Assessment of the Impact of Automatic Parking on Emissions of Harmful Substances in the Green Logistic System

Chapter · May 2021

DOI: 10.1007/978-3-030-75275-0_89

5 authors, including:

Liubov Bovnegra
National Academy of Sciences of Ukraine
34 PUBLICATIONS **68** CITATIONS
SEE PROFILE

Olena Chukurna
State University of Intelligent Technologies and Communications
46 PUBLICATIONS **199** CITATIONS
SEE PROFILE

Vitalii Dobrovolskyi
9 PUBLICATIONS **17** CITATIONS
SEE PROFILE

ASSESSMENT OF THE IMPACT OF AUTOMATIC PARKING ON EMISSIONS OF HARMFUL SUBSTANCES IN THE GREEN LOGISTIC SYSTEM

Filyppova Svitlana [1], Bovnegra Liubov [2], Chukurna Olena[3], Vudvud Oleksandr [4], Dobrovolskyi Vitalii[5]

[1] (Doctor of Economics sciences, Professor, Director of the Institute of Business, Economics and Information Technology, **ORCID:** 0000-0003-2245-3599б *s.filyppova@gmail.com*)

[2](Candidate of technical sciences, Private professor , Head of Department information technology design in mechanical engineering, Odessa National Polytechnic University, **ORCID:** 0000-0003-0429-2816, *dlv5@ukr.net*)

[3](Doctor of Economics sciences, Professor of marketing department, Odessa National Polytechnic University, **ORCID:** 0000-0001-9285-7068, *elenachukurna@gmail.com)*

[4](Candidate of technical sciences, department of Lifting and Robotic Equipment Odessa National Polytechnic University, **ORCID:** 0000-0002-4807-3634, *o.m.vudvud@opu.ua*)

[5](Master of Logistics systems engineering, Odessa National Polytechnic University, **ORCID:** https://orcid.org/0000-0002-9388-9528, *dobrovit05@gmail.com*)

ABSTRACT:

The article is devoted to the current problem of "green" logistics - emissions of harmful substances in road transport. It was considered the main directions for reducing emissions related to both technical improvement of cars and administrative and organizational planning of traffic in cities. The article focuses on such an important aspect of planning activities related to the infrastructure of car operation as the installation of a car in a parking lot in large cities and their impact on the environment. Variants of constructions of automatic parkings are considered and their efficiency from the point of view of emissions of harmful substances was estimated.

Keywords: *green logistics, road transport, carbon emissions, automatic parkings, emissions of harmful substances*

---

1. INTRODUCTION

The global car fleet is constantly growing, so in 2015 it numbered 1.25 billion cars, and by 2050 could reach 2.5 billion, due to the globalization of the economy and significant displacement of people [1]. The main environmental problem of road transport is the high toxicity of exhaust gases. They contain more than 200 toxic components, including such biologically active ones as carbon monoxide, nitrogen oxides, hydrocarbons, aldehydes, lead compounds and many others. The problem of harmful substances is especially acute in large cities, where usually the highest density of cars, which in turn is exacerbated by extremely suboptimal modes of operation. To change the current state of

influence of road transport multiplied only by complex measures based on the principles of "green logistics", which includes environmentally friendly logistics technologies and measures [2]. In transport - is the use of environmentally friendly vehicles with electric, gas, hydrogen engines; use of ecological fuel; advanced training of drivers for the purpose of energy efficiency of driving; optimization of transportation routes, organization of traffic in cities, etc.

2. OTHER TOPICS

The methodological basis of the research is mainly composed of the works of foreign and domestic researchers in this field, the main of which are the following: A. McKinnon [3], J.-P. Rodrigue [4], D. Rogers [5], R. Tibben-Lembke [5], L. Janbo [6], P. Murphy [7], etc.

A. MacKion interprets ecological logistics as follows: “Science and a set of measures that ensure the movement of material during any production process, up to its transformation into goods and production waste, with subsequent bringing the waste to disposal or to safe storage in the environment, as well as the collection and sorting of consumption wastes, their transportation, disposal or safe storage in the environment” [3].

J.-P. Rodrigue gives the following interpretation of green logistics: "Environmentally sound and efficient transport distribution system" [4]. In turn, D. Rogers and R. Tibben-Lembke understand green logistics as a set of actions to assess and minimize the environmental consequences of logistics activities [5]. L. Janbo reveals the content of ecological logistics as follows: “A system of planning, design and management using advanced logistics technologies and ecological design methods in the field of pollution reduction and resource consumption, dictated by ecological principles. The main goal is the coordination of logistics activities and the socio-environmental effect ” [6].

2.1. The title of Part chapter

Environmental friendliness of cars is mainly determined by their fuel-consumption characteristics, the less hydrocarbon fuel the car consumes, the less environmental damage is caused to the atmosphere by exhaust gases. In the case of equal distribution of fuel consumption, the most environmentally friendly car will be the one whose toxicity and emissions will be less. That is why there is currently a tendency to reduce the specific fuel consumption [8]. Fuel consumption and emissions of harmful substances into the atmosphere are measured on running drums (Fig. 1) according to a certain method. In these conditions, the features of the car in real time are completely ignored. However, there are a number of reasons that make testing impossible in real working conditions. First, the comparability of the results should not be affected by weather conditions, the condition of the road surface and other factors that may distort the result. Secondly, an important reason is the collection of exhaust gases for analysis. Collecting them in real car conditions is a difficult and costly process. This is the reason that the tests are carried out on treadmills, simulating real road conditions.

Today, the world's most common three methods for determining fuel consumption: the European NEDC, American FTP-75 and Japanese JC 08. They differ in many respects. The longest and fastest - American. The Japanese have the lowest average speed - only

24.4 km / h. This is due to the imitation of significant downtime at traffic lights. Europe's most sluggish - the maximum acceleration does not exceed 0.83 m / s2. But they also have one thing in common: all three techniques are far from the real cycle of the car, so car companies have learned to adapt to them.

Fig.1. A running drum on which carbon footprint measurements are made

The following technical measures are used to reduce emissions of harmful substances: improvement of mixture formation and neutralization of exhaust gases; application of fundamentally new engine designs; improving fuel quality and adding additives; use of environmentally friendly fuels; reducing the weight of the car and improving its aerodynamics forms; use of alternative energy sources [9,10,11].

There is indeed a big problem with CO2 emissions in the automotive sector. The European Union sets out its own rules and conditions, which must be followed by all car companies, in order to reduce emissions. Also, with the help of the data presented in the tables and graphs, we can see how more economical and environmentally friendly is automatic parking.

It definitely saves a lot of time, the driver only needs to put his car on the element of automatic parking and that's it. The autopilot loses to automatic parking in the sense that in modern city conditions it will feel quite uncomfortable. The quality of the road surface is not always optimized for free parking lots, many drivers leave their car just on the sidewalk or on public transport lanes. In terms of environmental automatic parking also has an absolute advantage over other options.

This is due to the fact that falling into the grip of automatic parking, the car stops and no longer requires any action related to the engine. The autopilot will have a large CO2 emission due to poor optimization of parking spaces in the city.

Automatic parking lots such as "Tower" and "Shuttle" will be evaluated in the work. In general, there are many of them, but these 2 are the so-called "basic", because all other modernized and modified parking lots are based on the principle of operation, as in one of these. Below is a histogram and report table of the plane for each type of parking. All dimensions were calculated on the basis of official parking documents.

The decision was made to calculate the plane for 1 and 12 cars. The number 12 was taken because many automatic car parks have racks for cars multiples of the number 12 (for example, "Tauri" and several subspecies of "Shuttle"). Also for comparison the plane at usual parking on usual parking will be calculated.

Calculation of the plane for ordinary parking:

– 16.8 m2 requires a distance to park 1 car, plus we take into account the driveways and columns of 79 m2. Together with passages for 12 cars, we get 291.6 m2 of the required area for cars.

Calculation of the plane for automatic parking of the Tower type:

– 12.19 m2 requires a distance to park 1 car, plus we take into account the lift of 16 m2. Together with the lift for 12 cars we receive 162.28 m2 of the necessary plane for cars.

Calculation of the plane for automatic parking type "Shuttle":

– 12.88 m2 requires a distance to park 1 car, plus we take into account the travel of 83.8 m2. Together with passages for 12 cars we receive 240.4 m2 of the necessary plane for cars.

Summary data presented in the Fig. 2 and table. 1.

Table 1. Calculation of the plane for different types of parking [*developed by the authors*].

	For 1 car	Additional plane	A total of 12 cars
Calculation of the plane for ordinary parking	16,80	79	291,6
Calculation of the plane for parking "Tower"	12,19	16	162,28
Calculation of the plane for the Shuttle car park	12,88	83,8	240,4

After analyzing the data, we can conclude that automatic parking has a number of advantages over conventional parking, including a large advantage in the plane, it allows us to make parking more compact and convenient than conventional parking. Of the three options, the best is the automatic parking type "Tower", as it occupies a smaller area, this is due to its design, as its lift does not take up much space and does not require additional mechanisms (such as the same "Shuttle")

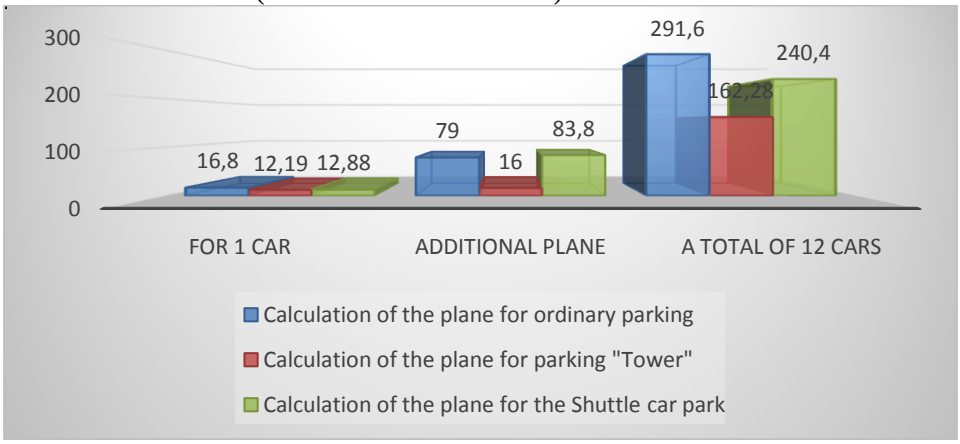

Fig.2. Summary histogram of planes [*developed by the authors*].

In the course of the research it was proved that parking cars in automatic parking lots helps to reduce carbon emissions. The results of assessing the degree of impact on the amount of carbon emissions by different modes of transport in different states, including parking are presented in Fig.3.

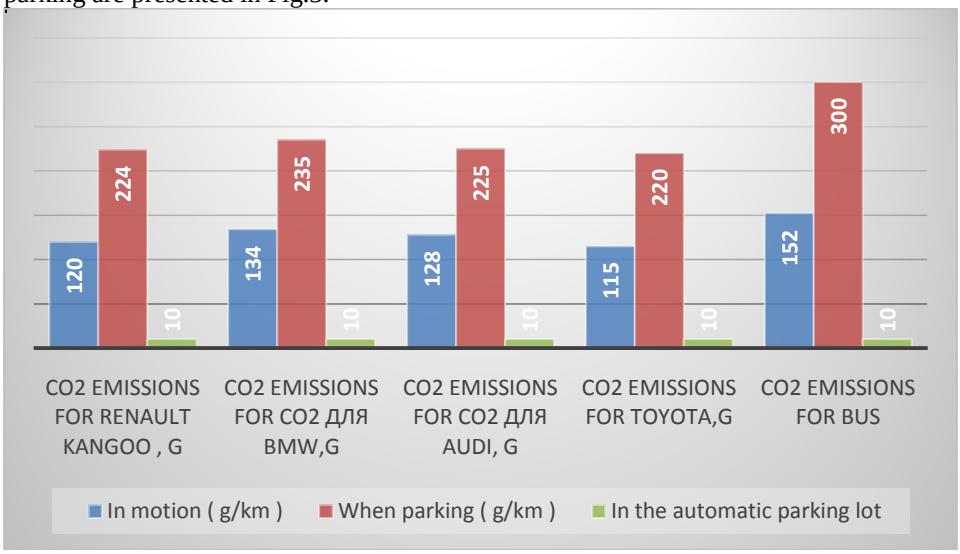

Fig.3 . Graph of total CO_2 emissions for the assessed cars [*developed by the authors*].

It should be noted that even the introduction of such environmentally friendly vehicles as electric cars is actually still quite far from environmentally friendly as the production and disposal of their batteries is harmful to the environment. Battery life is not long, which in turn exacerbates the situation. Only at emergence of qualitatively new types of accumulation of electric energy it is possible electric cars will become ecologically safe and will displace vehicles with other types of power plants.

The process of transition to "environmentally friendly" vehicles is quite inert and cars of old designs will work next to them for a long time, so in addition to the introduction of the latest technical measures and re-equipment of the car fleet, attention should be paid to administrative measures. Regulation itself is an important factor in "green" logistics.

The administrative and organizational measures for transport include:

- development of the city road network;
- improving the organization of traffic in order to reduce and, if possible, eliminate congestion on city streets;
- withdrawal of transit transport from the city, by reconstruction of bypass highways;
- introduction of underground and above-ground parking lots, especially automatic ones, which will allow unloading the streets from parked cars and increase the capacity of city roads;
- transition to service of the population of the city by buses of average and bigger capacity with modern economic engines, development of city electric transport (trolleybuses, trams).

Problems with car storage, which affect the environment and the general state of urban life are very acute. According to statistics, up to 95% of their time each car spends in the parking lot. But in recent years in large cities there is an acute shortage of parking spaces, especially in areas of large crowds - shopping malls, markets, airports, train stations, stadiums. The lack of free spaces for parking has led to the creation of automated parking systems, which are designed to ensure efficient use of space for storing vehicles at a high-tech level [10, 11, 12, 13,14, 15].

Multi-level automatic parking lots, give the following advantages:

– high density of parking, saving of the area on 35-50% more than at usual parking, and an opportunity to eliminate the spontaneous parkings interfering with traffic and creating traffic jams especially in areas with high density of building;

– time saving - parking or issuance for 50-90 seconds;

– low level of energy consumption. Which in turn also has a positive effect on reducing emissions - 1 cycle (parking + delivery) - 1 kW;

– noiselessness - in our equipment the noise level is less than 30 dB (permissible standard noise level is 60 dB);

– environmental friendliness (without emissions and pollution, without gassiness), the car does not need to manoeuvre in cramped conditions, and its movement occurs by means of lifting mechanisms;

– some car parks have heating systems, which in turn minimizes "cold start" emissions.

There are many automatic parking lots, consider the typical ones, as others are derived from them. In multi-storey automatic car parks, parking / issuing of cars takes place in a fully automatic mode. The driver enters the car in the parking lot, turns off the engine, closes the car, puts it on the alarm, and leaves the parking lot, on the control panel of the parking system confirms his desire to put the car in the parking lot, the outer gate of the reception closes, then the equipment parking lot moves the car to the storage room of the parking lot, delivering it to the desired storage cell. According to the type of movement system used, automatic parking systems are divided into:

– pallet (system of moving the car on a special pallet (pallet);

– pallet exchange system (more advanced pallet system) to eliminate the disadvantage of the pallet system - increase the waiting time due to the need to return the pallet (pallet) in place during the mass delivery of cars;

– pallet less systems, which today are represented by several solutions that allow you to move the car without the use of pallets (capture the wheels of the car by a mechanism such as "scissors", fixed lattice system, lattice system with sliding grip etc.). These systems are free from the lack of pallet systems on the need to return the pallet in place, have the highest speed of turnover of the car in the parking lot. In addition, due to the possibility of correcting the location of the car relative to the central axis, reduce the width of the parking space to 2300 mm, which is absolutely impossible when using pallet systems.

Multi-level automatic parking lots can be:

1. Tower type - the principle of operation is based on the movement of a high-speed lift in the tower, on both sides of which are parking spaces. One of the most compact parking lots - occupies an area of only 3 parking spaces (~ 50 m2), and the

number of parking spaces in it is limited only by the standard height of buildings in the area and can reach up to 70 cars. For example, hotels
The modern version of the tower type provides for the placement of a much larger number of parking spaces on one tier of storage. The overall dimensions of the building in length and width will change, depending on the local conditions of the parking lot, but the height of the parking lot can be taken any, which will not violate the requirements of current regulations, which limit it to 28 meters.

2. Conveyor, cassette type - the operation of the mechanisms of this system is similar to the principle of operation of the conveyor (horizontal displacement of pallets of the entire level), on both sides of which are lifts (vertical movement). This parking system is recommended for small and medium parking areas, especially for limited width. This horizontal-oriented solution can be underground, underground, aboveground, built-in, attached and detached.

3. Mixed type - the principle of operation is based on the operation of vertically moving lifts and horizontally moving robots - conveyors, which work at different levels simultaneously (special case). Ideal for medium and large parking areas.

3. CONCLUSION

The study allowed to identify areas for reducing emissions associated with both the technical improvement of cars and administrative and organizational planning of traffic in cities. Calculations on various variants of automatic parking designs are carried out and their efficiency from the point of view of emissions of harmful substances is estimated. The relationship between the type of parking and the amount of carbon emissions has been proven. Estimation of carbon emissions allowed us to conclude on the effectiveness of the use of automatic parking as a tool and technology that helps reduce carbon emissions in the green logistics system.

4. REFERENCES

[1] Valavanidis, Athanasios (2018). The Shift to Diesel Fuel Engines and How the Emission Scandal of Diesel Vehicles Unfolded. *World Energy Consumption of Transportation Sector*. 1. 1-26.
[2] Perkumienė D, Pranskūnienė R, Vienažindienė M, Grigienė J. (2020) The Right to A Clean Environment Considering Green Logistics and Sustainable Tourism. Int J *Environ Res Public Health*. 17(9): 254. URL:http:// *doi:10.3390/ijerph17093254*
[3] McKinnon A. (2010) Green Logistics: the Carbon Agenda. LogForum 6, 3, 1. URL: http://www.logforum.net/vol6/issue3/no1
[4] Rodrigue, Jean-Paul & Slack, Brian & Comtois, Claude. (2001). Green Logistics (The Paradoxes of). *The Handbook of Logistics and Supply-Chain Management*. London.: Pergamon. 339–350.
[5] Rogers, D., Tibben-Lembke, R. (2001). An examination of reverse logistics practices. *Journal of Business Logistics*. 22(2). 129–145.
[6] Janbo, L., Songxian, L. (2008). The Forms of Ecological Logistics and Its Relationship Under the Globalization. *Ecological Economy*. 4. 290–298.

[7] Murphy, P.R., Braunschweig, R.F., Charles, D. (1996). Green logistics: Comparative views of environmental progressives, moderates, and conservatives. *Journal of Business Logistics*. URL: findarticles.com.
[8] Gaponov V.L., Badalyan L. Kh., Kurdyukov V.N., Kurenkova T.N. (2008) Modern methods of reducing harmful emissions from exhaust gases from vehicles. *Technosphere safety technologies*. 6. 2-11.
[9] Puškár, M., Jahnátek, A., Kuric, I. et al. (2019). Complex analysis focused on influence of biodiesel and its mixture on regulated and unregulated emissions of motor vehicles with the aim to protect air quality and environment. *Air Qual Atmos Health* 12, 855–864 URL:https://doi.org/10.1007/s11869-019-00704-w
[10] A.M. Liaquat , M.A. Kalam, H.H. Masjuki, M.H. (2010) Jayed. Potential emissions reduction in road transport sector using biofuel in developing countries. *Atmospheric Environment*. 44. 32. 10. 3869-3877. URL:https://doi.org/10.1016/j.atmosenv.2010.07.003
[11] Guangmei Wu, Xianhao Xu, Xinyuan Lu (2020) Considering the influence of queue length on performance improvement for a new compact robotic automated parking system. *International Journal of Information Management*. 50. 2. 487-497 URL:https://doi.org/10.1016/j.ijinfomgt.2019.04.002
[12] URL:http://parkmatik.com.ua/content/111
[13] AJ Automated Parking Systems. URL:http://ajaps.co.kr/assets/AJ%20DONGYANG%20MENICS_CATALOGUE.pdf
[14] Pat US 8,632,290 B2 United States Patent. Automated parking system / Christopher Alan - Prior Publication Data US 2011 FO1827O3 A1 Jul. 28, 2011. 46
[15] Pat 2515668 C2 RF, IPC E04H 6/28. Automatic parking system / SALMENAHO Teemu. - 2011137860/03, 22.02.2010; publ. WO 2010/097507 (02.09.2010). - 15 p.

CORRESPONDANCE:

Filyppova Svetlana
D. Sc. Econom., Professor, Director of the Institute of Business, Economics and Information Technology,
Odessa, Ukraine
E-mail: s.filyppova@gmail.com

Bovnegra Lubov
Candidate of technical sciences, Private Professor,
Head of Department information technology design in mechanical engineering,
Odessa National Polytechnic University
Odessa, Ukraine
E-mail: dlv5@ukr.net

Chukurna Olena
D. Sc. Econom., Professor of marketing department
Odessa National Polytechnic University
Odessa, Ukraine
E-mail: elenachukurna@gmail.com

Vudvud Oleksandr
Candidate of technical sciences, department of Lifting and Robotic Equipment
Odessa National Polytechnic University,
Odessa, Ukraine
E-mail: o.m.vudvud@opu.ua

Dobrovolskyi Vitalii
Master of Logistics systems engineering,
Odessa National Polytechnic University
Odessa, Ukraine
E-mail: dobrovit05@gmail.com