financial risks	Corporate risks	The degree of influence the sustainability of activities
Consumers and cargo owners	L	A	A	A	A
Owners of assets and infrastructure	H	H	H	H	H
Asset and infrastructure operators	A	A	H	H	H
Optimization and outsourcing of supply chain management	L	L	A	A	H

H High influence **A** Average influence **L** Low impact

The decarbonization agenda affects different industry players at various levels. The owners and operators of assets and infrastructure are under the greatest pressure.

However, industry companies are becoming themselves drivers of change, supporting the most ambitious goals of international associations. Climate conference COP26 fixed the willingness of industry to adopt more important goals and develop a low-carbon economy. The maritime industry has adopted more ambitious targets than those previously created by the IMO, with industry players agreeing to increase ambition from a 50% reduction in GHG emissions by 2050 (relative to 2008, IMO) to net zero targets. 14 countries have signed the Declaration on Zero Emission Shipping by 2050, and 237 companies have signed the Call to Action for Shipping Decarbonization.

In the long term, most companies reflect both components of climate strategies: adaptation (reducing the negative effects of climate change on business, preventing possible consequences from tightening regulation, investment and insurance costs) and mitigation (reducing the impact on the climate; specific steps to decarbonize the activities of companies and their suppliers) .

In the field of maritime transport in 2018, as noted earlier, the international MARPOL Convention and the relevant resolutions of the IMO Marine Environment Protection Committee, as well as regional legislative acts of coastal states, formulated goals for reducing GHG emissions, including reducing emissions when transportation by at least 50% by 2050 compared to 2008. In the field of railway transport, there are no uniform goals for carbon neutrality; they vary depending on the country or region. Following supranational, national and regional decarbonization policies for rail and maritime transport, companies have also published their decarbonization strategies.

Let's look at them using the example of the largest European and Asian railway and shipping companies. In the rail industry some of the companies have carbon neutrality targets by 2030-2050. In particular the German Deusche Bahn (DB), Indian Railways and East Japan Railway Company. Many other companies have not yet announced such ambitious goals.

Regarding the measures taken for decarbonization, most of the companies agree that it is necessary to develop already traditional measures for energy efficiency, electrification and waste recycling. The next most popular method is the use of renewable energy sources and batteries, which is quite logical given that all companies consider electrification as one of the main measures for decarbonization. For example, DB has already achieved the target of recycling more than 95% of raw materials by the end of 2020, and by 2025 all depots, office buildings and stations in Germany will be powered entirely by green energy.

Companies are also turning to alternative fuels, with hydrogen, biofuels and methane the most commonly mentioned in decarbonization strategies.

In the field of maritime transport, companies set themselves goals to achieve carbon neutrality by 2040-2050, in particular the German AP. Moller–Maersk, Mediterranean Shipping Company, CMA CGM Group, Hapag-Lloyd, Evergreen Line and HMM. Other companies do not yet declare such ambitious goals and many of them stick to the goals, established by MARPOL.

Regarding the measures taken for decarbonization, most of the companies companies agree that it is necessary to develop energy efficiency measures that have already become traditional. Some companies in their strategies indicate a transition to diesel fuel with low sulfur content (Low-sulfur oil/VLSFO), while some companies do not highlight this method. However, it is highly likely that all companies use this type of fuel due to IMO regulations regarding sulfur emissions[30].

[30] *International Maritime Organization (IMO), 2020 // URL.* *https://www.imo.org/en/MediaCentre/HotTopics/Pages/Sulphur-2020.aspx*

The next most popular method is the use of biofuels and methane as alternative fuels. Biofuels are used mainly in mixtures with diesel fuel, and companies note methane as the most suitable transition fuel with a reduced carbon footprint. Also, some companies separate biomethane. Thus, BP and Maersk Tankers, with the support of the Danish Maritime Authority, successfully completed trials using biofuel-based marine fuel in product tankers, demonstrating that environmentally friendly biofuel can be used as a marine fuel to reduce carbon dioxide emissions[31].

2.5 REGIONAL WORLD EXPERIENCE IN DECARBONIZATION PORTS

Ports are the gateway to world trade and therefore are crucial for the economic development of countries.

Thousands of ports around the world are engaged in maritime trade.

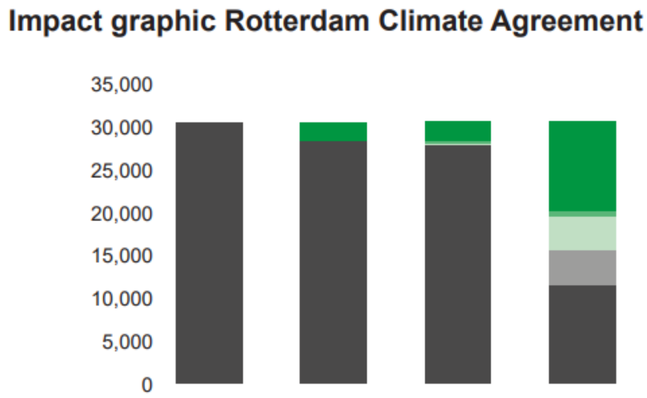
Ports play a key role in decarbonizing the economy. They can catalyze change in a variety of sectors, from maritime to energy, as they link land and sea. Ports themselves are ecosystems in which many industrial sectors interact, such as maritime, energy, logistics and transport. Currently, each of these sectors has its own decarbonization goals and strategies to reduce carbon dioxide and other GHG emissions. As a link between them, ports can act as potential hubs for decarbonization and leaders in the energy transition.

Ports and port cities use different configurations of the above methods. Thus, the port of Rotterdam has concluded a multilateral agreement, the Rotterdam Climate Agreement[32] (Figure 16), which contains about 50 measures to improve the sustainability of the port city and aims to bring emissions below 12 000 kilotons (reduce by 50%) by 2030. Strong support from central government is essential in achieving this.

---

[31] *BP, Maersk Tankers successfully trial biofuel blend on ships, 2021 // URL.* https://www.reuters.com/markets/commodities/bp-maersk-tankers-successfully-trial-biofuel-blend-ships-2021-12-17/

[32] *Rotterdam Climate Agreement // URL.* https://cdn.locomotive.works/sites/5ab410c8a2f42204838f797e/content_entry5ab410faa2f42204838f7990/5be174d6337f770010c1b69f/files/1.2.2_Rotterdam_Climate_Agreement_ENG.pdf



Certain	-	2,149	2,273	10,630
Expected	-	9	311	672
Intended	-	10	157	4,152
Remaining	-	-	-	3,983
CO_2 emissions	31,167	29,021	28,485	11,832

Figures in kiloton CO_2

Figure 16 - Impact Graphic Rotterdam Climate Agreement

The agreement involves three steps:

1. Performance indicators. The residual heat will be used to heat houses, industrial buildings and greenhouses. The CO2 will be captured and stored in the North Sea.

2. Changing the energy system. Many industrial processes require high temperatures. This requires affordable electricity from sustainable sources such as solar, wind and water.

3. Transition from fossil fuels to sustainable energy sources

Singapore has adopted The Maritime Singapore Decarbonization Blueprint: Working Towards 2050, which requires up to 50% of Singapore-flagged ships to be green by 2050; by 2030, all inland port ships will be required to run on low-carbon fuels; and by 2050, — on electricity.

The Port of Los Angeles, the Port of Shanghai and C40 Cities are working to reduce GHG emissions along one of the world's busiest freight routes. Thus, the two ports and industry partners, including shipping lines and cargo owners in China and the United States, have committed to submit a green corridor implementation plan by the end of 2022.

2.6 RISKS AND OPPORTUNITIES OF DECARBONIZATION OF RAIL AND SEA LOGISTICS

Decarbonization can represent both risks and new business opportunities for the railway and maritime shipping industry. The table below (Table 6) provides an analysis of the likely risks and opportunities they generate[33].

Table 6 - Risks and possibilities of decarbonization in rail and train transportation

RAIL TRANSPORT	
TRAINS	
RISKS	POSSIBILITIES
• Electric trains require network electrification, which is an expensive process. • Electrification may lead to increased demand for electricity during peak hours load, which will require the use of a combination of renewable energy sources and fossil fuels, this will reduce the effects of decarbonization. • Electric trains rely on overhead electrification lines, which can suffer from power failures and mechanical problems. • The carbon footprint of railway electrification construction work can be very high. This must be offset by measures to reduce carbon emissions gas • Development of railway infrastructure requires high costs compared to, for example, automotive. • On low-load routes, electrification is not practical • New "green" locomotives require high capital costs. • Poorly developed refueling infrastructure. Long cycles of technological adaptation (about 20 years), which does not allow quick switch to low carbon solutions	• Electrification reduces GHG emissions. Now this is the only alternative to diesel fuel with zero CO2 emissions (provided that they are powered by renewable energy sources). • Accelerates faster and is quieter. • Electric trains are lighter than diesel trains and therefore cause less wear on the wheels. • Strengthening the climate agenda gives a competitive advantage to railway transport, in particular, it is possible to attract large investments for the construction of a new infrastructure or redirect traffic flows to the railway as less carbon-intensive transport • The introduction of energy efficient technologies reduces the carbon footprint. • Attracting green and sustainable financing for projects • Use of hybrid engines

[33] *IRENA (2021), International Renewable Energy Agency // URL. https://www.irena.org/Publications/2021/Oct/A-Pathway-to-Decarbonise-the-Shipping-Sector-by-2050*

TERMINALS	
RISKS	**POSSIBILITIES**
• Development of railway infrastructure requires high costs compared to, for example, automotive.	• Own generation of renewable energy sources will allow selling electricity during low load hours • Consumer demand for next day delivery has increased. Due to increased public attention to the low-carbon agenda, there is a demand for goods which must be delivered quickly and as environmentally friendly as possible environment way. • Some companies are looking to revive the parcel and light freight business, using electric passenger rolling stock to deliver light freight and parcels from ports and airports to central urban areas by rail. Not only is this a low-carbon option, but it also avoids traffic.

MARINE TRANSPORT	
PORTS	
RISKS	**POSSIBILITIES**
• Ports may have difficulty providing different bunkering services with different fuel types.	• Own generation of renewable energy sources will allow selling electricity during low load hours. • Renewable energy generation allows for low-carbon "charging" of ships from shore, which reduces emissions both on ships and from infrastructure. This creates a demand for a new business arrangement: a kind of trading alliance between the port, the network operator and the ship owner. • Another role could be to create a service provider that could play a role in the electrification of transport within and outside the port area. • Also in the ports, green hydrogen can be produced and sold for ships and other consumers in the port and city. • Decarbonization of ships serving ports currently has great potential. For example, according to IRENA, the most acceptable option is hybrid vessels. Also, "testing" new technologies on small vessels can serve as a good starting point for scaling them to large-tonnage vessels. • Creation of technology partnerships and

	creation of green corridors

SHIPS

RISKS	POSSIBILITIES
• Increasing carbon regulation • Going it alone is difficult for companies as shipping is a sector that difficult to decarbonize quickly • New "green" ships require high capital costs • Poorly developed refueling infrastructure for alternative fuels • Long cycles of technological adaptation (about 20 years), which does not allow a quick transition to low-carbon solutions	• High demand for international maritime transport • Creation of technology partnerships • Development of energy efficient technologies • Co-location of fuels produced from natural gas and fuels produced from RES could lead to further cost reductions. • Younger ships operating today need to be modernized to accelerate the transition to zero-carbon fuels.

CONTAINERS

RISKS	POSSIBILITIES
• The container must be returned, returning an empty container increases carbon track	• Collapsible containers • Joint Tenancy

2.7 DEVELOPMENT OF SUSTAINABLE LOGISTICS AND ENVIRONMENTAL RESPONSIBILITY OF COMPANIES IN THE WORLD

In modern business, sustainable logistics plays an important role in increasing the competitiveness of companies. Consumers are becoming more conscious. Environmental issues are becoming key when choosing products and services. Companies that are committed to sustainable logistics can expect increased customer confidence, strengthened their reputation and improved business performance.

One of the main reasons why environmental responsibility is becoming increasingly important in logistics is climate change and the threat of environmental crisis. Responsible use of resources and reducing harmful impacts on the environment are essential measures to preserve nature and create a sustainable future economy.

Sustainable logistics is a concept that aims to reduce the negative impact of logistics operations on the environment and ensure long-term economic sustainability. It is based on the integration of the principles of ecology, social responsibility and economic efficiency in all aspects of logistics activities.

Features of sustainable logistics are as follows:

1. Sustainable logistics follows a circular approach in which resources are managed based on their full utilization and recycling. Here the emphasis is on reducing direct and indirect resource losses, which contributes to the creation of a closed consumption cycle.

2. Sustainable logistics strives to reduce emissions of greenhouse gases and other harmful substances, which is achieved through the use of low carbon footprint technologies, energy efficient vehicles and optimization of delivery routes.

3. Sustainable logistics focuses on efficient use of resources, including energy, water and materials. This is achieved through optimizing warehousing and storage processes, using smart inventory management systems and increasing the efficiency of vehicle use.

Logistics can have a negative impact on the environment due to a number of environmental issues, including:

Firstly, logistics operations, especially those related to transportation and storage require significant use of vehicles, which can be a source of greenhouse gas emissions such as carbon dioxide (CO2), methane or nitrogen oxides. These emissions contribute to climate change and poor air quality.

Second, logistics operations require large amounts of energy to drive vehicles, light warehouses, and perform other operations. Some of this energy comes from sources that negatively impact the environment, such as fossil fuels.

Thirdly, logistics operations often generate waste, such as packaging materials, pallets and other materials that eventually become garbage. Large warehouses and distribution centers may also experience soil and water contamination.

Examples of the negative impact of logistics operations on the environment:

1. One of the key challenges in logistics is transporting goods over long distances. This requires the use of cars, trucks, trains and planes, which emit harmful substances into the atmosphere and contribute to air pollution. In addition, a large number of moving vehicles leads to traffic congestion, which causes additional emissions and wasted time and resources.

2. Logistics operations require the use of packaging materials to protect goods during transportation and storage. However, the large amount of packaging materials used especially plastic, leads to waste accumulation and environmental pollution. Most of this waste is not recycled and, of course, harmful for our planet.

3. Logistics operations associated with warehousing and storage of goods requires the use of energy to maintain optimal temperature conditions and lighting of warehouse premises. This

leads to increased energy consumption and the possibility of releasing harmful substances into the air.

It is important to note that limiting the negative impact of logistics on the environment is a pressing concern, and the assistance of sustainable logistics technologies and processes can help reduce these issues and achieve greener logistics.

Sustainable logistics strives to reduce negative impacts of logistics operations on the environment by applying the following principles:

1. Sustainable logistics strives to use resources, such as energy and materials, more efficiently. This can be achieved by optimizing delivery routes, reducing empty shipments, using energy-efficient vehicles and using innovative technologies such as automated warehouse management systems.

2. Sustainable logistics strives to reduce greenhouse gas emissions associated with the transport and storage of goods. This can be achieved through the use of electric or hybrid vehicles, the use of alternative energy sources and the implementation of emission reduction programs for transport operations.

3. Sustainable logistics aims to reduce the amount of waste generated and use resources efficiently. This can be achieved by using more sustainable packaging materials, reusing packaging and introducing recycling systems and supporting the concept of a circular economy.

Describe how these principles can be applied to reduce environmental impact:

1. The use of routing and geopositioning technologies helps optimize delivery routes, minimize mileage and reduce time costs. This helps reduce greenhouse gas emissions and fuel consumption, as well as reduce the negative impact on road traffic.

2. Replacing traditional vehicles with electric or hybrid cars and trucks can significantly reduce greenhouse gas emissions. This is especially important in the context of urban logistics, where electric vehicles can reduce air pollution in densely populated areas.

3. The use of automated warehouse management systems and Internet of Things technologies allows you to effectively manage inventory, optimize warehouse processes and reduce energy consumption. Stocking items according to demand and using energy-efficient lighting systems can significantly reduce the environmental impact of warehouse operations.

Sustainable logistics principles help reduce the negative environmental impact of logistics operations while increasing the efficiency and economic sustainability of logistics processes. Implementing these principles requires collaboration between companies and innovative thinking in developing more environmentally sustainable approaches to logistics.

Examples of successful implementation of innovations to reduce negative environmental impacts:

1. Many logistics companies are successfully switching to using electric trucks and vans to deliver goods. For example, DHL has deployed electric trucks in urban delivery centers around the world, reducing greenhouse gas emissions and improve air quality in cities.

2. Some logistics companies are investing in renewable energy and installing solar panels in their warehouses and terminals to generate their own electricity. For example, UPS has installed solar panels in its warehouses and uses them to power of their operations.

3. Some logistics companies are actively implementing smart warehouse management systems, which can effectively manage inventory, optimize storage space and reduce energy consumption. For example, Amazon used robots in its warehouses to process orders faster and more accurately, resulting in reduced turnaround times for processing orders and reducing energy consumption.

These examples demonstrate how the application of innovations in logistics can significantly reduce the negative impact on the environment and make logistics operations more sustainable. However, for successful the implementation of such innovations requires government support organizations, incentive policies and cooperation between companies in in order to find new solutions and innovations for sustainable logistics.

Study of specific measures and actions those companies taken to reduce their environmental footprint:

1. Companies can use biodiesel, electric vehicles and others alternative fuels to reduce carbon emissions and other harmful substances.

2. Planning optimal delivery routes and combined delivery allows you to reduce fuel costs and travel time.

3. Using automated systems to manage the supply chain can help streamline processes and reduce errors, resulting in a reduction in unnecessary freight movements.

4. Companies can design and use reusable or recyclable packaging to reduce waste.

5. Collaboration with suppliers and their involvement in the process of sustainable logistics helps reduce the environmental footprint of the supply chain.

These are just some examples of best practices in sustainable logistics. Each company can develop its own measures and actions that suit its characteristics and goals. However, implementing sustainable practices to reduce your environmental footprint can bring significant benefits to the company and the environment.

Sustainable practices in logistics are important for business and the environment. Environmental responsibility is not only helps reduce harm to the environment, but can also provide companies competitive advantages in the market.

Using sustainable logistics can reduce fuel costs and energy, optimize resource use and improve performance efficiency. This allows companies to reduce their environmental footprint load, meet regulatory requirements and satisfy the needs of environmentally conscious customers.

However, the application of sustainable practices in logistics also requires investments and long-term strategy. Companies must be ready to implement new technologies, train your employees and collaborate with suppliers, having similar values.

Overall, sustainable logistics and environmental responsibility are becoming increasingly important in the modern world. Businesses that understand the importance of sustainability can not only create profits, but also contribute contribution to the preservation of the environment for future generations.

3. DRIVING DECARBONIZATION: MULTIMODAL LOGISTICS ADVANTAGE IN SUPPLY CHAIN AND MEASUREMENT OF CO_2 EMISSIONS

As part of the calculation of emissions associated with transport logistics, we will consider 2 methodologies: GLEC (Global Logistics Emissions Council) methodology in the framework of Scope 3 and calculations made using the GREENROUTER platform.

Both methodologies will use numerical data using the example of Tailormade logistics.

3.1 EXAMPLE OF TAILORMADE LOGISTICS

In the realm of transport logistics, precision in assessing CO_2 emissions is paramount. To delve deeper into the calculations of CO_2 emissions in transport logistics and obtain more accurate results using various methodologies, a specific logistics company will be used as an example.

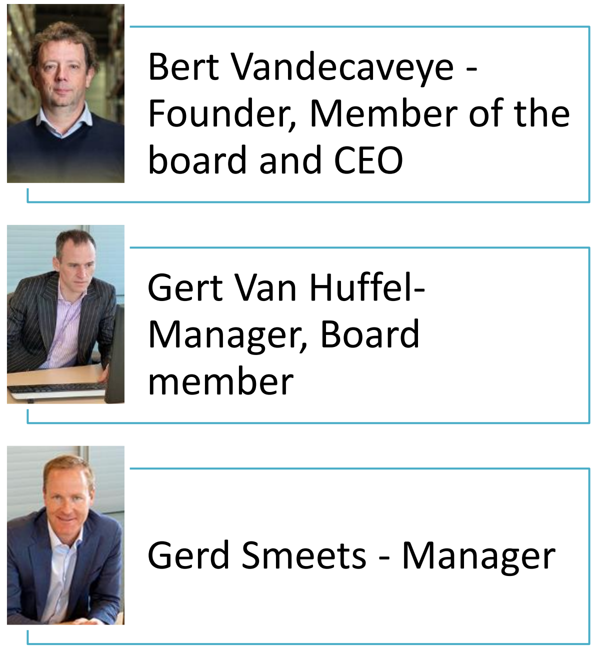
This study will use the data taken from the notable practices of Tailormade Logistics, a prominent player in the industry. Tailormade Logistics will serve as a benchmark for the calculations conducted in the following chapters.

3.1.1 COMPANY DESCRIPTION

Figure 17 – Company Logo

- **COMPANY NAME:** Tailormade Logistics
- **COMPANY LOGO:** provided on Figure 17
- **TYPE OF BUSINESS STRUCTURE**: Limited company
- **OWNERSHIP/MANAGEMENT TEAM:** Names of the key people behind the company[34]

[34] *TML official web-site // URL.* https://www.tailormade-logistics.com/



- **LOCATION:**

TML has expanded to across 25 sites in 8 countries with Head office in Korte Mate 5 9042, Gent Belgium. Tailormade Hubs strategically situated at the heart of Europe, in close proximity to key gateways such as Antwerp, Zeebrugge, and Rotterdam. Company has access to 400,000 square meters of warehouse space and managing an extensive intermodal network, facilitating the seamless import and export across Europe and beyond (Figure 18).

Tailormade Logistics key destinations include:

- BENELUX - ITALY
- BENELUX - SCANDINAVIA
- BENELUX - FRANCE
- BENELUX – ITALY

The Port of Ghent facilitates a daily train service from Ghent to Mortara, a city nestled in northern Italy near Milan. This international container shuttle, a pioneering initiative for Ghent port, operates six times a week in both directions, boasting a capacity of approximately 80 TEU.

Figure 18 – Strategic positioning in Europe

- **COMPANY HISTORY**

Tailormade Logistics was established in 1996 by Bert Vandecaveye at the Port of Ghent, Belgium, stands as a beacon of innovation and excellence in the realm of logistics. Company is strategically close to Europe's primary gateways. Ghent enjoys proximity to major cities like Paris, London, Cologne, and Amsterdam, merely within a 3-hour reach.

The port's exceptional road, rail, and inland waterway connections makes Ghent an optimal hub for logistical operations across Europe. Its advantages include:

Swift worldwide deep-sea connections, accessible within 30 minutes to Antwerp/Terneuzen, 50 minutes to Zeebrugge and Vlissingen ports, and a 2-hour reach to Rotterdam.

Daily European rail links spanning north and south Europe, facilitating seamless transportation. Short-sea connections extending to Scandinavia, Russia, the UK, and Ireland, broadening the scope of logistics. Proximity to major airports such as Paris, London, Amsterdam, Cologne, and Brussels, all within a 3-hour radius.

Over 25 years, Tailormade Logistics has become a major logistics service provider, receiving recognition and accolades for its commitment to innovation and customer service. Bert Vandecaveye emphasizes, "We rely on outstanding customer service and innovation to stay ahead in a competitive world. The key to our success is simple: Give your customers knowledge, ease, and savings."

The company's achievements include numerous awards, including HR awards such as multicultural and diversity awards, environmental recognition, and consecutive years as the fastest growing company. Tailormade Logistics has also received awards such as the Green Truck Award.

The pioneering efforts highlight Tailormade Logistics' commitment to sustainability and efficiency. In Belgium it became a pioneer with the introduction of natural gas trucks and pioneering innovations. These innovations include special XL mega-trailers, heavy-duty trailers, as well as new concepts such as reverse logistics in the automotive and fashion retail sectors. The company also pioneered new urban distribution models and introduced cross-warehouses for automobiles and fashion, setting industry standards.

Tailormade Logistics embodies the spirit of innovation and sustainability, constantly pushing boundaries to redefine excellence in logistics and transportation.

- **MISSION STATEMENT:**

The company believes that every person and every business is unique. That's why they are committed to providing customized logistics solutions designed specifically for customers' specific needs. Since its founding in 1996, Tailormade's management has focused transportation and logistics on customer needs, prioritizing innovation, cross-cultural management, flexibility and results-oriented strategies.

- **PRODUCTS/SERVICES AND TARGET MARKET:**

Company provides the main the service mainly in the following areas (Figure 19):

Automotive industry. This is one of the most complex sectors of all, given the ever-increasing flows of materials between continents and the diverse range of supply-chain strategies deployed. Automotive industry accounts for around 28 percent of the company's business.

The fashion industry accounts for 24 percent of the company's services. The sector's challenges include rapid turnover from one collection to another, seasonal peaks and globally integrated production systems.

Garden centers. Delivery of goods on pallets to garden centers: from Euro pallets to display pallets and large packages. Products range from lawn and garden products including fertilizers, grass seed, spreaders and soils (13 percent of company services).

Flooring. Among the responsibilities are coordination of all transport, distribution and related logistics activities such as warehousing, cutting, repackaging, display logistics, sample management and circular economy logistics (15 percent of company services).

Flooring products include: carpet, carpet, vinyl, artificial grass, laminate, hardwood, LVT, tile and other related products such as carpeting, baseboards and store supplies.

General cargo Industrial goods logistics accounts for 20 percent of the company's services. Tailormade Logistics handles B2B industrial products, such as deliveries of packaging materials, plastic wraps, tying materials and equipment. Company has special procedures for shipping these high-quality goods and semi-finished products.

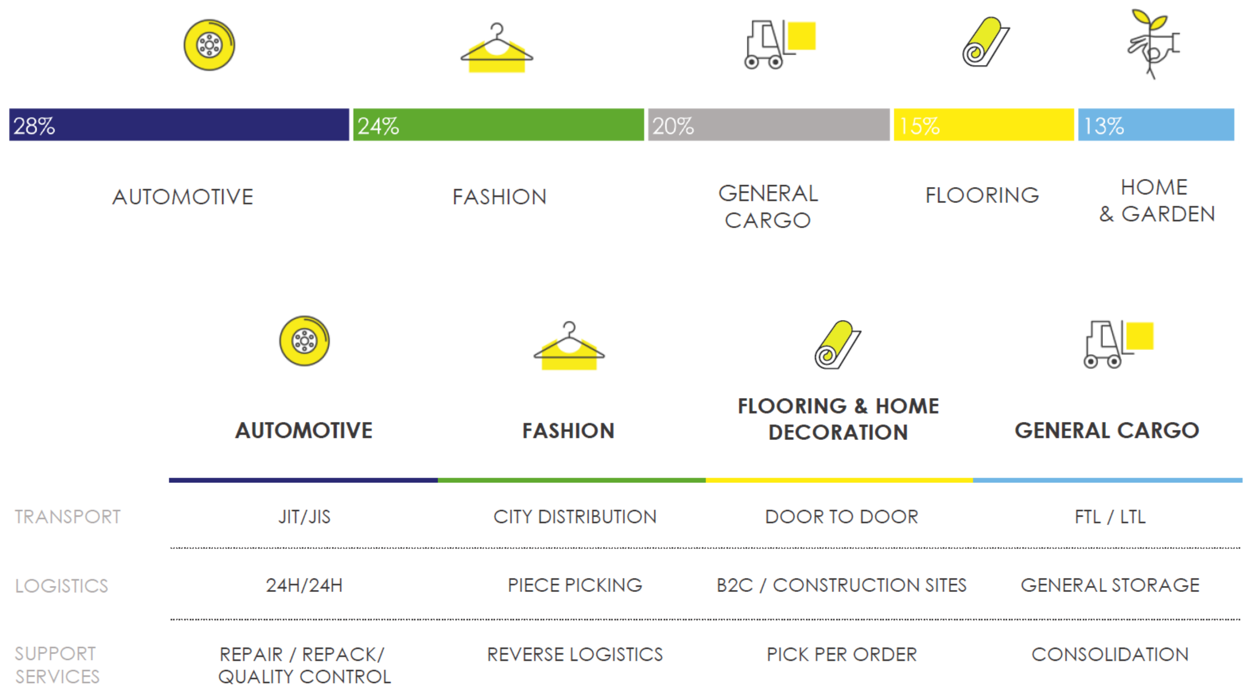


Figure 19 – Focus Areas

3.1.2 TAILORMADE ANNUAL ACCOUNTS

Annual report presentation should explain the company's vision. The following financial statements: Income statement (Table 7), Balance sheet after profit distribution (Table 8) - provided in the financial year covering the period of 01/01/2022 – 31/12/2022 and the "previous financial year" of the annual accounts covering the period of 01/01/2021 – 31/12/2021.

Table 7 – Income statement

INCOME STATEMENT

	FINANCIAL YEAR	PREVIOUS FINANCIAL YEAR
Operating income	**127.953.997**	**99.714.571**
Revenue	116.624.617	94.690.615
Stock of goods in progress and finished products orders in progress: increase (decrease)		
Manufactured fixed assets		
Other operating income	11.329.380	5.022.932
Non-recurring operating income	0	1.024
Operating costs	**130.681.460**	**101.745.173**
Trade goods, raw materials and consumables	78.460.802	58.997.642
Purchases	78.433.078	59.040.663
Stock: decrease (increase)	27.724	-43.021
Services and miscellaneous goods	27.409.468	21.822.148
Remuneration, social security contributions and pensions	20.238.126	16.682.276
Depreciation and write-downs on formation costs, on intangible and tangible fixed assets	4.175.970	3.646.096
Write-downs on stocks and orders	-173.062	107.742
execution and on trade receivables: additions (repossessions)		
Provisions for risks and costs: additions (expenditures and withdrawals)	-7.000	-14.618
Other operating costs	338.309	335.431
Operating costs capitalized as restructuring costs		
Non-recurring operating costs	238.847	168.456
Operating profit (loss)	**-2.727.463**	**-2.030.602**

Table 8– Balance sheet after profit distribution

BALANCE SHEET AFTER PROFIT DISTRIBUTION

	FINANCIAL YEAR	PREVIOUS FINANCIAL YEAR
	44.920.474	43.824.954
Intangible assets	11.936.109	13.365.781
Tangible fixed assets	14.441.496	11.988.926
Land and buildings	13.750	17.709
Plants, machines and equipment	772.904	249.462
Furniture and rolling equipment	772.924	802.149
Leasing and similar rights	12.239.268	9.658.941
Other material fixed assets	642.650	1.022.670
Assets under construction and advance payments	0	237.996
Financial fixed assets	18.542.869	18.470.247
Affiliated companies	18.496.897	18.425.397
Participations	18.496.897	18.425.397
Claims		
Companies with which there is a participating interest		
Participations		
Claims		
Other financial fixed assets	45.971	44.849
Shares		
Claims and sureties in cash	45.971	44.849

	Financial year	Previous financial year
Current Assets	**31.969.763**	**27.454.220**
Amounts receivable after more than one year		
Trade receivables		
Other receivables		
Inventories and orders in progress	**183.438**	**211.162**
Stocks	183.438	211.162
Raw materials and consumables	32.403	31.605
Goods in process		
Finished product		

Trade goods	151.035	179.557
Real estate intended for sale		
Advance payments		
Orders in progress		
Amounts receivable within one year	**30.500.306**	**24.281.028**
Trade receivables	29.049.438	19.760.210
Other receivables	1.450.868	4.520.818
Investments		
Own shares		
other investments		
Liquid assets	**837.782**	**2.911.489**
Accrued accounts	**448.237**	**50.541**
TOTAL ASSETS	**76.890.236**	**71.279.174**

	Financial year	**Previous financial year**
Passive Equity	**17.726.339**	**19.223.810**
Input	1.705.470	1.705.470
Capital	1.705.470	1.705.470
Issued capital	1.705.470	1.705.470
Uncalled capital		
Outside capital		
Issue premiums		
Others		
Revaluation surpluses	**220.000**	**220.000**
Reserves	**571.951**	**579.980**
Unavailable reserves	170.547	170.547
Statutory reserve	170.547	170.547
Statutory unavailable reserves		
Share buyback		
Financial assistance		
Other		
Tax-free reserves	386.404	394.433
Available reserves	15.000	15.000
Profit (loss)	**15.228.918**	**16.718.360**
Capital subsidies		
Advance to the partners on the distribution of the net assets		

Services and postponed taxes	0	**7.000**
Provisions for risks and costs		
Pensions and similar obligations	0	7.000
Taxes		
Major repairs and maintenance works		
Environmental obligations		
Other risks and costs		
Deferred taxes	0	7.000

	FINANCIAL YEAR	PREVIOUS FINANCIAL YEAR
DEBT	**59.163.897**	**52.048.364**
Debts due after more than one year	**22.127.808**	**23.938.474**
Financial debts	22.127.808	23.938.474
Subordinated loans		
Unsubordinated debentures		
Leasing debts and similar debts	8.118.959	6.638.474
Credit institutions	12.008.849	15.300.000
Other loans	2.000.000	2.000.000
Trade debts		
Suppliers		
Bills payable		
Advance payments on orders		
Remaining debts		
Debts due within one year	**36.885.058**	**28.002.110**
Debts due after more than one year that mature within one year	5.987.361	5.179.941
financial debts	5.430.263	0
Credit institutions	5.430.263	0
Other loans		
Trade debts	20.172.735	15.754.011
Suppliers	20.172.735	15.754.011
Bills payable		
Advance payments on orders	0	22.384
Debts related to taxes, salaries and social security contributions	3.515.557	2.960.812
Taxes	1.046.332	552.080
Remuneration and social security contributions	2.469.225	2.408.733
Remaining debts	1.779.142	4.084.962
Accrued accounts	**151.031**	**107.781**
TOTAL LIABILITIES	**76.890.236**	**1.279.174**

The key figures as of 12/31/2022 can be compared with those as of 12/31/2021 as follows in Table 9.

Table 9– Comparison of key indicators

Income statement	**31/12/2022**	**31/12/2021**	**Difference (EUR)**	**Difference (%)**
Revenue	175.845.415	135.294.888	40.550.527	30%
Other operating income	5.176.072	3.897.372	1.278.700	33%
Non-recurring operating income	207.891	335.648	- 127.756	- 38%
Trade goods, services and miscellaneous goods	- 116.244.770	- 83.497.967	- 32.746.803	39%
Gross margin	**64.984.609**	**56.029.941**	**8.954.668**	**16%**
Remuneration, social security contributions and pensions	- 55.745.775	- 43.923.675	- 11.822.100	27%
Depreciation and amortization	- 7.916.691	- 6.959.561	- 957.130	14%
Other operating costs	- 958.071	- 758.716	- 199.354	26%
Non-recurring operating costs	- 392.493	- 657.407	264.914	40%
Operating result	**- 28.421**	**3.730.581**	**- 3.759.002**	**- 101%**
Financial income and costs	- 2.608.366	- 9.298.846	6.690.479	- 72%
Profit (loss) for the financial year	**- 2.636.787**	**- 5.568.264**	**2.931.477**	**- 53%**
Taxes	- 715.189	- 1.142.206	427.017	- 37%
Profit (loss) for the financial year after taxes	**- 3.351.976**	**- 6.710.471**	**3.358.494**	**- 50%**

Comments on the key figures changes during the period:

a) Turnover. The non-recurring operating costs have decreased in the current financial year by an amount of € 264,914 or 40%. The decrease in non-recurring operating costs can mainly be explained by non-recurring excise duties to be repaid in 2021.

The increase in the gross margin can mainly be explained by the fact that the recurring operating income (turnover and other operating income) has increased by 30%, while the costs related to trade goods, services and miscellaneous goods have only increased by 39%. The absolute gross margin compared to turnover has fallen from 41% to 37%. Turnover has increased in the current financial year by € 40,550,527 or by 30% and this increase can mainly be explained by a growth in turnover in transport and logistics activities in TML, TML Westerlo, TML UK and TML France.

b) Other operating income. The other operating income equals € 5,176,072 on 31/12/2022 and has increased by € 1,278,700 or 33%. This increase can mainly be explained by the recovery of excise duties, operating subsidies received and the sale of waste.

c) Non-recurring operating income. Non-recurring operating income fell from €335,648 to €207,891 or €127,756. This decrease can mainly be explained by non-recurring provisions compared to 2021.

d) Trade goods, services and miscellaneous goods. The costs related to trade goods, services and miscellaneous goods have increased in the current financial year by € 32,746,802 or by 39% and this increase can mainly be explained by higher turnover growth, but also by higher transport costs and higher inflation.

e) Gross margin. On 31/12/2022 the gross margin is € 64,984,609 and this gross margin has increased by € 8,954,668 or by 16%. The increase in the gross margin can mainly be explained by the fact that the recurring operating income (turnover and other operating income) has increased by 30%, while the costs related to trade goods, services and miscellaneous goods have only increased by 39%. The absolute gross margin compared to turnover has fallen from 41% to 37%.

f) Remuneration, social security contributions and pensions. The costs related to remuneration, social security contributions and pensions have increased in the current financial year by € 11,822,100 or by 27% from € 43,923,675 as of 12/31/2021 to € 55,745,775 as of 12/31/2022. This increase can mainly be explained by the further expansion of the organization to support the growing turnover (drivers, workers and employees).

g) Depreciation and amortization. The increase in depreciation and amortization from €6,959,561 to €7,916,691 can mainly be explained by additional investments in capex in the 2022 financial year.

h) Other operating costs. The other operating costs have increased in the current financial year by an amount of € 199,354 or 26% compared to the previous financial year. This increase can mainly be explained by additional property taxes in TMW.

i) Non-recurring operating costs. The non-recurring operating costs have decreased in the current financial year by an amount of € 264,914 or 40%. The decrease in non-recurring operating costs can mainly be explained by non-recurring excise duties to be repaid in 2021.

j) Operating result. The operating result on 31/12/2022 is € - 28,421 and this operating result has decreased by an amount of € 3,759,002. The decrease in the operating result can mainly be explained by the fact that, despite the increase in the gross margin in the current financial year, the costs relating to remuneration, social security contributions and pensions, depreciation and amortization and other operating costs have increased more sharply compared to the previous year.

k) Financial income and costs. The financial result has decreased by an amount of € 6,690,479 or 72% as of 31/12/2022. The decrease in the financial result can mainly be explained by a decrease in depreciation on positive consolidation differences by an amount of €7,088,122, by an increase in the costs of debts by € 314,400 and by an increase in other financial costs by an amount of €129,207.
The decrease in depreciation on the positive consolidation differences can mainly be determined by the fact that the positive consolidation differences, being a total amount of € 8,860,153, were fully written off in the previous financial year. This resulted in an additional depreciation of the positive consolidation differences of € 6,202,107 in the 2021 financial year.
The increase in debt costs can mainly be explained by the fact that the Tailormade Logistics group has concluded additional leasing agreements in the 2022 financial year.
The increase in other financial costs can mainly be explained by additional bank costs and exchange results.

l) Profit (loss) for the financial year. In the current financial year, the consolidated loss before tax is € 2,636,787 and this consolidated result before tax has increased by an amount of € 2,931,477 or 53% compared to the previous financial year. This increase can be explained, among other things, by a decrease in depreciation on positive consolidation differences in 2021. Despite strong turnover growth, the operating result was lower due to a high negative impact of sharply increased transport and fuel prices and high inflation.
m) Taxes. The taxes amount to € 715,189 and have decreased by € 427,017 or 37%, partly as a result of the decrease in the consolidated profit before taxes.

n) Profit (loss) for the financial year after taxes. The consolidated loss after tax is equal to € 3,351,976 as of 31/12/2022 and has decreased by an amount of € 3,358,494 compared to the previous financial year.

Description of the main risks and uncertainties.

During 2022, companies faced the impact of rising costs, especially in fuel and personnel and utilities, due to generally rising inflation.
Notwithstanding that there has been a consolidated loss for the financial year for 2 consecutive financial years; the board of directors is of the opinion that the application of the valuation rules can be maintained under the assumption of continuity.
In order to once again achieve a positive result, various actions will be taken within the various companies that will lead to a more efficient execution of the transport and logistics activities, together with the further optimization of the internal organizations, processes and systems.

Non-financial key performance indicators.

With regard to personnel: in 2022, the total workforce increased from 976 in 2021 to 1,188 in 2021, i.e. 22% or 212 additional employees.
A Sustainability project was started during 2021 with the aim of publishing a Sustainability Report in the course of 2022 in which Sustainability is presented in various areas within the Group and how this will be further developed in the future.

3.1.3 TAILORMADE DECARBONIZATION AMBITIONS

Tailormade Logistics has a range of initiatives to become climate-neutral. According to TML Sustainability Report[35] by 2025, company is willing to achieve a reduction of 90% in greenhouse gas emissions. This goal is supposed to be achieved by activities (Figure 20) that not only greatly reduce CO2 emissions but also offset the remaining CO2 emissions.

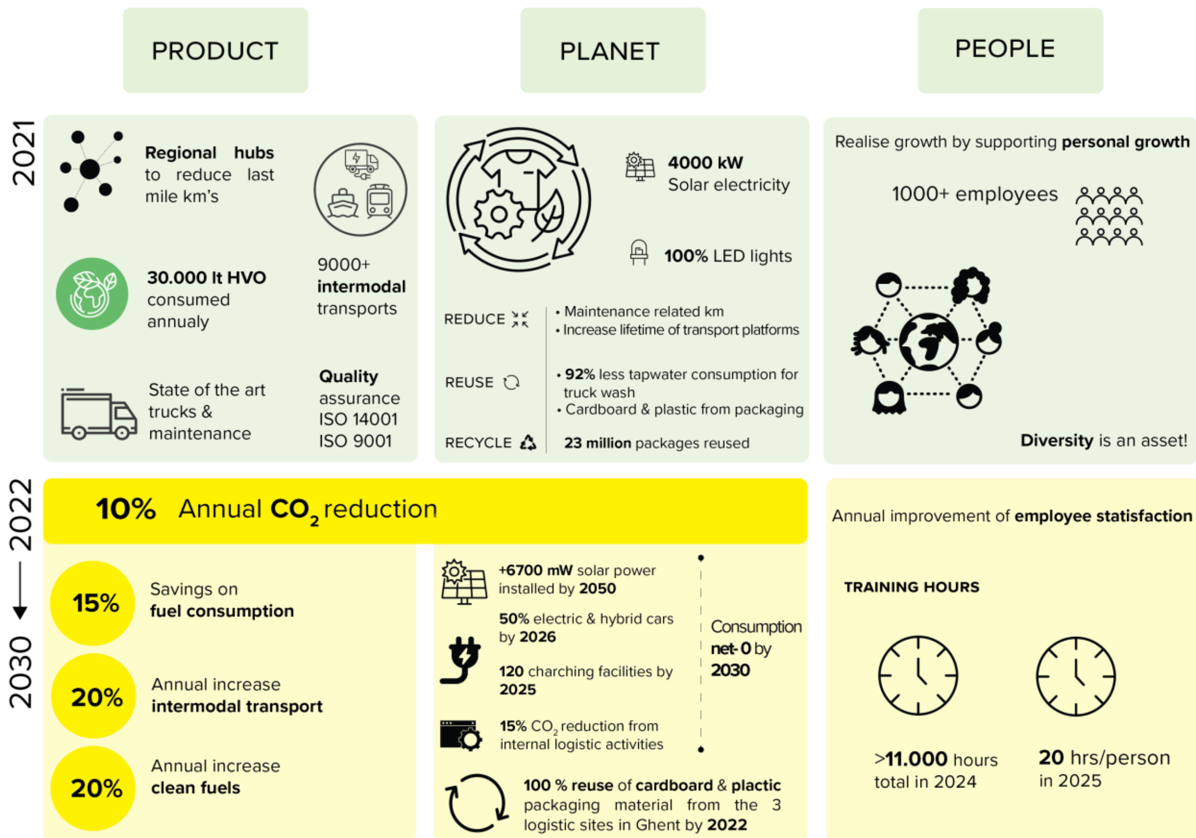


Figure 20 – TML ambitions

TRANSPORT RELATED CO_2 REDUCTION

Alternative & clean fuels

TML increasingly uses HVO (Hydrogenated Vegetable oil) for last mile transport, leading to more than 90% of green-house gas savings compared to fossil fuels. HVO is a biobased fuel, produced from vegetable oil, animal waste fats, used oils and algae. According to the Sustainability report, only from 2021 to 2022 the company has increased the usage of HVO by 20% (Figure 21).

[35] *TML Sustainability Report // URL.* *https://www.tailormade-logistics.com/en/co2-neutral*

Innovation:

TML actively looking at solutions beyond currently available transportation methods. The fast developments when it comes to Hydrogen powered transport certainly feed TML ambition to be a hydrogen pioneer.

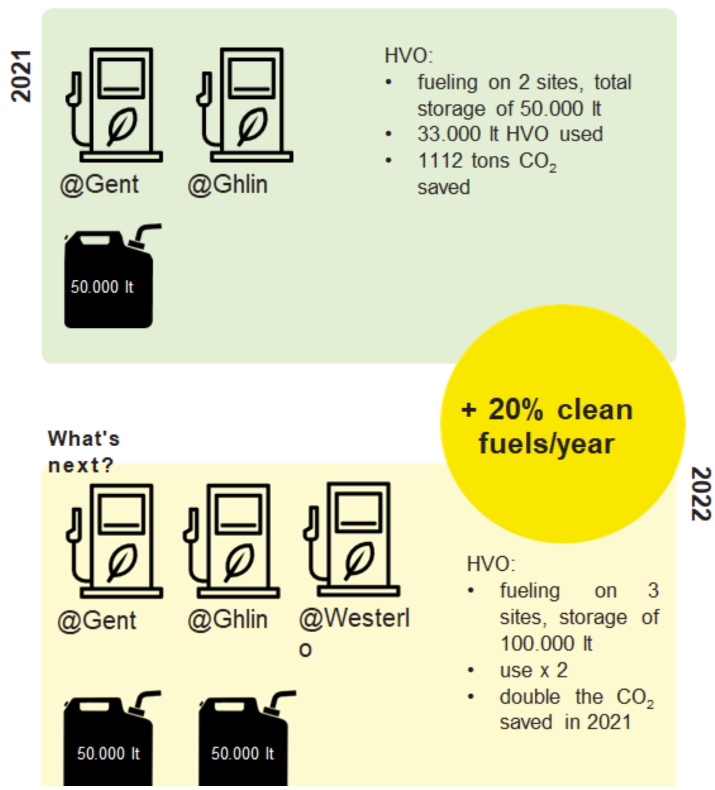


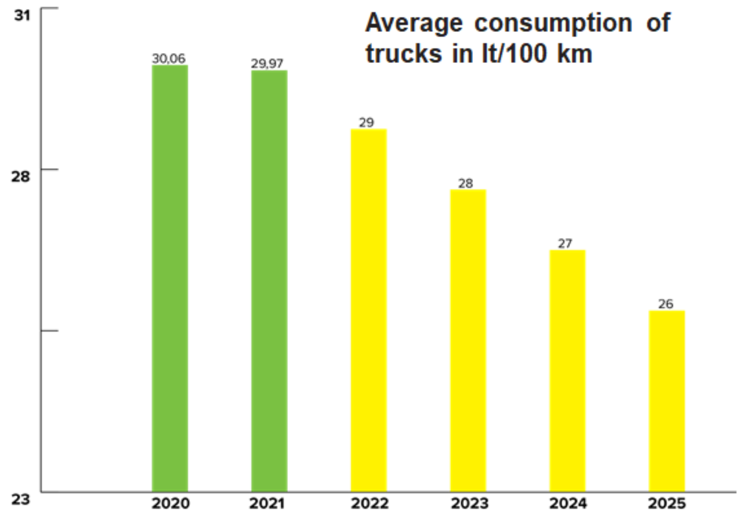
Figure 21 – HVO fuel usage

Reduce fuel consumption per km

The future perspectives of the company include:

- adaptive cruise control on all new vehicles
- introduction of the ‘eco-score’ module in the vehicle and driver management system
- eco-drive training and rehearsal for all drivers
- gradually upgrade the truck park to “Euro 7 level” or better through close partnership with truck providers

Through these actions they reduce TML average fuel consumption per 100 km (compared to 2020) (Picture 11).



Picture 11 – Average consumption of trucks in lt/100 km

Innovation:

Despite TML best efforts to increase the use of HVO and intermodal transport, traditional road transport with diesel trucks remains an important part of the equation. To mitigate the impact of these activities, TML focuses on technology.

Company's fleet of trucks is kept up to date, so they can take advantage of the latest and cleanest generation diesel engines, with reduced emissions to meet EURO 7 norms.

TML new trucks ordered for next year are developed in close partnership with DAF and focus on: fuel efficiency, safety and driver comfort. The enhanced design (weight, engine, aerodynamics) leads to a total fuel reduction of 10% compared to the current state of the art flagship trucks.

For the following chapter "Driving decarbonization: multimodal logistics advantage in supply chain and measurement of CO2 emissions" Tailormade data will be used for the analysis of the CO2 emissions in the different scenarios of transport solutions.

3.2 THE INPUT DATA

For the research five main routes were chosen (Table 10). The following routes are the most important and regularly done by the company. For each routed can be used scenarios with road and multimodal solutions and 2 types of fuel: diesel and HVO fuels (Table 11).

Table 10 - Routes regularly done by the company

	DEPARTURE	ARRIVAL	FIGURE
1	**NOVI LIGURE - IT**	**TILBURY - UK**	**Figure 22**
2	**GHLIN - BE**	**CASALPUSTERLENGO - IT**	**Figure 23**
3	**GHLIN - BE**	**TRIBIANO – TRAVAGLIATO - IT**	**Figure 24**
4	**GATTATICO**	**AMIENS - FR**	**Figure 25**
5	**GHLIN - BE**	**MONTEROTONDO - IT**	**Figure 26**

Table 11 - Possible Scenarios

	TRANSPORTATION TYPE	FUEL TYPE
1	ROAD	DIESEL
2	ROAD	GREEN (HVO)
3	MULTIMODAL	DIESEL
4	MULTIMODAL	GREEN (HVO)

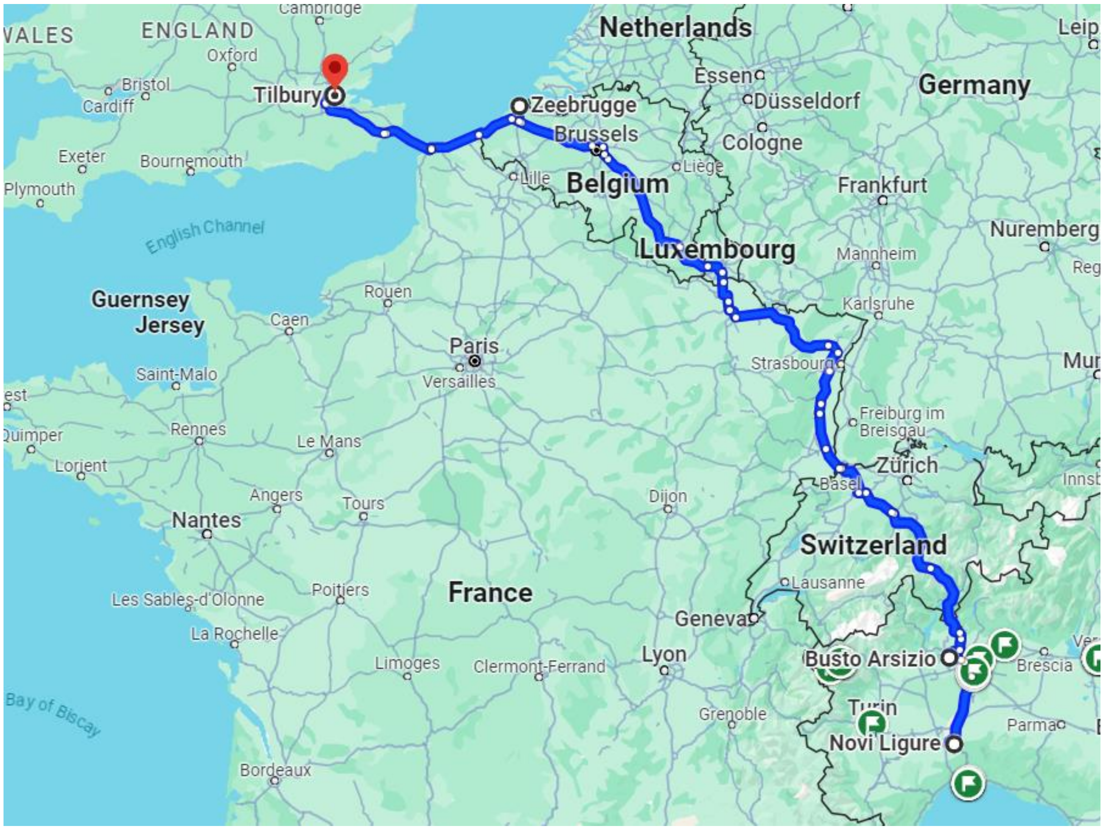


Figure 22 – Route 1

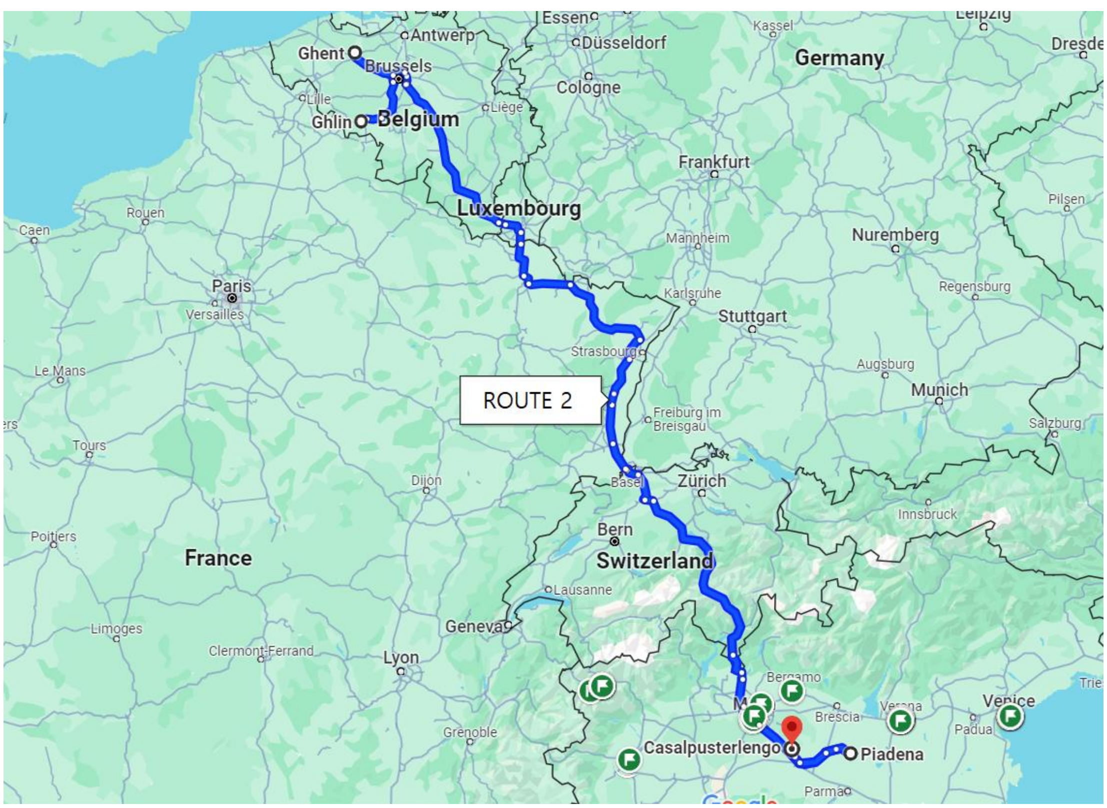


Figure 23 – Route 2

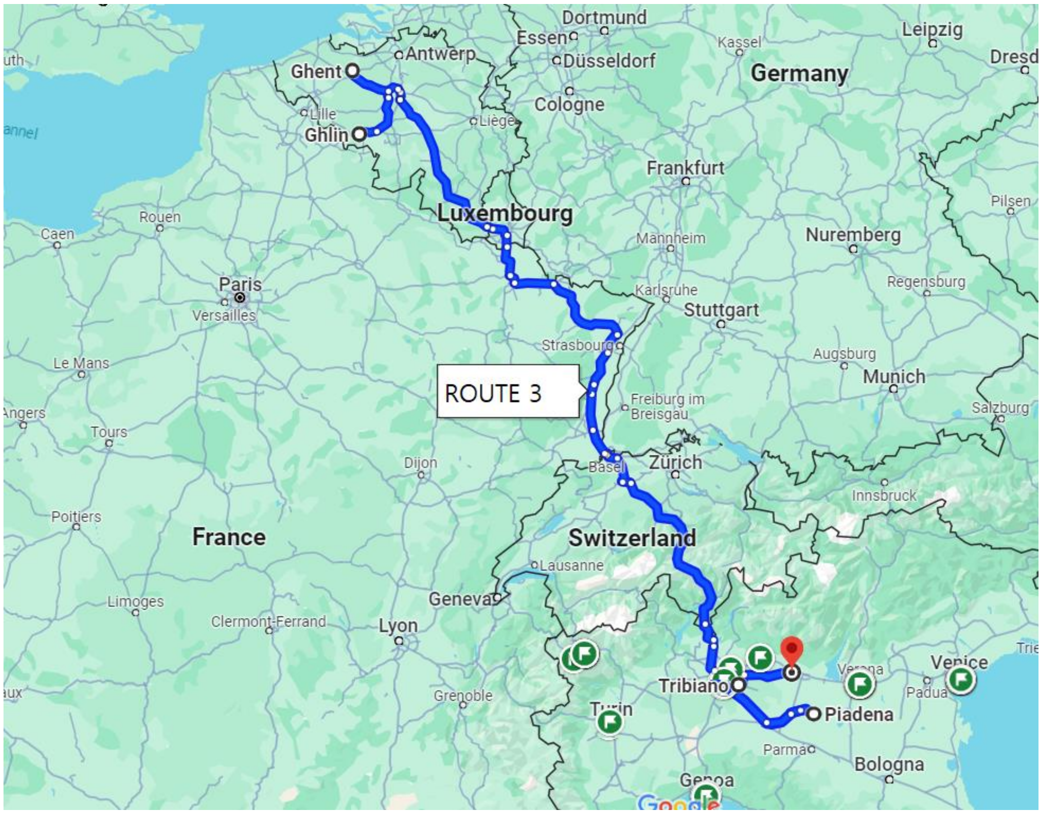


Figure 24 – Route 3

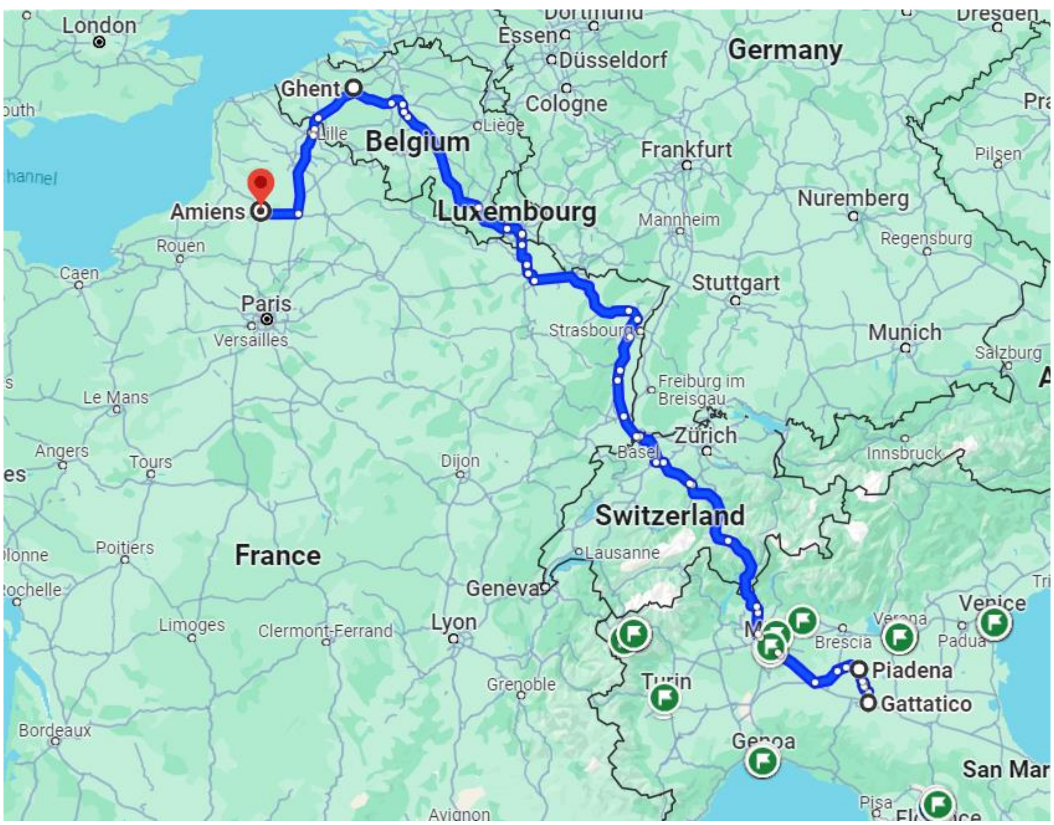


Figure 25 – Route 4

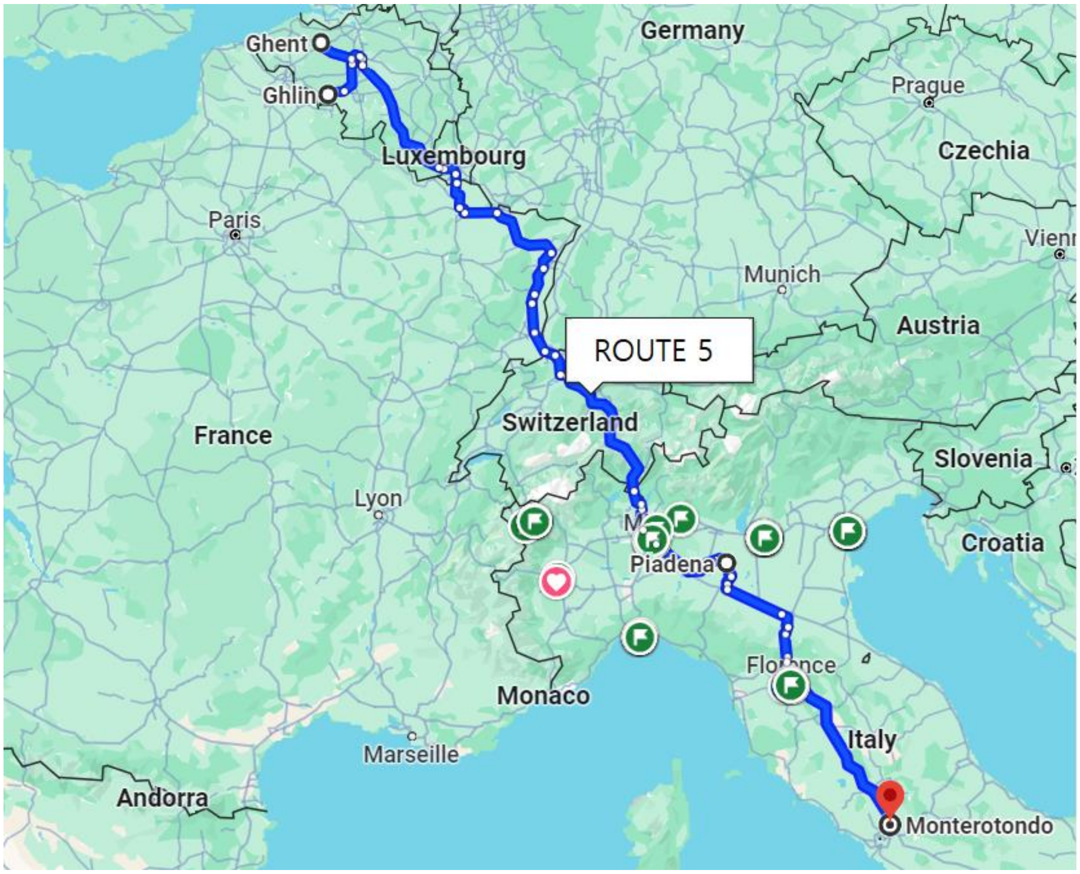


Figure 26 – Route 5

The full representation of Routes according to the all possible scenarios is listed in the Table 12.

Table 12 - Routes with all Possible Scenarios

ROUTES		FUEL	KM
1	**NOVI LIGURE**	**TILBURY**	
	ROAD	DIESEL	1434
	ROAD	GREEN (HVO)	1434
	MULTIMODAL	DIESEL	1434
	MULTIMODAL	GREEN (HVO)	1434
2	**GHLIN**	**CASALPUSTERLENGO**	
	ROAD	DIESEL	1251
	ROAD	GREEN (HVO)	1251
	MULTIMODAL	DIESEL	1251
	MULTIMODAL	GREEN (HVO)	1251
3	**GHLIN**	**TRIBIANO - TRAVAGLIATO**	

	ROAD	DIESEL	1371
	ROAD	GREEN (HVO)	1371
	MULTIMODAL	DIESEL	1371
	MULTIMODAL	GREEN (HVO)	1371
4	**GATTATICO**	**AMIENS**	
	ROAD	DIESEL	1.321,00
	ROAD	GREEN (HVO)	1.321,00
	MULTIMODAL	DIESEL	1.321,00
	MULTIMODAL	GREEN (HVO)	1.321,00
5	**GHLIN**	**MONTEROTONDO**	
	ROAD	DIESEL	1474
	ROAD	GREEN (HVO)	1474
	MULTIMODAL	DIESEL	1474
	MULTIMODAL	GREEN (HVO)	1474

3.3 GLEC METHODOLOGY

3.3.1 METHODOLOGY OVERVIEW

Recently, there has been a lot of attention to decarbonization in supply chains. The Global Logistics Emissions Council indicates that if nothing is changed in carbon regulation, then greenhouse gas emissions from all vehicle types may double and amount up to 6.2 billion tons of CO2 by 2050.
GLEC or the Global Logistics Emissions Council is a methodology created by Smart Freight Center as a universal way to calculate logistics emissions (Figure 27)[36].

Figure 27 – GLEC Methodology

One of the main sections of the methodology is the definition of scopes (SCOPE 1,2,3) of the carbon footprint.

[36] *GLEC framework // URL.* https://www.feport.eu/images/downloads/glec-framework-20.pdf

The goal of the GLEC Framework is to compute all relevant logistics emissions produced by the company's operations and supply chain processes. All emissions can be classified into three following categories: Scope 1, 2 and 3 emissions (Figure 28).

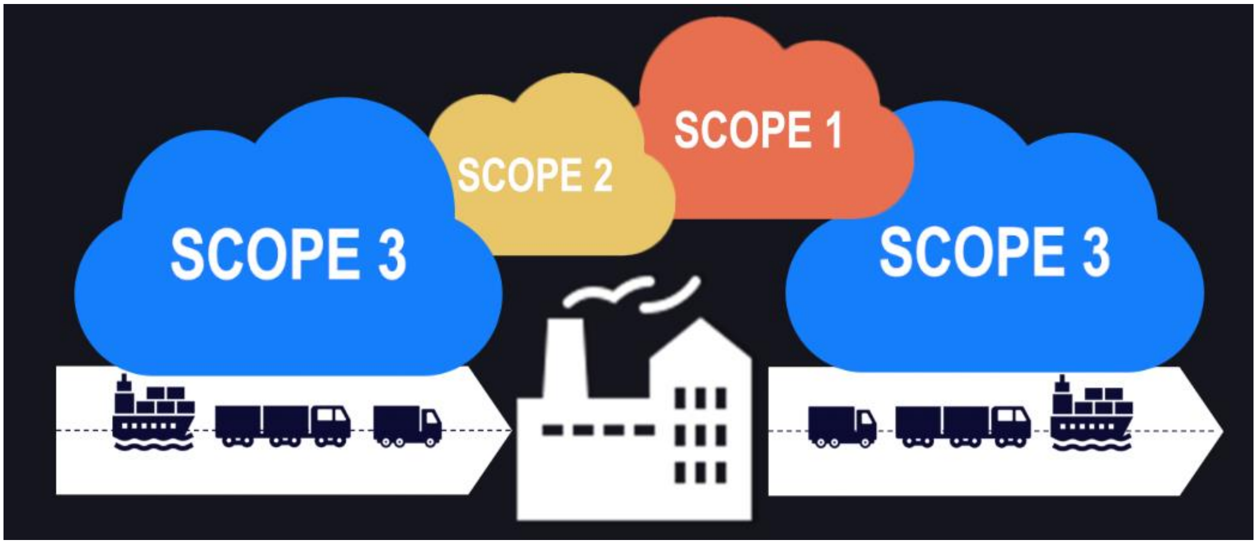


Figure 28 – Scope 1, 2 and 3 emissions

Scope 1 emissions: direct greenhouse gas emissions emissions (company's own activities).

GHG (greenhouse gas) emissions from controlled or own sources of the company.

Examples: GHG emissions from fuel combustion of fuels to produce energy, heat or steam by own vehicles, stationary or mobile equipment, boilers, steam generators, forklifts, buildings. The emissions are released into the atmosphere directly as a result of the company's daily activities (Figure 29).

Scope 2 emissions: indirect GHG emissions (electricity).

Indirect GHG emissions from purchased by the end-user (corporations) for its own logistics assets.

Examples: office power consumption, room lighting, electric vehicle battery charging, equipment power consumption, heating and cooling.

Scope 3 emissions: indirect GHG emissions (supply chains).

The indirect GHG emissions – not incorporated in scope 2 – of the supply chain. Examples: GHG emissions from fuel combustion by contractors to move goods from suppliers to the reporting company and, eventually, to the final customer. Both upstream and downstream emissions are included.

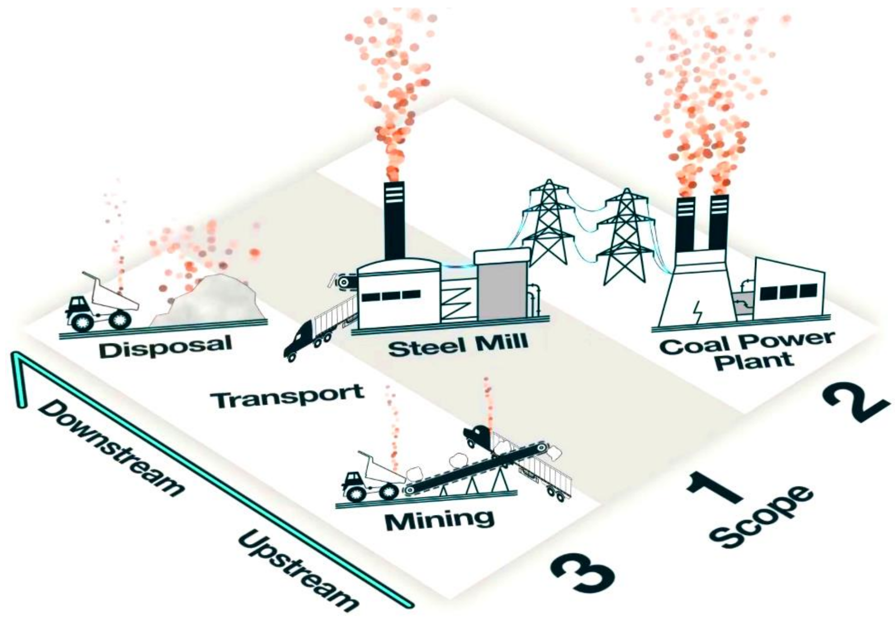


Figure 29 – Scope 1, 2 and 3 emissions

3.3.2 CALCULATION OF EMISSIONS WITH GLEC. SCOPE 3 EMISSIONS

As part of the calculation of emissions related to logistics and transport, we will consider the application of the GLEC methodology in the framework of Scope 3.

Steps before carrying out the analysis are listed in the Figure 30.

Figure 30 – Steps before carrying out the analysis

Set a boundary.
First of all, before carrying out the analysis one needs to outline the borders of extent of the activities included. The analyst needs to study information on the transport activities, vehicles, and carriers. All that will lead to the correctness of the analytic results.

End Goals.
The calculation strategy depends on the final use of emission values. Calculating total annual emissions of a logistics company is one of the most common uses. Moreover, the GLEC can be

applied to various scopes of decision making processes. The analysis can help determine the emission distribution to the logistic activities.
The most relevant and transparent way to evaluate the efficiency of freight transport is emissions per tonne-kilometre.

Determine data needs.

Each data type influences differently the calculation approach used and the analysis outcome.

Data types according to the GLEC framework (Figure 31):

• **Primary data.** A transport buyer should try to collect accurate data from carriers for Scope 3 emissions accounting. Primary data can range from extremely accurate information, such as fuel receipts or annual costs, to aggregated numbers that show fuel or emission intensity for a year's worth of vehicle movements.

• **Program data.** Green freight programs play a significant role as a neutral platform for transport operators and their clients to collect and share trustworthy data in a neutral, controlled environment. Program data is used to guide carrier selection and identify potential energy, cost, and emission-saving options.

• **Modeled data.** Fuel usage and emission consumption can be modeled by using information on good types, packages dimensions, destination locations, and any information about the vehicles used, load factors, etc.

The crucial factor that influences the model's output is the level of detail that is available on the transport operation and the assumptions made, as well as the model's algorithms.

Usually, assumptions rely on default data, rather than primary data, since the latter lowers the accuracy of the output.

• **Default data.** In case no other data are available, the last option is to use default data, which is a representative of average operating practices in industry. Default data can provide a general level of emissions and offering a structure for prioritizing data collection to improve accuracy.

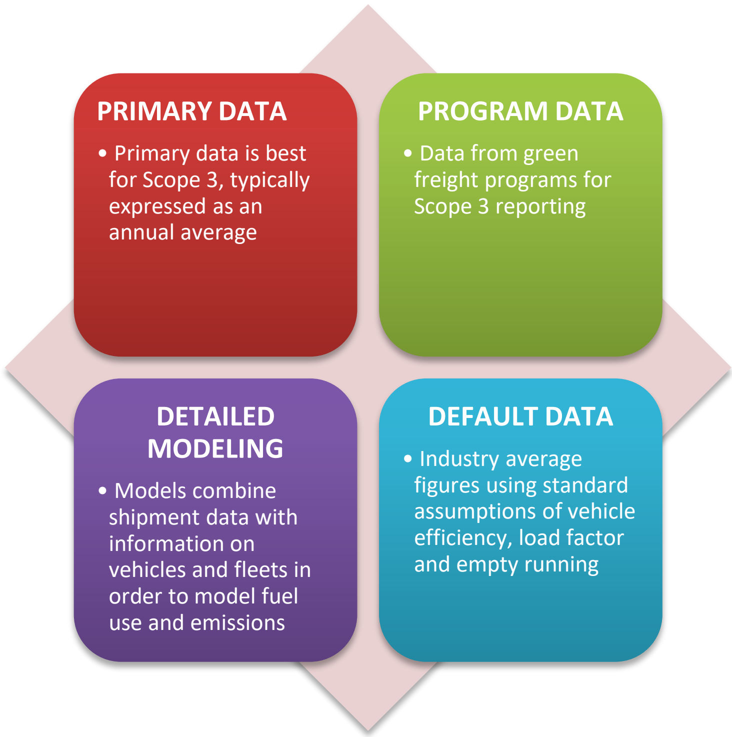


Figure 31 - Data types according to the GLEC framework

GLEC involves the multiple steps in creation of reliable calculation of the logistics emissions. The process flow for a multi-modal supply chain is shown on the Figure 32.

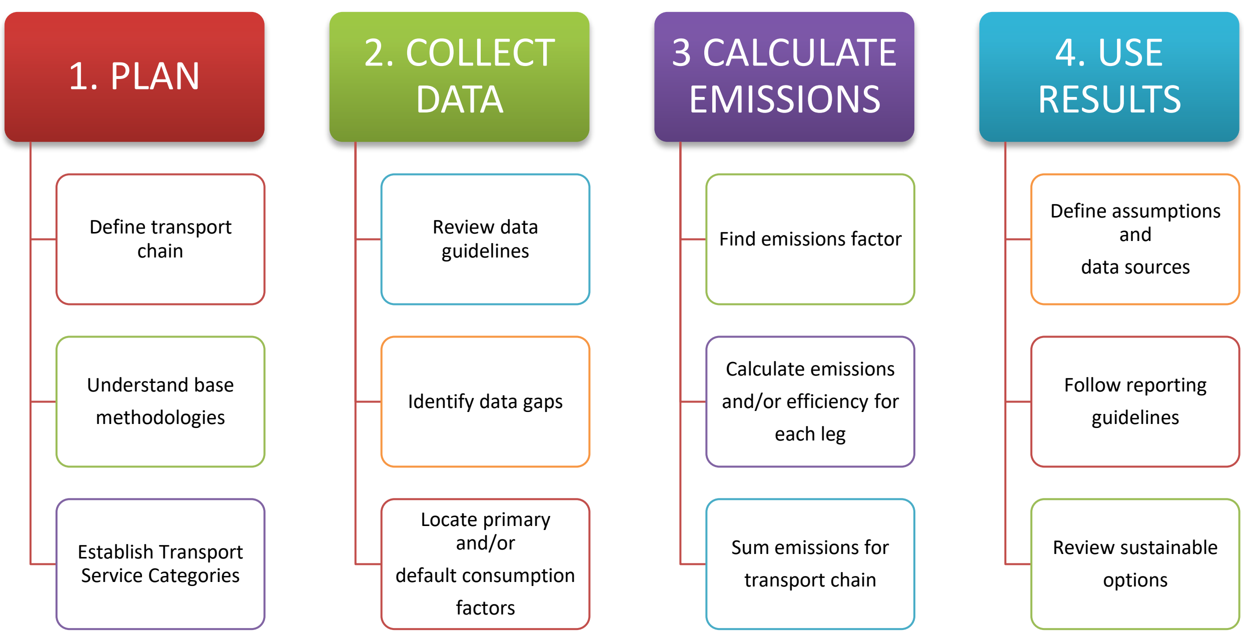


Figure 32 - Data types according to the GLEC framework

THE PROCESS FLOW FOR A MULTI-MODAL SUPPLY CHAIN

MAJOR STEPS IN THE FRAMEWORK

DEFINE TRANSPORT CHAIN

Set the transport mode and start/final destination point for each transport chain component. Ports, terminals and warehouse are noted as transhipment centers locations (Figure 33).

Figure 33 - The process flow for a multi-modal supply chain

- Shipment data collection

Weight. For each transport chain element set the shipping weight. Volume and density are also common attributes of freight, but weight is a GLEC Framework selected measure because it has a consistent application during the supply chain process. Other metrics may be also useful for analysis and reporting, but weight should be always present alongside these measurements. It will to guarantee stability along the multimodal supply chain.

Depending on the mode of transport, packaging materials provided for transport by the shipper can be included in the weight (e.g. pallets). But any additional packaging or handling equipment used by the carrier is not included in Scope 3 calculations. Weight information is noted on invoices, bills of lading, within a Transport Management System, etc.

Distance. The shipment distance made by a vehicle is calculated starting from the point where a carrier receives the goods and ends when the shipment is received by the final client. The process may seem easy, especially in the light of GPS development, but distance determining in logistics is still making carbon emissions estimation challenging.

Some shipments require multiple stages of transportation, and some of them are handled by different carriers. Sometimes carrier companies choose the routs that are not direct, but convenient for the carrier's transport network. Routs can be changed due to the weather conditions, tides, construction work, or road conditions, strikes and other unforeseen situation.

The situation may also be complicated by consolidated shipments, when deliveries are combined to maximize vehicle loading and hence efficiency. Eventually, this may result in the total distance increase.

There are four common approaches to calculating distance:

- **Actual distance.** The real physical distance usually only known by the carrier and based on odometer readings or knowledge of the real route.

- **Great circle distance (GCD).** GCD, often known as direct distance, is a distance measuring method that is currently focused on air transport. GCD is simply standardized and has little bearing on actual transportation network circumstances. This is an attractive alternative for harmonizing distance measurement across multimodal supply chains, but, unfortunately, is not well known and accepted outside of the aviation sector at the moment.

- **Shortest feasible distance (SFD).** The shortest possible distance between two points is often determined using route planning software. SFD is not an optimum solution since it does not account for real-world operating conditions such as vehicle physical constraints, topography, type of road, congestion, or construction.

- **Planned distance.** Also calculated with a route planning software, tends to be the shortest distance taking into account actual operating conditions and making optimal choices like avoiding traffic jams or road blocks.

- **Network distance.** It is essentially a variation of planned distance and used when the route alternatives are limited.

GCD is used to quantify distance in air travel; for most other instances, planned or network distance is suggested. Planned distance is the most widely accessible and recognized method of measuring distance for the various participants in a supply chain.

Effectively a variation of planned distance, network distance is used where the route options that can be taken are limited (e.g. rail or inland waterways).

CHOOSE APPROPRIATE CONSUMPTION FACTOR (INTENSITY FACTOR)

Tonne-kilometers. To evaluate freight transport activities, it’s important to consider together the weight of the shipment and the distance it was transported. As such, the tonne-kilometer is the key unit for freight transport, representing one tonne of cargo moving for one kilometer.

$$\text{tonne-km} = \text{tonnes} \times \text{kilometers}$$

For a set of consignments, to calculate the total tonne-kilometers, the weight and loaded distance are multiplied together for each consignment and then the individual tonne-kilometer values are added together. Tonne-kilometers have to be calculated separately for different transport services and fuel types to improve the accuracy of carbon emission calculations.

$$\sum_{trip=1}^{n} tkm = tonne_{trip\ 1} \times kilometer_{trip\ 1}$$

$$\ldots + tonne \times kilometer \ldots + tonne_{trip\ n} \times kilometer_{trip\ n}$$

FIND FUEL EFFICIENCY OR EMISSION INTENSITY FACTORS

There are many different sources of data that can be used to estimate fuel and emissions for Scope 3, each with varying levels of accuracy and usefulness for different applications. Typically, the data are classified into fuel efficiency or emission intensity factors (fuel use tkm or CO2e t-km), which are combined with activity data (tkm) to calculate a final total value. The type of data may range from primary to program, modeled, or default data, as previously discussed. It is recommended that independent, third party assurance of the input data and any assumptions embedded within the calculation process are carried out.

CONVERT ACTIVITY DATA TO EMISSIONS

The final calculation for Scope 3 emissions brings together the tonnes, kilometers and efficiency or intensity factors. The approach varies depending on the factor being adopted – fuel efficiency or CO2e intensity.

With a fuel efficiency factor:

$$\text{kg } CO_2\text{e emissions} = \sum_{1}^{n} \left(\textit{total}\ \text{tkm} \times \text{fuel efficiency factor} \left(\frac{\text{kg fuel}}{\text{tonne-km}} \right) \times \textit{fuel emission factor} \left(\frac{\text{kg } CO_2\text{e}}{\text{kg fuel}} \right) \right)$$

This step must be carried out separately for each type of fuel; fuel emission factors are available in the table below[37] (Table 13).

[37] *CO2-Performance ladder// URL.* https://www.co2emissiefactoren.be/

Table 13 - CO2 emission factors to measure the consumptions

Type of goods	Freight transport	Weightclass/fuel	Unit	EF total (Well to Wheel) [$kgCO_2e$/ unit]
Container	Truck	>20t	tonne-kilometre	0.212
Container	Truck	< 20 t with trailer	tonne-kilometre	0.122
Container	Truck	LHV	tonne-kilometre	0.109
Container	Train	Average	tonne-kilometre	0.015
Container	Train	Diesel	tonne-kilometre	0.0361
Container	Vessel	Average	tonne-kilometre	0.01

All factors are based on full load (FTL) 24 tonne.

With a CO2e intensity factor:

$$\text{kg } CO_2\text{e emissions} = \sum_1^n \left[\textit{total}\ \text{tkm} \times CO_2\text{e } \textit{intensity factor} \left(\frac{\text{kg } CO_2\text{e}}{\text{tonne-km}} \right) \right]$$

In this case, the fuel is already converted to CO2e. Be sure the underlying data account for the full fuel life cycle (WTW) and all GHGs (CO2e).

GLEC Framework doesn’t allow considering the usage of alternative fuels, therefore during the calculations two main scenarios will be used: Road Solution-Diesel and Multimodal Solution – Diesel.

ROAD SOLUTION SCENARIO

The Calculation for the Road Solutions is presented in the Table 14. CO2 intensity factor corresponds to the Truck with the weight class > 20t and equals 0,212.

Table 14 - Road solution

№	Routes		Tonne	km	Vehicle	Total tkm	CO2 intensity factor	kg CO2e (Scope 3)
1	Nove Ligure	Tilbury	24	1434	Truck	34416	0,212	7296,192
2	Ghlin	Casalpusterlengo	24	1251	Truck	30024	0,212	6365,088
3	Ghlin	Travagliato	24	1371	Truck	32904	0,212	6975,648
4	Gattatico	Amiens	24	1321	Truck	31704	0,212	6721,248
5	Ghlin	Monterotondo	24	1651	Truck	39624	0,212	8400,288
		TOTAL		**7028**		**168672**	**0,212**	**35758,464**

MULTIMODAL SOLUTION SCENARIO

The Calculation for the Multimodal Solutions is presented in the Table 15. CO2 intensity factor corresponded to the Truck with the weight class > 20t is equal 0,212, CO2 intensity factor for the Average train equals 0,015 and for the Vessel – 0,01.

Table 15 - Multimodal solution

№	Routes		Tonne	km	Vehicle	Total tkm	CO2 intensity factor	kg CO2e (Scope 3)
1	Novi Ligure	Tilbury						
			24	**1434**		**34416**		**1090,872**
	Nove Ligure	Busto	24	127	Truck	3048	0,212	646,176
	Busto	Zeebrugge	24	1011	Train	24264	0,015	363,96
	Zeebrugge	Tilbury	24	294	Vessel	7056	0,01	70,56
	Tilbury	Tilbury	24	2	Truck	48	0,212	10,176
2	Ghlin	Casalpusterlengo						
			24	**1251**		**30024**		**1225,752**
	Ghlin	Gent	24	90	Truck	2160	0,212	457,92
	Gent	Piadena	24	1087	Train	26088	0,015	391,32
	Piadena	Casalpusterlengo	24	74	Truck	1776	0,212	376,512

3	Ghlin	Tribiano - Travagliato						
			24	**1371**		**32904**		**1570,872**
	Ghlin	Gent	24	90	Truck	2160	0,212	457,92
	Gent	Piadena	24	1087	Train	26088	0,015	391,32
	Piadena	Tribiano	24	116	Truck	2784	0,113	314,592
	Tribiano	Travagliato	24	80	Truck	1920	0,212	407,04
4	Gattatico	Amiens						
			24	**1321**		**31704**		**1581,912**
	Gattatico	Piadena	24	46	Truck	1104	0,212	234,048
	Piadena	Gent	24	1087	Train	26088	0,015	391,32
	Gent	Amiens	24	188	Truck	4512	0,212	956,544
5	Ghlin	Monterotondo						
			24	**1651**		**39624**		**3260,952**
	Ghlin	Gent	24	90	Truck	2160	0,212	457,92
	Gent	Piadena	24	1087	Train	26088	0,015	391,32
	Piadena	Monterotondo	24	474	Truck	11376	0,212	2411,712
		TOTAL		**7028**		**168672**		**8730,36**

As a result of the Comparison of solution scenarios (Table 16), it is evident that the usage of Multimodal Solutions reduces CO2 emissions by 76% in average. The best result of CO2 reduction (85%) was achieved in the Multimodal solution 1, where the maximum amount of different freight transportation types was used (3 types: truck, vessel, train).

Table 16 - Comparison of solution scenarios

	Road Solution scenario	**Multimodal Solution scenario**	
№	kg CO2e (Scope 3)	kg CO2e (Scope 3)	CO2 reduction with Multimodal Solution
1	7296,192	1090,872	85%
2	6365,088	1225,752	81%
3	6975,648	1570,872	77%
4	6721,248	1581,912	76%
5	8400,288	3260,952	61%
TOTAL	35758,464	8730,36	76%

3.4 GREENROUTER TOOL CALCULATION

GreenRouter is an Italian portal that uses cutting-edge algorithms that are developed to match all the most important carbon accounting standards.[38]

The GreenRouter is a pioneer in CO_2e emissions management and specialized in sustainable Logistics forwarded towards Carbon Footprint reduction.

In contrast to the previous methodology, GreenRouter platform offers the capability to incorporate the influence of HVO fuel. Therefore the all 4 scenarios will be used:

- Road solution scenario – diesel (Table 17)
- Road solution scenario – HVO fuel (Table 18)
- Multimodal solution scenario – diesel (Table 20)
- Multimodal solution scenario –HVO Fuel (Table 21)

ROAD SOLUTION SCENARIO – DIESEL

All the results provided by the platform GreenRouter in kg CO2e.

Table 17 - Road solution scenario - Diesel

№	Routes		km	Vehicle	Tonne	kg CO2e/km	kg CO2e (Scope 3)
1	Nove Ligure	Tilbury	1434	Truck	24,00	1,66	2380,44
2	Ghlin	Casalpusterlengo	1251	Truck	24,00	1,62	2026,62
3	Ghlin	Travagliato	1371	Truck	24,00	1,60	2193,60
4	Gattatico	Amiens	1321	Truck	24,00	1,67	2206,07
5	Ghlin	Monterotondo	1651	Truck	24,00	1,65	2724,15
		TOTAL					11530,88

ROAD SOLUTION SCENARIO – HVO FUEL

Table 18 - Road solution scenario – HVO fuel

№	Routes		km	Vehicle	Tonne	kg CO2e/km	kg CO2e (Scope 3)
1	Nove Ligure	Tilbury	1434	Truck	24,00	0,34	487,56
2	Ghlin	Casalpusterlengo	1251	Truck	24,00	0,34	425,34

[38] *GreenRouter portal // URL. https://www.greenrouter.it*

3	Ghlin	Travagliato	1371	Truck	24,00	0,34	466,14
4	Gattatico	Amiens	1321	Truck	24,00	0,34	449,14
5	Ghlin	Monterotondo	1651	Truck	24,00	0,34	561,34
		TOTAL					2389,52

As a result of the Comparison of Road solution scenarios (Table 19), it is evident that the usage of HVO fuel reduces CO_2 emissions by 79% in average.

Table 19 - Comparison of Road solution scenarios

	Road Solution scenario - Diesel	**Road Solution scenario – HVO**	
№	kg CO2e (Scope 3)	kg CO2e (Scope 3)	CO2 reduction with Road Solution -HVO
1	2380,44	487,56	80%
2	2026,62	425,34	79%
3	2193,60	466,14	79%
4	2206,07	449,14	80%
5	2724,15	561,34	79%
TOTAL	11530,88	2389,52	79%

MULTIMODAL SOLUTION SCENARIO - DIESEL

Table 20 - Multimodal solution scenario - Diesel

№	**Routes**		**km**	**Vehicle**	**kg CO2e/km**	**kg CO2e (Scope 3)**
1	**Novi Ligure**	**Tilbury**	**1434**			**672,13**
	Nove Ligure	Busto	127	Truck	1,73	219,71
	Busto	Zeebrugge	1011	Train	0,34	343,74
	Zeebrugge	Tilbury	294	Vessel	0,36	105,84
	Tilbury	Tilbury	2	Truck	1,42	2,84
2	**Ghlin**	**Casalpusterlengo**	**1251**			**652,3**
	Ghlin	Gent	90	Truck	1,76	158,4
	Gent	Piadena	1087	Train	0,34	369,58
	Piadena	Casalpusterlengo	74	Truck	1,68	124,32
3	**Ghlin**	**Tribiano - Travagliato**	**1371**			**819,76**

	Ghlin	Gent	90	Truck	1,67	150,3
	Gent	Piadena	1087	Train	0,34	369,58
	Piadena	Tribiano	116	Truck	1,53	177,48
	Tribiano	Travagliato	80	Truck	1,53	122,4
4	**Gattatico**	**Amiens**	**1321**			**771,56**
	Gattatico	Piadena	46	Truck	1,75	80,5
	Piadena	Gent	1087	Train	0,34	369,58
	Gent	Amiens	188	Truck	1,71	321,48
5	**Ghlin**	**Monterotondo**	**1651**			**1316,2**
	Ghlin	Gent	90	Truck	1,67	150,3
	Gent	Piadena	1087	Train	0,34	369,58
	Piadena	Monterotondo	474	Truck	1,68	796,32
		TOTAL				**4231,95**

MULTIMODAL SOLUTION SCENARIO – GREEN HVO FUEL

Table 21 - Multimodal solution scenario – Green HVO Fuel

№	Route		km	Vehicle	kg CO2e/km	kg CO2e (Scope 3)
1	**Novi Ligure**	**Tilbury**	**1434**			**493,44**
	Nove Ligure	Busto	127	Truck	0,34	43,18
	Busto	Zeebrugge	1011	Train	0,34	343,74
	Zeebrugge	Tilbury	294	Vessel	0,36	105,84
	Tilbury	Tilbury	2	Truck	0,34	0,68
2	**Ghlin**	**Casalpusterlengo**	**1251**			**425,34**
	Ghlin	Gent	90	Truck	0,34	30,6
	Gent	Piadena	1087	Train	0,34	369,58
	Piadena	Casalpusterlengo	74	Truck	0,34	25,16
3	**Ghlin**	**Tribiano - Travagliato**	**1371**			**460,94**
	Ghlin	Gent	90	Truck	0,34	30,6

	Gent	Piadena	1087	Train	0,34	369,58
	Piadena	Tribiano	116	Truck	0,31	35,96
	Tribiano	Travagliato	80	Truck	0,31	24,8
4	**Gattatico**	**Amiens**	**1321**			**449,14**
	Gattatico	Piadena	46	Truck	0,34	15,64
	Piadena	Gent	1087	Train	0,34	369,58
	Gent	Amiens	188	Truck	0,34	63,92
5	**Ghlin**	**Monterotondo**	**1651**			**561,34**
	Ghlin	Gent	90	Truck	0,34	30,6
	Gent	Piadena	1087	Train	0,34	369,58
	Piadena	Monterotondo	474	Truck	0,34	161,16
		TOTAL	**7028**			**2390,2**

As a result of the Comparison of Multimodal solution scenarios (Table 22), it is evident that the usage of HVO fuel reduces CO2 emissions by 44% in average. As we can see the influence of HVO is bigger for Road Solution than for Multimodal Solution, since we apply alternative green fuel for truck only.

Table 22 - Multimodal solution scenario – Comparison Multimodal of solution scenarios

	Multimodal Solution scenario - Diesel	**Multimodal Solution scenario - HVO**	
№	kg CO2e (Scope 3)	kg CO2e (Scope 3)	CO2 reduction with Multimodal Solution -HVO
1	672,13	493,44	27%
2	652,3	425,34	35%
3	819,76	460,94	44%
4	771,56	449,14	42%
5	1316,2	561,34	57%
TOTAL	4231,95	2390,2	44%

As a result of the Comparison of all solution scenarios (Table 23), it is evident that the usage of Multimodal Solutions has the lowest CO2 emissions in average. The Second Best solution according to the GreenRouter is the Road Solution with HVO fuel (Figure 34).

Table 23 - Comparison of all solution scenarios

	Road Solution scenario - Diesel	Road Solution scenario – HVO	Multimodal Solution scenario - Diesel	Multimodal Solution scenario - HVO
№	kg CO2e (Scope 3)	kg CO2e (Scope 3)	kg CO2e (Scope 3)	kg CO2e (Scope 3)
1	2380,44	487,56	672,13	493,44
2	2026,62	425,34	652,3	425,34
3	2193,6	466,14	819,76	460,94
4	2206,07	449,14	771,56	449,14
5	2724,15	561,34	1316,2	561,34
TOTAL	**11530,88**	**2389,52**	**4231,95**	**2390,2**

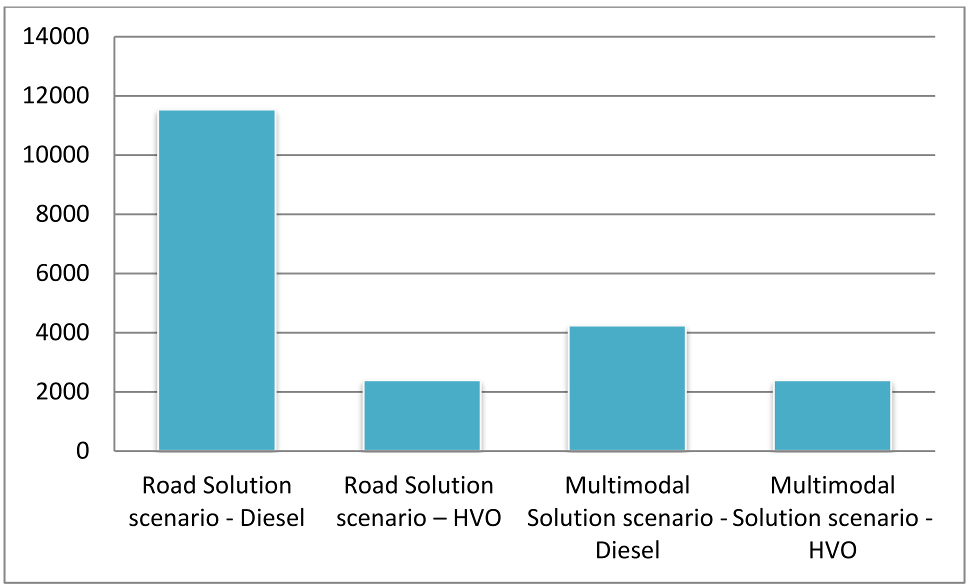


Figure 34 - Comparison of all solution scenarios

3.5 FINAL COMPARISON OF METHODOLOGIES

As it was mentioned in previous chapters, GLEC Framework currently precludes the consideration of alternative fuel utilization (as in our example: Green HVO fuel). Therefore, the calculations of the relative scenarios: Road Solution-HVO and Multimodal Solution-HVO were conducted only by GreenRouter methodology.

According to the final comparison of all the scenarios calculated by 2 different methodologies, we can see that the results of the 2 methodologies differ significantly (Table 24).

Table 24 - Comparison of all solution scenarios

	Road Solution scenario - Diesel GreenRouter	Road Solution scenario - Diesel GLEC	Road Solution scenario – HVO GreenRouter	Multimodal Solution scenario - Diesel GreenRouter	Multimodal Solution scenario - Diesel GLEC	Multimodal Solution scenario - HVO GreenRouter
№	kg CO2e	kg CO2e	kg CO2e	kg CO2e	kg CO2e	kg CO2e
1	2380,44	7296,192	487,56	672,13	1090,872	493,44
2	2026,62	6365,088	425,34	652,3	1225,752	425,34
3	2193,6	6975,648	466,14	819,76	1570,872	460,94
4	2206,07	6721,248	449,14	771,56	1581,912	449,14
5	2724,15	8400,288	561,34	1316,2	3260,952	561,34
TOTAL	**11530,88**	**35758,464**	**2389,52**	**4231,95**	**8730,36**	**2390,2**

But, at the same time, both frameworks are keeping the influence of Multimodal Solutions usage on the reduction of CO_2 emissions (in comparison with the Road solution) at the similar percentage (Table 25). The average influence of Multimodal Solutions for GreenRouter methodology is 64%. When the results for GLEC methodology are 76%. The Discrepancy in the Methodologies' results doesn't exceed 14%, having 12% as average discrepancy.

Therefore, we can conclude that both methodologies show high effectiveness of Multimodal Solutions and Green fuels for the reduction of CO_2 emissions.

Table 25 – Usage of Multimodal Solution on the reduction of CO_2 emissions in comparison with the Road solutions

	GreenRouter CO2 reduction with Multimodal Solution	GLEC CO2 reduction with Multimodal Solution	Discrepancy in the results
	72%	**85%**	**13%**
	68%	**81%**	**13%**
	63%	**77%**	**14%**
	65%	**76%**	**11%**
	52%	**61%**	**9%**
Average	**64%**	**76%**	**12%**

The significant differences between the values obtained using the GLEC methodology and the GreenRouter calculations highlight the complexity and variability inherent in estimating carbon emissions in logistics and transport.

The GreenRouter platform does not allow us to track the entire path of the calculations performed, so we cannot be sure what specific data or formulas influenced the result obtained and, consequently, the final difference in the calculations of the two methodologies.

It is possible to assume the following reasons in the data: methodological differences, differences in the level of detail, different data sources.

The GLEC methodology and CO2 GreenRouter calculations likely use different approaches and formulas to calculate the carbon emissions estimate. CO2 GreenRouter calculations can use proprietary algorithms or specific data sets.

Discrepancies may also arise from differences in the scale and detail of the emissions considered. The GreenRouter methodology can highlight specific aspects of emissions related to route efficiency or modes of transport.

Changes in data sources, input parameters, and underlying assumptions may also contribute to differences in emissions estimates. Differences in the quality, reliability, and currency of the data used by GLEC and GreenRouter may result in different results.

In conclusion, while the differences in the values obtained using the GLEC methodology and CO2 GreenRouter calculations may seem significant, they highlight the complexity and nuances associated with measuring carbon emissions in logistics and transport.

3.6 COST COMPARISON

Costs related to the Truck trip in Italy are calculated based on the average cost of all the main Italian traction drivers. All the drivers have at the base the minimum cost up to a certain amount of kilometers. All the exceeding kilometrage has an agreed rate of a cost per kilometer (Table 26).

Table 26 - List of agreed costs and their average

	MINIMUM COST	KM AMOUNT FREE OF EXTRA COSTS	€/KM MIN	EXTRA COST PEPR KM
1	€ 600	300,00	2,00	1,28
2	€ 600	400,00	1,50	1,20
3	€ 570	350,00	1,63	1,30
4	€ 560	350,00	1,60	1,25
5	€ 530	350,00	1,51	1,25
AVERAGE	€ 572	350,00	1,65	1,26

The Cost for Truck (Diesel) trip in Italy can be defined based on the average cost. Costs related to the Belgium, UK and France are defined fully on the separate agreements results of which are mentioned exclusively for the each destination on the table below (Table 27)

Table 27 - Multimodal solution scenario – Comparison of Costs for Diesel and HVO fuels

№	Routes		Tons	km	Vehicle	Costs, Euro (Diesel)	Costs, Euro (HVO)	Total Cost difference, %
1	**Novi Ligure**	**Tilbury**	**24**	**1434**		**1928**	**1970**	**2,11%**
	Nove Ligure	Busto	24	127	Truck	572	599	
	Busto	Zeebrugge	24	1011	Train	748	748	
	Zeebrugge	Tilbury	24	294	Vessel	315	315	
	Tilbury	Tilbury	24	2	Truck	293	307	
2	**Ghlin**	**Casalpusterlengo**	**24**	**1251**		**1612**	**1654**	**2,53%**
	Ghlin	Gent	24	90	Truck	300	314	
	Gent	Piadena	24	1087	Train	740	740	
	Piadena	Casalpusterlengo	24	74	Truck	572	599	

3	**Ghlin**	**Tribiano - Travagliato**	**24**	**1371**		**1612**	**1654**	**2,53%**
	Ghlin	Gent	24	90	Truck	300	314	
	Gent	Piadena	24	1087	Train	740	740	
	Piadena	Tribiano	24	116	Truck	572	599	
	Tribiano	Travagliato	24	80	Truck			
4	**Gattatico**	**Amiens**	**24**	**1321**		**1662**	**1706**	**2,59%**
	Gattatico	Piadena	24	46	Truck	572	599	
	Piadena	Gent	24	1087	Train	740	740	
	Gent	Amiens	24	188	Truck	350	367	
5	**Ghlin**	**Monterotondo**	**24**	**1651**		**1768**	**1817**	**2,72%**
	Ghlin	Gent	24	90	Truck	300	314	
	Gent	Piadena	24	1087	Train	740	740	
	Piadena	Monterotondo	24	474	Truck	728	763	
		TOTAL		**7028**		**8582**	**8801**	**2,49%**

The costs of train and vessel transportation are also stated as agreed with the relative companies.

Taking in consideration that Fuel typically accounts for 30-40% of the cost of a truck-mile we can calculate the effect of HVO fuel usage in comparison to Diesel fuel usage (Table 28)[39].

Table 28. The difference in the fuel costs per liter

DIESEL PRICE, €/l	1,9
HVO PRICE, €/l	2,25
DIFFERENCE, %	0,16

The difference in the cost related to the usage of HVO fuel was applies to the 30 % of the full truck trip to reflect the increase of the Fuel related cost part.[40]

According to the final results the HVO usage increases the total price of the Multimodal solution scenario trip in average on 2,49%.

[39] *Fuel costs // URL. https://www.paragonrouting.com/en-us/blog/post/rising-diesel-fuel-prices-make-manual-routing-and-scheduling-pricey-choice/*

[40] *HVO Fuel Price // URL. https://lubiq.uk/hvo-fuel-price-per-litre-uk/#:~:text=Fortunately%2C%20we%20can%20both%20deliver,VAT%20per%20litre%20at%20present.*

Table 29 - Road solution scenario – Comparison of Costs for Disel and HVO fuels

№	Routes		km	Vehicle	Costs, Euros (Diesel)	Costs, Euros (HVO)	Total Cost difference,%
1	Nove Ligure	Tilbury	1434	Truck	4500	4716	4,58%
2	Ghlin	Casalpusterlengo	1251	Truck	1325	1389	4,58%
3	Ghlin	Travagliato	1371	Truck	1325	1389	4,58%
4	Gattatico	Amiens	1321	Truck	2000	2096	4,58%
5	Ghlin	Monterotondo	1651	Truck	2100	2201	4,58%
		TOTAL			11250	11790	4,58%

The costs for the road solution scenarios mentioned in the Table 29 are agreed based on external traction drivers offers.

Table 30 - Multimodal solution scenario – Comparison of Costs for Disel and HVO fuels

			Road Solution		Multimodal Solution	
№	**Routes**		**Costs, Euros (Diesel)**	**Costs, Euros (HVO)**	**Costs, Euros (Diesel)**	**Costs, Euros (HVO)**
1	Nove Ligure	Tilbury	4500	4716	1928	1969,52
2	Ghlin	Casalpusterlengo	1325	1388,6	1612	1653,856
3	Ghlin	Travagliato	1325	1388,6	1612	1653,856
4	Gattatico	Amiens	2000	2096	1662	1706,256
5	Ghlin	Monterotondo	2100	2200,8	1768	1817,344
		TOTAL	11250	11790	8582	8800,832

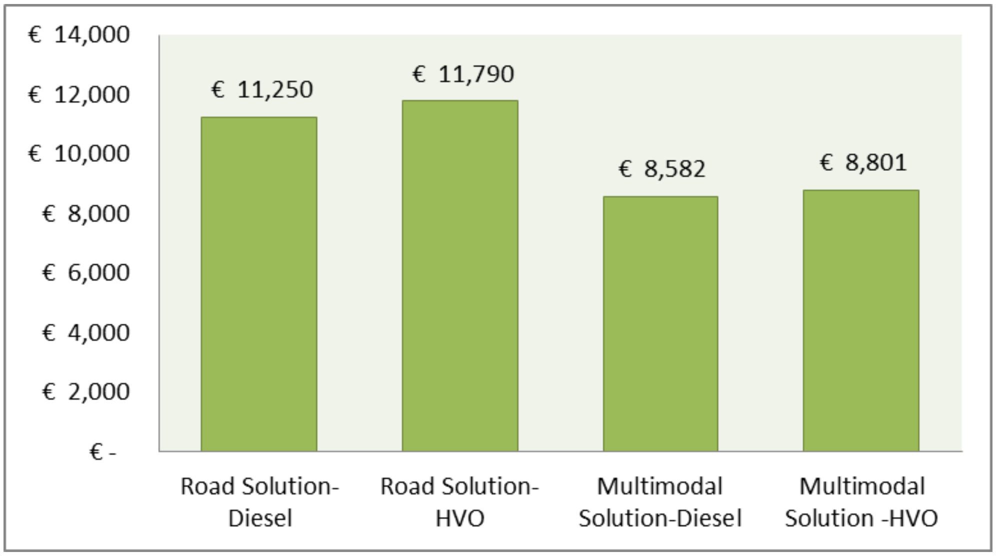


Figure 35 - Costs comparison

According to the final results of the all four scenarios comparison Table 30 we can see that the most costly scenario is Road Solution HVO and the less one is Multimodal solution Diesel. Multimodal solutions are in general cheaper because of the usage of other cheaper transport solutions (Figure 35).

According to the final results the HVO usage increases the total price of the Road solution scenario trip in average on 4,58%. Since in the following scenario the decrease in cost is applied for the full kilometrage of the whole trip, the percentage of the increase in price is significantly higher than in Multimodal solution scenario.

3.7 IMPLEMENTATION OF GREEN SCENARIOS IN MULTIMODAL AND ROAD SOLUTIONS IN WORLWIDE PRACTICE

Both multimodal and road-based transportation systems require significant investment in infrastructure. Governments and private entities need to prioritize **funding for green infrastructure projects**. Implementing policies such as carbon pricing, emission standards, and incentives for green technologies can encourage the adoption of sustainable transportation practices.

Continued **research and development** in transportation technologies are crucial for achieving significant reductions in CO2e emissions across both multimodal and road-based systems.

Ultimately, a combination of both multimodal and road-based transportation systems, along with supportive policies and technological advancements, will be necessary to effectively reduce CO2 consumption in transportation. Each approach has its strengths and can be optimized based on specific contexts and needs (Table 31).

Table 31 - Green scenarios in Multimodal solution and Road solution

Multimodal Solution	**Road Solution**
Implementation of green scenarios	
• **Intermodal Integration:** Integrating different modes of transportation such as trains, ships, trucks, and even bicycles can reduce overall emissions by optimizing routes and utilizing the strengths of each mode. • **Efficient Logistics:** Using a combination of transportation modes can optimize logistics, reducing the number of trips required and minimizing empty cargo space. • **Electrification:** Transitioning to electric vehicles across different modes can significantly reduce CO2e emissions, especially if the electricity comes from renewable sources.	• **Electric Vehicles (EVs)**: Shifting from conventional internal combustion engine vehicles to electric vehicles can substantially reduce CO2e emissions, particularly when the electricity used for charging comes from renewable sources. • **Efficient Routing:** Implementing smart routing technologies can help optimize road transportation, minimizing fuel consumption and emissions through more efficient routes. • **Vehicle Efficiency Standards**: Implementing stricter vehicle efficiency standards and promoting the use of hybrid vehicles can also contribute to reducing emissions in road transportation.
Advantages	
• Often more energy-efficient for long-distance transportation, especially for goods. • Can leverage the benefits of different modes, such as the efficiency of rail for long hauls and the flexibility of trucks for last-mile delivery. • Reduces congestion on roads, leading to lower emissions from idling vehicles.	• More flexible and accessible for many types of transportation needs, particularly for short distances and urban areas. • Can accommodate evolving technologies such as electric and autonomous vehicles, which are becoming increasingly efficient and environmentally friendly. • Direct infrastructure investments can be made to improve road efficiency and reduce emissions.

CONCLUSION

The climate agenda is constantly increasing pressure on all areas of modern society. In particular, a huge share of this tension falls on the area of logistics and supply. This is not at all surprising, since transport logistics activities have aggravated the carbon footprint problem due to the regular increase in demand for transportation.

To highlight key environmental issues, this paper specifically presents the current global trends in green supply chain development.

Green logistics are systems and methods used in the transportation and logistics industry to promote sustainable development, reduce greenhouse gas (GHG) emissions and provide environmentally friendly solutions to industry problems. Sustainable logistics is one of the most pressing topics facing retailers and carriers today.

This paper used two different methodologies to explore the benefits of current trends in green logistics. Their impact was tested on a model organization that is already taking advantage of sustainable practices in reducing emissions in transport logistics. CO2 emissions before and after the use of various environmental initiatives were calculated, as well as the costs of their implementation.

In addition, this work showed global experience in transport decarbonization and technical complexity in reducing CO2 emissions. This study summarized the international experience of climate strategies of companies engaged in long-distance logistics.

Beyond the current issues, further research is needed to test and quantify the assumptions and conclusions made. The work seeks to contribute to the understanding of why certain decarbonization practices are adopted by leading companies. Such research is needed to provide a framework for logistics companies that seek to develop future-proof green logistics systems.

SITOGRAPHY

[1] NASA, World Radiation Centre, Krivova, Global Carbon Project (GCP), Carbon Dioxide Information Analysis Center (CDIAC); Annual climate report of Roshydromet, 2021

[2] Consequences of climate change for international transport networks and adaptation to them / European UN Economic Commission, 2013 // URL. https://unece.org/fileadmin/DAM/trans/main/wp5/publications/climate_change_2014r.pdf

[3] ITF Transport Outlook 2021 / International Transport Forum, May 2021 // URL. https://www.itf-oecd.org/itf-transport-outlook-2021

[4] Average CO2 Emissions by Passenger and Freight Transport Mode / IEA, 2019 // URL: https://transportgeography.org/contents/chapter4/transportation-and-environment/co2-emissions-passenger-freight-transport-mode/

[5] Global Logistics Emissions Council Framework for Logistics Emissions Accounting and Reporting Version 2.0 / Smart Freight Centre, GLEG, 2019 // URL. https://www.feport.eu/images/downloads/glec-framework20.pdf

[6] Explanations by Industry (Logistics Industry) for the Basic Guidelines on Accounting for Greenhouse Gas Emissions Throughout the Supply Chain, Ver. 1.0 (Draft), Ministry of the Environment, Japan 2013

[7] Greenhouse Gas Protocol // URL. https://ghgprotocol.org/

[8] Electric Vehicles: Benefits, Challenges, and Potential Solutions for Widespread Adaptation // URL. https://www.mdpi.com/2076-3417/13/10/6016

[9] Different kinds of EVs // URL. https://www.ev-resource.com/ev-types.html#/

[10] Freight Transport and Logistics Masterplan, German Federal Ministry of Transport, Building and Urban Affairs, 2019 // URL. https://bmdv.bund.de/SharedDocs/EN/Documents/masterplan-freight-transport-and-logistics-publication.pdf?__blob=publicationFile

[11] Net-zero by 2050: Achieving shipping decarbonization through industry momentum and the new ambition at IMO// URL. https://unctad.org/news/transport-newsletter-article-no-108-net-zero-by-2050#:~:text=In%20July%2C%20Member%20States%20of,emissions%20by%20or%20around%202050.

[12] The opportunities, challenges, and the latest developments of electrification in the shipping industry // URL. https://platformzero.co/the-opportunities-challenges-and-the-latest-developments-of-electrification-in-the-shipping-industry/

[13] What are the Sustainable Fuel Alternatives for Logistics Operations? // URL. https://www.koganpage.com/logistics-supplychain-operations/what-are-the-sustainable-fuel-alternatives-for-logistics-operations

[14] Ambitious Corporate Climate Action / Science Based Targets // URL. https://sciencebasedtargets.org/

[15] Greenhouse Gas Protocol // URL. https://ghgprotocol.org/

[16] NTMCalc 4.0 - Network for Transport Measures // URL. https://ntmcalc-fb.transportmeasures.org

[17] Small business carbon calculator / Climate Impact Partners // URL. https://climatecare.org/calculator/

[18] LOG-NET Carbon Calculator // URL. http://sustainability.lognet.com/

[19] Climate change and P&C insurance: The threat and opportunity / McKinsey & Company, November 2020 // URL. https://www.mckinsey.com/industries/financialservices/our-insights/climate-change-and-p-and-cinsurance-the-threat-and-opportunity

[20] The database of fossil fuel divestment commitments made by institutions worldwide / Global Fossil Fuel Divestment // URL. https://divestmentdatabase.org

[21] Green finance conference, November 2019 // URL. https://www.mnb.hu/letoltes/07- cecile-moitry-bnp-paribas-slides.pdf

[22] Glasgow Financial Alliance for Net Zero (GFANZ) // URL. https://www.gfanzero.com/

[23] Green Bond Principles // URL. https://www.icmagroup.org/sustainable-finance/the-principles-guidelines-and-handbooks/green-bond-principles-gbp/

[24] European corporate governance institute, «ESG rating disagreement and stock returns», Cristensen, Serafeim, Sikochi «Why is Corporate Virtue in the Eye of The Beholder? The Case of ESG Ratings» 2021

[25] Science Based Targets // URL. https://sciencebasedtargets.org/

[26] CDP Global Supply Chain Report 2021 // URL . https://cdn.cdp.net/cdp-production/cms/reports/documents/000/006/106/original/CDP_SC_Report_2021.pdf

[27] Annual Sustainability Report Maersk 2021 calendar year

[28] The sustainability imperative /Nielsen Consumer LLC, October 2015 // URL. https://nielseniq.com/global/en/insights/analysis/2015/the -sustainability-imperative-2

[29] Cargo Owners for Zero Emission Vessels // URL. https://www.cozev.org

[30] International Maritime Organization (IMO), 2020 // URL. https://www.imo.org/en/MediaCentre/HotTopics/Pages/Sulphur-2020.aspx

[31] BP, Maersk Tankers successfully trial biofuel blend on ships, 2021 // URL. https://www.reuters.com/markets/commodities/bp-maersk-tankers-successfully-trial-biofuel-blend-ships-2021-12-17/

[32] Rotterdam Climate Agreement // URL. https://cdn.locomotive.works/sites/5ab410c8a2f42204838f797e/content_entry5ab410faa2f42204838f7990/5be174d6337f770010c1b69f/files/1.2.2_Rotterdam_Climate_Agreement_ENG.pdf

[33] IRENA (2021), International Renewable Energy Agency // URL. https://www.irena.org/Publications/2021/Oct/A-Pathway-to-Decarbonise-the-Shipping-Sector-by-2050

[34] TML official web-site // URL. https://www.tailormade-logistics.com/

[35] TML Sustainability Report // URL. https://www.tailormade-logistics.com/en/co2-neutral

[36] GLEC framework // URL. https://www.feport.eu/images/downloads/glec-framework-20.pdf

[37] CO2-Performance ladder// URL. https://www.co2emissiefactoren.be/

[38] GreenRouter portal // URL. https://www.greenrouter.it

[39] Fuel costs // URL. https://www.paragonrouting.com/en-us/blog/post/rising-diesel-fuel-prices-make-manual-routing-and-scheduling-pricey-choice/

[40] HVO Fuel Price // URL. https://lubiq.uk/hvo-fuel-price-per-litre-uk/#:~:text=Fortunately%2C%20we%20can%20both%20deliver,VAT%20per%20litre%20at%20present.