INNOVATIVE MANAGEMENT OF LOGISTIC PROCESSES IN THE CONTEXT OF REDUCING GREENHOUSE GAS EMISSIONS

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Abstract

The article compares approaches to managing logistic processes to reflect the need to reduce greenhouse gas emissions. The issue of climate change is a current global challenge. Not only industry but also human society has a significant effect on global warming, including logistic processes. Logistic processes, especially freight transport, produce significant amounts of greenhouse gas emissions (carbon dioxide, sulphur dioxide, nitrogen oxides, etc.). Companies are trying to find ways to reduce their greenhouse gas emissions to implement elements of sustainability into their daily operations. One of these ways is also the innovation of logistic process management with the use of emission calculators in everyday logistic planning and decision-making. The implementation of emission calculators when deciding on the choice of mode of transport and its parameters can lead to a reduction of greenhouse gas emissions. This article focuses on the design of an innovative approach to logistic planning and decision-making in the field of freight transport using the EcoTransIT emission calculator. The proposed innovative approach is tested and validated on a case study.

Key words: freight transport, emission calculator, well to wheel, transportation, carbon dioxide emissions

JEL Code: M10, L23, Q56

Introduction

Logistics and transport are among the most important fields in the national economy of most countries. With the growing needs of people, the demands on mobility and transport are also increasing and in the event of insufficient implementation of various measures, increase its negative effects on the environment which need to be reduced. Ways to reduce the negative effects of transport on the environment may also depend on the maturity of individual countries and their culture.

There are a bunch of problems dealing with freight transport. In recent years, logistic companies have been making efforts to rationalize freight transport services, in order to decrease the number of lorries in road traffic on one hand, but on the other hand to decrease the level of greenhouse gas emissions (GHG). At the same time, global environmental agreements seek to reduce CO_2 emissions not only from trucks and cars. Efforts to minimize negative impacts on the environment did not escape logistics either, and so the term "green logistics" or "sustainable logistics" was created. It is the implementation of logistic activities in ways that reduce the negative impacts of logistics on the environment. In the field ofreducing energy consumption and carbon emissions, logistics is one of the most important economic activities playing a key role in the development of low-carbon technologies. The evolving low-carbon economy is characterized by low emissions, low pollution, and low energy consumption, which has become a global consensus to achieve the sustainable development of the economy and human society. To develop a decision-making tool that will help reduce low-carbon emissions, it is extremely important to know how to measure the performance of logistic operations.

1 Theoretical Background

Logistics is an integral part of today's operation and is used in all industries. It contributes not only to the positive effects on society but also to the negative effects that affect not only the health of the population but also the environment. With the higher demands of the company are also increasing the requirements for logistics, where in recent years emphasis has been placed on improving its impact on the environment. Car manufacturers are among the major air pollutants in the world and their logistics need to be less harmful to the environment. Improvements are possible in many areas, e.g. alternative fuels, re-routing, better capacity utilization, eco-packaging or emissions tracking.

The number of studies dealing with environmental issues is gradually increasing. There is an impetus for organizations to become more environmentally conscious or green. Nageswara et al. (2019) stated that this environmental context has driven many organizations to invest in green technologies, with an emphasis on reducing GHG emissions. Marcucci et al. (2020) argue that planning is a function that recursively interlinks with piloting, deployment, and evaluation. Benjaar et al. (2013) adds that planning is very important for low-carbon transportation systems. Nageswara et al. (2019) stated that the environmental decision can be addressed by operational planning or vehicle type selection while considering carbon emissions from vehicles.

Transport has various impacts on the environment, such as resource consumption, land use, acidification, toxic effects on ecosystems and humans, noise, and GHG emissions (Borken-Kleefeld et al., 2003). Ahn et al. (2008) stated that due to congestion, motorists face a difficult trip-planning process when attempting to reduce delays and improve travel time reliability. This decision-making process is based on the drivers' urgency, experience, and current information on travel time, trip distance, and other trip-related factors. However, energy and environmental impacts are not typically utilized in drivers' decision-making process.

In practice, the performance of logistic systems highly depends on the effectiveness of key decision-making processes in logistic operations, which involve facility location and layout, logistic network planning, transportation scheduling, vehicle routing, and performance evaluation (He et al., 2017).

Ahn et al. (2008) argue that macroscopic emission estimation tools can draw erroneous conclusions because they ignore the transient behavior of a vehicle on a route. The findings suggest that emission-optimized and energy-optimized route assignment can significantly improve emissions over standard user balance and optimal system assignment formulations. He et al. (2017) stated that decision-makings in logistic enterprises depend largely on the operators' experience or simple computation because of the lack of basic data, the lack of effective decision-making methods and the insufficiency of qualified logistic professionals. He et al. (2017) argue that the poor decision-making performance in logistic operations largely lowers their daily operational performance, increase the wastes of human and material resources, and leads to higher energy consumptions and emissions. It is thus a significant barrier for developing low-carbon logistics.

He et al. (2017) stated that with increasing global warming and environmental degradation, green and low-carbon development models have been more widely accepted globally. The Paris Agreement appeals to all countries around the world for reducing GHG emissions (Shi et al., 2020). At the same time, global environmental agreements seek to reduce CO_2 emissions from both hauliers' and passenger cars (Taniguchi & Thompson, 2002). When it comes to energy consumption and carbon emissions, McKinnon (2010) emphasized that logistics as one of the most important economic activities play a crucial role in low-carbon development. Shi et al. (2020) nowadays claim that logistic companies, as profit-making enterprises, do not only consider improving service quality and reducing operating costs but also should take a certain corporate social responsibility for reducing GHG emissions.

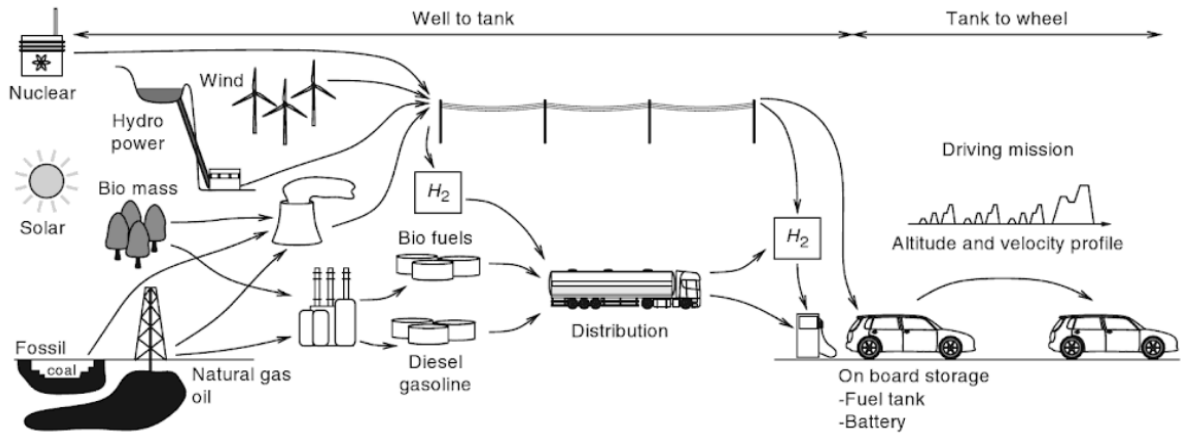
On the other side, He et al. (2017) stated that the developing low-carbon economy, characterized by low emission, low pollution, and low energy consumption, had become the consensus of the world to achieve sustainable development of the economy and human society. In addition to GHG emissions, improving logistics operation efficiency has also been a major concern of logistics companies (Shi et al., 2020). To develop a decision-making tool that will help in decreasing a low-carbon emission, it is of huge importance to know how to measure the performance of the logistics operations. Ahn et al. (2008) claim that the faster highway route choice is not always the best from an environmental and energy consumption perspective. The aim of this article is to design an innovative approach to logistic planning and decision-making in the field of freight transport using the EcoTransIT emission calculator.

2 Methodology

In this chapter, the proposed innovative approach to logistic planning and decision-making in the field of freight transport will be described.

Nowadays, there are three main approaches to GHG emissions calculations: Well-to-Wheel (WtW), Well-to-Tank (WtT), and Tank-to-Wheel (TtW). The visualization of approaches to GHG emission calculations is presented in Fig. 1. The WtW (the sum of WtT and TtW) approach is based on the monitoring of energy consumption and associated emissions production that covers the whole process from the generation of electricity or fuel through the supply to the appropriate transport means through the distribution network to the consumption associated with the operation of the means of transport (Eriksson & Nielsen, 2014).

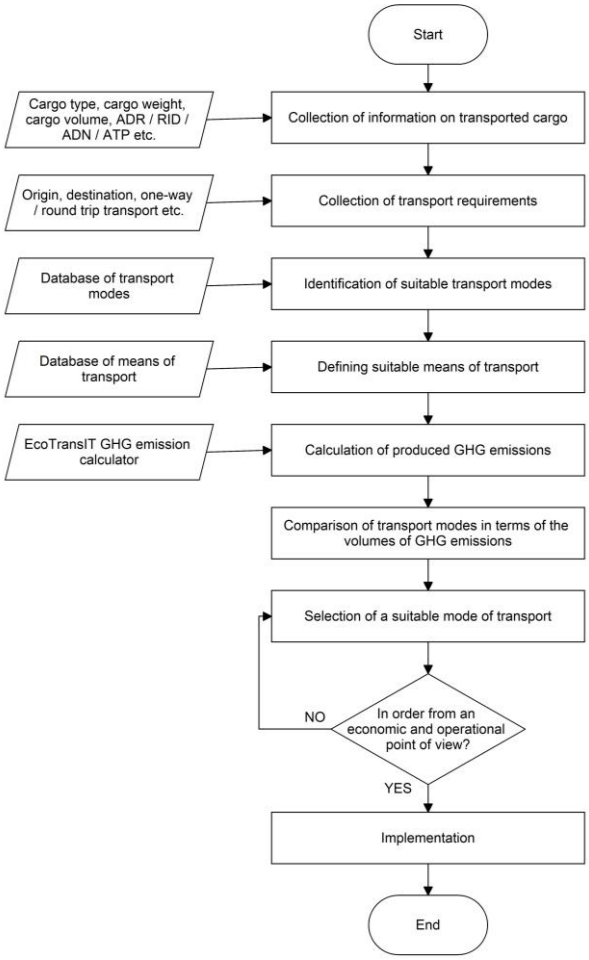
Fig. 1: The visualization of approaches to GHG emissions calculations



Source: Eriksson & Nielsen (2014)

The WtT approach is based on the energy consumption and production of emissions related to the production of energy or fuel. The indicator covers all activities from the extraction of raw materials through the production of energy or fuel, up to the supply to the respective means of transport through the distribution network; the indicator does not include the transport mode (Eriksson & Nielsen, 2014). The TtW approach is based on the energy consumption and production of emissions related to the operation of the means of transport; the indicator does not include the next life cycle of the fuel or transport means (Eriksson & Nielsen, 2014). The correct procedure is based on the calculation of GHG emissions using the WtW approach because these are the total GHG emissions including the whole process. The proposed innovative approach to logistic planning and decision-making in the field of freight transport using the EcoTransIT emission calculator is presented in Fig. 2.

Fig. 2: The proposed innovative approach to logistic planning and decision-making



Source: authors

This innovative approach is not a standard part of the decision-making process in companies and it can be used in the case of choosing a transport mode and means

of transport with lower negative environmental impacts in terms of the volume of GHG emissions produced, as well as in selecting a supplier or locating a warehouse, logistic or distribution center.

In the first step it is necessary to collect all information about the transported cargo, e.g. type of cargo, weight of cargo, volume of cargo, specifics of cargo (dangerous goods – ADR (Accord européen relatif au transport international des marchandises Dangereuses par Route); RID (Règlement concernant le transport international ferroviaire des marchandises dangereuses); ADN (European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways) mode; perishable goods – ATP (Agreement on the International Carriage of Perishable Foodstuffs and on the Special Equipment to be used for such Carriage) mode, etc.). In the second step, transport requirements are collected, e.g. origin, destination, one-way or round trip transport (empty trip factor) etc. Based on the information from the first and second step, potential and suitable transport modes for transporting the given cargo are identified and defined in the third and fourth step. In the fifth step, GHG emissions are calculated for each potential and suitable mode of transport and means of transport. In the sixth step, the transport modes and means of transport are compared in terms of the volume of GHG emissions produced. In the seventh step, a suitable mode of transport and means of transport is selected in terms of the volume of GHG emissions produced. At the same time, a check is made as to whether the solution is in accordance with the economic and operational aspects. If so, the solution is implemented. If not, it is necessary to select another mode of transport or another means of transport.

The proposed innovative approach to logistic planning and decision-making in the field of freight transport using the EcoTransIT emission calculator will be presented in the form of a case study. The case study is the method of qualitative research based on the study of one or a small amount of situations for application of the findings for similar cases according to Nielsen, Mitchell & Nørreklit (2015).

3 Results and Discussion

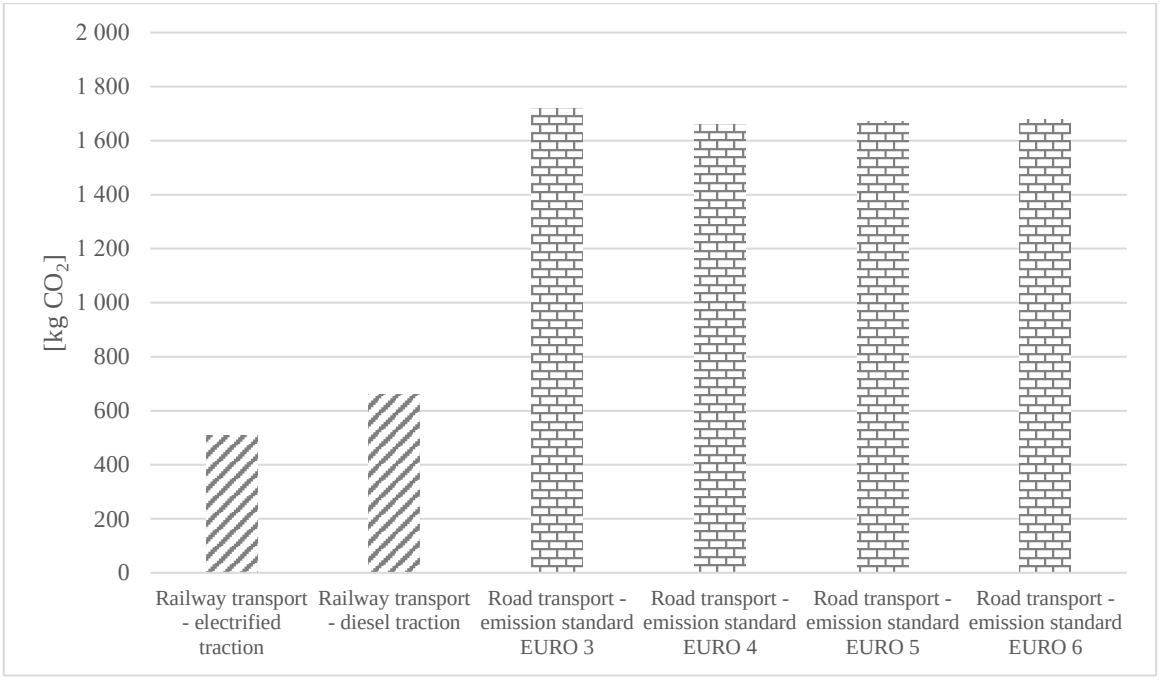
The proposed innovative approach to logistic planning and decision-making in the field of freight transport was tested and validated on a case study[1] with the following parameters: cargo transport (plastic semi-finished products), cargo weight 24,000 kg, cargo volume 90 cm^3, origin: Prague (Czech Republic), destination: Gent (Belgium), distance: 938 km for

[1] The case study was tested and validated for a specific transport requirement in a real company providing logistic services in the field of freight transport in the Pardubice region. The functionality of the proposed approach was also confirmed on the basis of feedback from the company's employees from the transport planning department.

road freight transport and 1,097.50 km for railway freight transport, one-way transport (empty trip factor 20 % for road freight transport, 50 % for railway freight transport).

The comparison of suitable transport modes and means of transport in terms of carbon dioxide emissions (CO_2) is presented in Fig. 3. Rail freight transport (electric traction and diesel traction), road freight transport (means of transport with emission standard EURO 3-6) were compared. The comparison shows that the production of CO_2 emissions is the lowest using rail freight transport (with the use of electric traction is the produced volume of CO_2 emissions 510 kg and in the case of diesel traction it is 660 kg). Road freight transport produces significantly higher CO_2 emissions. The use of road vehicles with different emission standards has a negligible effect on the volume of emissions produced because the difference between the emission standard EURO 4 and EURO 6 for a given transport is 20 kg of CO_2 produced. However, it is inappropriate to use the EURO 3 emission standard, where the CO_2 emissions produced are 2 to 4 percentage points higher.

Fig. 3: The comparison of suitable transport modes and means (WtW approach)



Source: authors based on EcoTransIT (2021)

The comparison of suitable transport modes and means of transport in terms of produced nitrogen oxides (NO_x) and sulphur dioxide (SO_2) emissions calculated by WtW approach is presented in Tab. 1.

The lowest volume of produced NO_x emissions in a given transport is with the use of rail freight electrified transport (total 0.70 kg NO_x). Significantly, higher values of this

indicator are achieved by rail freight diesel transport and road freight transport (emission standard EURO 3-5). The volumes of SO_2 emissions produced in a given transport are almost the same, with the lowest value being achieved by rail freight electrified transport.

Tab. 1: The comparison of suitable transport modes and means (WtW approach)

Specification	Transport mode					
	Railway		Road			
	Electrified	Diesel	EURO 3	EURO 4	EURO 5	EURO 6
NO_x [kg]	0.70	9.33	11.98	6.24	4.39	1.19
SO_2 [kg]	0.77	0.24	0.61	0.58	0.58	0.59

Source: authors based on EcoTransIT (2021)

Based on the results (Fig. 3, Tab. 1), it can be stated that the most environmentally responsible is the use of rail freight electrified transport, or rail freight diesel transport. Finally, it is necessary to check whether the resulting solution meets the economic and operational conditions and then implement it. In this case study, the proposed innovative approach to logistic planning and decision-making in the field of freight transport using the EcoTransIT emission calculator was tested and validated. It is an important innovative tool to support logistic planning and decision-making in the context of reducing the negative environmental impacts of logistic activities.

Conclusion

Logistics is a necessary part of business prosperity and contributes to a positive impact on society, as well as on the negative effects that affect not only the health of the population but also the environment. The environmental friendly decision can be addressed by operational planning (e.g. transport mode and vehicle type selection) while considering GHG emissions produced by transport. Nowadays claim that logistic companies, as profit-making enterprises, do not only consider improving service quality and reducing operating costs but also should take a certain corporate social responsibility for reducing GHG emissions and other negative impacts of its activities on the environment and human society.

Logistic planning and decision-making in the field of freight transport can use three main approaches to GHG emissions calculations, but WtW approach is the most correct because it includes total GHG emissions. The proposed innovative approach to logistic planning and decision-making in the field of freight transport can be used in the case of choosing a transport mode with lower negative environmental impacts in terms of the volume

of GHG emissions produced, as well as in selecting a supplier or locating a warehouse, logistic or distribution center. The case study showed that the use of rail freight electrified transport is the most environmentally friendly because of the lowest volume of produced CO_2 emissions and NO_x emissions in a given transport.

Owing to the fact that logistics is one of the most important economic activities, it is necessary to check whether the resulting solution meets the economic and operational conditions and then implement it. Of course, there is the potential for further improvement of logistic planning and decision-making and companies should focus on implementing an emission calculator into daily decision-making and planning activities, which is an important tool in the context of reducing the negative environmental impacts of logistic activities.

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