CARBON DIOXIDE EMISSION STUDY FROM HEAVY – DUTY VEHICLES AT THE PORT OF VARNA

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Contents

List of figures:

List of tables:

Abbreviations:

CO_2	Carbon Dioxide
HDV	Heavy – duty vehicles
JSC	Joint-stock company
TEU	Used to describe the capacity of container ships and container terminals
GloMEEP	Global Maritime Energy Efficiency Partnerships
EURO	European emission standards of vehicles
TAS	Truck Assignment System
VRS	Vehicle Reservation System

1. Summary

The purpose of the report is to clarify the condition and load of heavy road traffic on the territory of the terminals of the Port of Varna and to calculate the emissions emitted by the CO_2 from the above-mentioned vehicles operating within the Port. The main characteristics and specific features of the Port of Varna are considered. The legal status and ownership have been clarified. Clarifications were made on the scope of the geographical territory of the port areas, a summary of the processed cargoes during the study period was made, an analysis and counting of the heavy – duty vehicles entering the port per day / month was performed, and the average kilometers traveled by the heavy vehicles in the port were calculated. For day / year, an inventory of CO_2 emissions was made separated from heavy – duty vehicles in the port. After conducting an analysis of the activities performed by the Port of Varna JSC and the forwarding companies operating on the territory of the terminals, good practices have been identified that help reduce traffic and harmful emissions, and those that are innovative or borrowed from other ports around the world.

2. Introduction

Pursuant to a contract with the Ministry of Transport and Information Technology and Communications, the Port of Varna JSC is a port operator of port public transport terminals of national importance Varna - East and Varna - West. The company "Port of Varna" JSC is a joint stock company with 100% state participation. Subject of activity is port activity and related commercial and technical services; forwarding, investment and engineering activities; research and development; training and qualification of staff; domestic and foreign trade. Port of Varna JSC handles all types of cargo, including containers, bulk, general and bulk. Serves merchant, passenger, cruise, research ships and yachts.

3. Determining the geographical boundaries of the terminals of the Port of Varna JSC

The port of Varna is a port on the Black Sea. It is located both on the Black Sea coast near Varna (Terminal "Varna East") and in the interior of Beloslav Lake in its westernmost part near Devnya (Terminal "Varna West"). Two terminals are located about 30 km from each other.

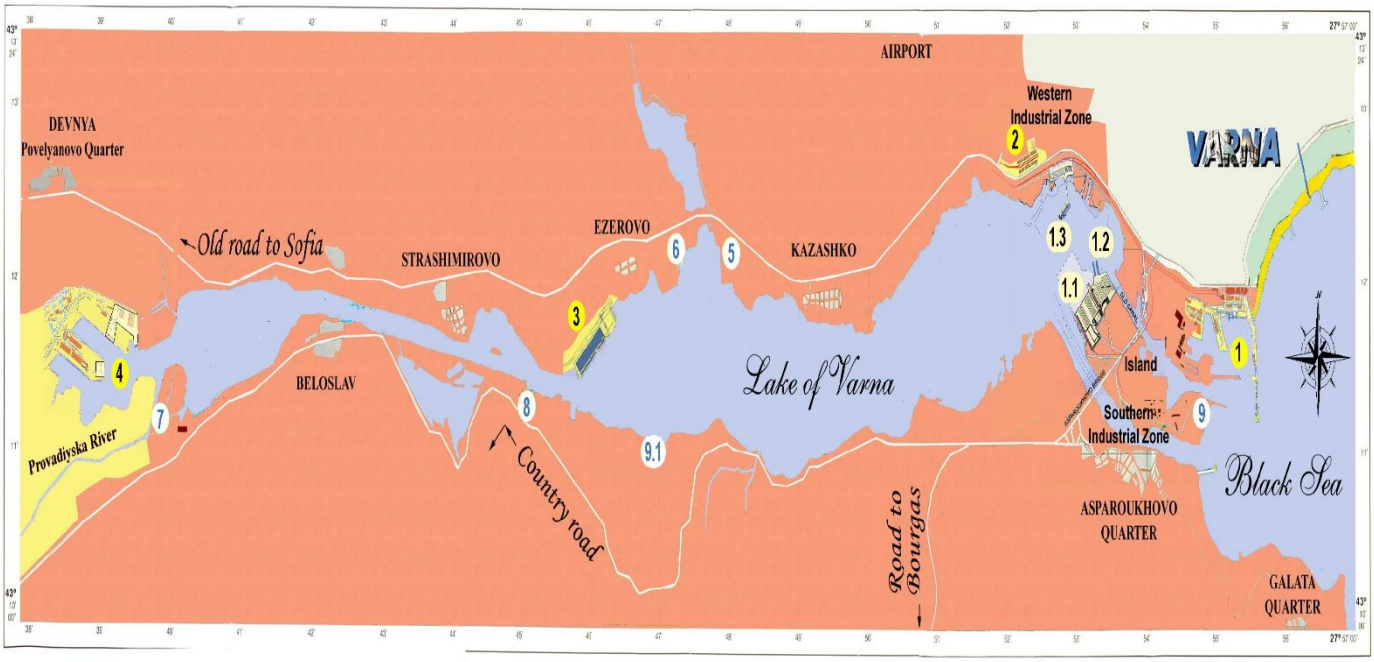

Fig. 1. Locations of the terminals of Port of Varna JSC.

1. Port terminal Varna – East;
2. Dry Port Warehouse;
4. Port terminal Varna – West.

The port of Varna-East is located in the Varna Bay, only 1 km from the center of Varna. The warehouse base is located around 5 kilometers from Port Varna-East, known as the „Dry Port". It is an isolated unit with a license for Customs bonded storage. The operations are carried out on an area of 15 decares. There are 6 covered warehouses that are used to store different types of grain and general cargo.

Fig. 2. Geographical boundaries of the Port Terminal Varna - East.

The port of Varna-West is the most modern and promising on the northern Bulgarian Black Sea coast. Its immediate proximity to the Devnya chemical plants allows efficient processing of goods under the direct plant-ship scheme. The port has modern technological lines for transshipment of soda, chemical fertilizers, cement, coal, ores, phosphorite, quartz sand and liquid chemicals.

Fig. 3. Geographical boundaries of the Port Terminal Varna - East.

For the purposes of the study, an inventory of the emissions of CO_2 and both terminals was made, and a detailed analysis of the average mileage, which is carried out by heavy – duty vehicles on the territory of the terminal.

4. Annual turnover of the cargoes of "Port of Varna" JSC.

On an annual basis, according to data for 2019, the cargoes that have passed and processed by the Port of Varna JSC are about 10 million tons, of which the terminal Varna - East has processed 3.6 million tons, and the terminal Varna - The West has handled 6.7 million tonnes, which is a good achievement for the scale of the terminals. In addition to what has been mentioned so far, again according to data for 2019, the port of Varna has processed over 193 thousand containers (TEU).

5. Survey period covered, number of heavy – duty vehicles passing through the port during the study period, kilometers traveled by heavy – duty vehicles in the territory of the port areas.

According to the GEF-UNDP-IMO GloMEEP Project and IAPH report, 2018: Port Emissions Toolkit, Guide No.1, Assessment of port emissions published by the Global Environment Facility (GEF), the United Nations Development Program (UNDP) and the International Maritime Organization (IMO), in order to be reliable and representative information on the implementation of inventory of harmful emissions, the study period should be within one year. According to the Methodological note, a time period of 6 months will be used to conduct the Joint Study provided by the lead partner of the SMOOTH PORTS project, Free and Hanseatic City of Hamburg, Ministry of Economy, Transport and Innovation. The team that developed the study decided to determine the amount of CO_2 emissions generated by heavy road traffic for a period of 8 months (February 1, 2020 - September 30, 2020), as the study period includes the restrictions imposed by the pandemic by COVID - 19 (for about two months), which greatly restricts the free movement of goods and cargo worldwide, thus it is believed that the initial requirements will be met.

The study covers all heavy – duty vehicles that meet the definition given by the European Commission: "heavy – duty vehicles are more than 3.5 tons (trucks) or passenger vehicles with more than 8 seats (buses)" that visited the terminals of "Port Varna JSC. The necessary basic information and the necessary basic data for conducting the study were obtained from the port operator Port of Varna JSC. In the course of the study, numerous field visits were made in order to study the specifics of the activities and processes necessary for their implementation. In addition, in order to gain a complete picture and the information obtained to be as reliable as possible, numerous interviews were held with the responsible persons and stakeholders, through which all processes take place in the port.

A study for the emitted emissions of CO_2, traffic analysis and counting of heavy - duty vehicle passing through the port was performed for both terminals, which the company "Port of Varna" JSC serves. For greater specificity and subsequent benefit from the results of the study, a separation of the kilometers traveled is made by own vehicles and vehicles external to the port.

At the port terminal Varna - East for the study period 01 February 2020 - 30 September 2020 the data are as follows:

Table № 1, External for port terminal Varna - East Heavy – duty vehicles.

	Emission standards for Heavy - duty vehicles							
Month	EURO I	EURO II	EURO III	EURO IV	EURO V	EURO VI	Total HDV	Total distance covered
February 2020	62	397	1210	1108	1126	883	**4786**	**9572**
March 2020	17	145	302	324	304	291	**1383**	**2766**
April 2020	60	208	549	845	547	553	**2762**	**5524**
May 2020	40	191	363	473	335	282	**1684**	**3368**
June 2020	46	244	277	524	354	209	**1654**	**3308**
July 2020	246	597	1744	2412	1558	1103	**7660**	**15320**
August 2020	146	292	753	943	717	602	**3453**	**6906**
September 2020	190	454	1224	1647	1099	696	**5310**	**10620**
Total	**807**	**2528**	**6422**	**8276**	**6040**	**4619**	**28692**	**57384**
% Total	2,81 %	8,81 %	22,38%	28,84%	21,06%	16,10%	**100,00%**	

The data presented in Table № 1 show the heavy - duty vehicles (HDV) that have passed through the territory of the Varna - East terminal. The data are summarized on a monthly basis, with a division of the vehicles according European emission standards (EURO) to which they meet. Table № 1 shows that for the period February - September 2020, 28,692 HDVs passed through the terminal, which from the moment of entering the port for inspection, loading / unloading and departure activities travel on average about 2 kilometers. As a result, it was found that the distance traveled by HDV for the study period was 57,384 kilometers. On average, about 120 trucks pass through the terminal per day, and it should be noted that there is a significant difference in load between the period in which cereals are exported and the rest of the year. It is expected that in 2020 about 43,800 HDVs will pass through the port terminal, traveling 87,600 km. As indicated in Table № 1, the heavy traffic generated by HDVs external to the port terminal is considered. As a percentage of HDVs served by the port, the share of those in the EURO IV and EURO III categories is the largest, accounting for about 51% of the traffic from trucks outside the port. The EURO V and EURO VI categories have a significantly high percentage, accounting for about 37% of external traffic. The most polluting HDVs,

according to their category, are those with standard EURO I and EURO II, which occupy an insignificant percentage of about 12% of external traffic.

Table № 2, Total distance traveled for the survey period 01 February 2020 - September 30, 2020 by own Heavy-duty vehicles, port terminal Varna - East.

Emission standards for Heavy duty vehicles	Total distance covered, km	% Total distance covered
EURO I	1 567	13,20%
EURO II	2 186	18,42%
EURO III	5 052	42,57%
EURO V	1 748	14,74%
EURO VI	1 314	11,07%
Total	11 867	100,00%

Table № 2 presents the distance traveled by own HDVs, which are again divided according to the standard for exhaust gases, as the distance traveled is presented as total for the whole period by different categories. Table № 2 shows that for the period February - September 2020 the own HDVs have traveled 11,867 km, which is an average of 50 kilometers per day, for 2020 a total of about 18,250 km is expected to be covered. The condition for the workload between the period in which the cereals are exported and the rest of the year applies here. In percentage terms, the highest share of the use of own HDVs is the share of those in category EURO III of 42.57%. This is because this category has the largest number of HDVs available at the port terminal. The percentage of operation of the other HDVs is relatively the same, without significant differences in mileage.

At the port terminal Varna - West for the study period 01 February 2020 - 30 September 2020 the data are as follows:

Table № 3, External for port terminal Varna - West Heavy - duty vehicles.

	Emission standards for Heavy - duty vehicles							
Month	EURO I	EURO II	EURO III	EURO IV	EURO V	EURO VI	Total HDV	Total distance covered
February 2020	486	2380	3785	4186	2891	1309	**15037**	**75185**
March 2020	394	1185	3149	3580	1368	912	**10588**	**52940**
April 2020	438	1447	3364	4271	1583	1132	**12235**	**61175**
May 2020	371	1560	3758	3724	1260	1183	**11856**	**59280**
June 2020	472	2100	3902	4214	1762	1441	**13891**	**69455**
July 2020	981	3028	4879	5730	3742	2243	**20603**	**103015**
August 2020	725	2653	4571	4860	2820	1677	**17306**	**86530**
September 2020	823	2428	4679	4738	2540	1590	**16798**	**83990**
Total	**4690**	**16781**	**32087**	**35303**	**17966**	**11487**	**118314**	**591570**
% Total	3,96%	14,18%	27,12%	29,84%	15,19%	9,71%	**100,00%**	

The data presented in Table № 3 show the HDVs that have passed through the territory of the Varna - West terminal. The data are summarized on a monthly basis, with a division of the vehicles according European emission standards (EURO) to which they meet. Table № 3 shows that for the period February - September 2020, 118 314 HDVs passed through the terminal, which from the moment of entering the port for inspection, loading / unloading and departure activities travel on average about 5 kilometers. As a result, it was found that the distance traveled by HDV for the study period was 591 570 kilometers. On average, about 493 trucks pass through the terminal per day. Since the Varna-West terminal is also used for grain exports, the different workload at different times of the year must be taken into account. It is expected that in 2020 about 179 945 HDVs will pass through the port terminal, traveling 899 725 kilometers. Here, too, a division is made between the traffic formed by external and own for the port terminal HDV. As a percentage of HDVs served by the port, the share of those in the EURO IV and EURO III categories is the largest, accounting for about 57% of the traffic from trucks outside the port. Those with EURO V and EURO VI categories, which occupy about 25%, and those with EURO I and EURO II standards, occupy about 18% of the external traffic, have a relatively equal percentage.

Table № 4, Total distance traveled for the survey period 01 February 2020 - September 30, 2020 by own Heavy - duty vehicles, port terminal Varna - West.

Emission standards for Heavy - duty vehicles	Total distance covered, km	% Total distance covered
EURO I	1 893	9,35%
EURO II	3 012	14,88%
EURO III	5 248	25,93%
EURO IV	4 348	21,48%
EURO V	2 360	11,66%
EURO VI	3 382	16,70%
Total	20 243	100,00%

Table № 4 presents the distance traveled by own HDVs, which are again divided according to the standard for exhaust gases, as the distance traveled is presented as total for the whole period by different categories. Table № 4 shows that for the period February - September 2020 the own HDVs have traveled 20 243 kilometers, which is an average of 84 kilometers per day, for 2020 a total of about 30 660 kilometers is expected to be covered. The condition for the workload between the period in which the cereals are exported and the rest of the year applies here. In percentage terms, the highest share of the use of own HDVs is the share of those in category EURO III and EURO IV of 47,41 %. This is because this category has the largest number of HDVs available at the port terminal. The percentage of operation of the other HDVs is relatively the same, with the highest share of those with category EURO VI, and the lowest with those of category EURO I.

6. Estimation and determination of CO_2 emissions emitting caused by heavy - duty vehicles on the territory of port terminals Varna - East and Varna - West.

In the guidelines Methodological note for conducting a Joint study provided by the lead partner (Free and Hanseatic City of Hamburg, Ministry of Economy, Transport and Innovation) under the project "SMOOTH PORTS - Reducing CO2 Emissions in Ports", to determine emissions CO_2 caused by heavy - duty vehicles, the methodology described in the GEF-UNDP-IMO GloMEEP Project and IAPH, 2018 was used: Port Emissions Toolkit, Guide No.1,

Assessment of port emissions: pp. 55 ff. It is presented in the following formula, and in the following lines an explanation of its essence will be made:

$$E\ i = Pop \times EF \times ACT\ ix\ FCF \times CF$$

- **E i** - emissions by grams / year. This formula can be used to calculate the pollution caused by various harmful emissions, for the purposes of this study only CO_2 emissions will be assessed.
- **Pop** - count of heavy-duty vehicles. In the course of the study, information was collected on the emission standards (EURO), which is met by HDV who visited the terminals of the Port of Varna during the study period.
- **EF** - emission factor, g / kilometer (km). The emission factor is calculated as an average value and cannot be universal for all operating modes in which HDVs are present during their stay at port terminals. In Bulgaria, emission factor data are published by the Executive Environment Agency of the Ministry of Environment and Water. The value determined for diesel pollution with carbon dioxide 840 grams per kilometer for 2018. Due to the lack of published according to current data at the time of completion of the study for the indicators of this coefficient in 2019 or 2020; the value that will be applied to perform the calculations is that of 2018.
- **ACT i** - activity by mode i, km for running mode, hours for idle mode, number of starts for cold start mode. Information on the different modes of operation of HDV during their stay at the port terminals is strictly individual for different cases and difficult to collect. Estimation of idle hours is obtained by examining the real time that HDVs have spent on the territory of the port terminal and their waiting time. In order to determine and calculate the number of cold starts after a certain rest of the vehicle, a survey of truck drivers must be conducted. For the purposes of this study, such information was not collected and analyzed.
- **FCF** - fuel correction factor. For the purposes of the study, the fuel correlation coefficient is assumed to be 1, as no information is available on the quality and model of the fuel used by HDV.

- **CF** - control factor. The control factors are specific to the emission control equipment and the mode in which the HDV is operated.

Using the data presented above, separate calculations were made for port terminals Varna East and West, as the emitted emissions of CO_2 were determined for own and external HDV.

The data for the port terminal Varna - East are calculated on the basis of estimated traffic and mileage for 2020, as it was calculated the expectations are to be 87,600 kilometers which multiplied by the emission factor, which is 840 grams per mile we get that the estimated emissions of CO_2 from external to the terminal HDV is 73.6 tons per year.

From its own HDV, the expected to travel 18,250 kilometers multiplied by 840 grams / kilometer generate 15.3 tons per year, which is approximately equal to 17% of the total emissions of CO_2 at the terminal.

The data for the port terminal Varna - West are also calculated on the basis of estimated traffic and kilometers traveled for 2020. The expected distance is 899,725 kilometers multiplied by 840 grams / kilometer generate approximately 755.8 tons of CO_2 emissions per year from external to the terminal HDV.

From its own HDV, it is expected to travel 30,660 kilometers multiplied by 840 grams / kilometer generate 25.8 tons per year, which is approximately equal to 3% of the total CO_2 emissions of the terminal.

As an absolute estimated value for the road traffic from HDV for 2020 for the two surveyed port terminals of "Port of Varna" JSC, on which an inventory of the emissions of CO_2 has been made, 1 036 235 kilometers have been traveled. Moreover, 870.5 tons of CO_2 emissions were generated from them. The emissions generated by the Varna-East terminal are about 10% of the total emissions, and the remaining 90% are the Varna-West terminal. The lower workload and intensity of the activities performed at the Varna - East terminal is because it is located in the central part of the city of Varna.

7. Good practices and opportunities for reduction of CO_2 emissions caused by HDV in port terminals Varna - East and Varna - West.

In recent years, the problem of reducing harmful emissions caused by road traffic has become increasingly relevant and urgent to solve. According to recent studies, the transport

sector is the fastest growing source of emissions from CO_2, an increase of 32% compared to 1990. The purpose of this study conducted under the Smooth ports project is not only to inventory the emissions of CO_2 in the terminals of the port of Varna is also to identify opportunities to reduce these emissions and in the long run limited to a minimum. In recent years, following the international trends for implementation of measures and investments in order to reduce harmful emissions, the Port of Varna together with its largest customers has implemented projects that have led to a significant reduction of road traffic caused by HDV in port terminals.

7.1. Good practices for reducing CO_2 emissions caused by HDV implemented so far.

7.1.1. Construction of rubber - belt conveyors at the port terminal Varna - West.

The first such investment was made at the port terminal Varna - West. The favorable location of the terminal and its close proximity to the Devnya chemical plants allowed the construction of efficient stationary systems of rubber - belt conveyors, through which the cargo is processed by a direct plant - ship scheme. This achieves better efficiency and significantly increases the loading speed of ships stationed on the quay. Consecutively, in a period of several years, 7 rubber - belt conveyors were built, which connect the Varna - West terminal with the largest customers and users of the port, which are Agropolichim, Solvay Sodi and Devnya Cement. The investments made for these innovations have significantly reduced the traffic generated by HDV, which in turn contributes favorably to the reduction of emissions of CO_2.

Fig. № 4. Factories that are connected by rubber - belt conveyors with the port terminal Varna - West.

7.1.2. Construction of a warehouse for storage of grain in close proximity to the port terminal Varna - West.

Following the experience of the above good practice and in order to alleviate traffic and congestion from HDV around the port terminal Varna - East, in 2017 in the immediate vicinity of the port terminal Varna - West the construction of a storage warehouse was started of grain - 10 silos with unloading and railway unloading. The project was implemented and completed at the end of 2019, with a total investment of about BGN 50 million. The warehouse has a storage capacity of 100 thousand tons of grain, has indoor stations for trucks and wagons, thanks to which interruptions of loading and unloading in the rain are avoided. A complex unloading site has been built, which consists of two double unloadings with a capacity of 600 tons per hour and one single single shaft with a capacity of 250 tons per hour. The railway unloading capacity is 600 tons per hour. The base is equipped with 1 railway scale and 3 truck scales, two of which are used only for incoming HDV, and the third is used only for towing empty grain trucks leaving the base. The implementation of the project has a tangible beneficial effect on reducing emissions of CO_2 emitted by HDV for the following reasons:

- With the completion of the warehouse, conditions are created for the export of grain through the port terminal Varna - West, which reduces the freight flow to the port terminal Varna - East, from where until now the export of grain to local farmers.
- Within the grain storage facility, the unloading rate for grain acceptance is 3 times higher than the one with which grain is received at the port terminal Varna - East. This has led to a reduction in air pollution with exhaust gases from HDVs waiting to be unloaded.
- Also, the newly built warehouse contributed to the reduction of freight traffic related to the transportation of grain for export to the port of Bourgas.
- Built on the territory of the warehouse railway unloading provided for the first time in the country an opportunity to transport grain for export by rail and a corresponding reduction in HDV traffic.

The last two benefits of building a storage facility for grain storage have a positive effect on reducing CO_2 emissions not only in the port of Varna, but also at regional and national level.

In 2020, more than 1.5 million tons of grain passed through the warehouse, which is about 75% of the total amount of grain exported in 2019 through the port terminal Varna - East.

The grain stored in the base is transported from redlers, elevators and self-flowing pipes to a belt conveyor located in an overpass. The belt conveyor in a closed gallery takes the grain from the base to cargo ships at the port terminal Varna - West. At the end of the transport facilities on the overpass, the grain is loaded on a ship stationed on the quay. The maximum loading capacity of ships reaches 1500 tons per hour, and one ship of 20 thousand tons is loaded on average in 1 day.

Fig. № 5. Warehouse for storage of grain, Varna - West.

7.1.3. Limit the number of empty journeys by return freight.

The choice of site for the construction of the grain storage warehouse from the above-mentioned good practice is not accidental. It is built on the production site of the company "Agropolichim" JSC, which is the only producer of mineral fertilizers in the region and whose main customers are farmers. The main activity of the company is production and wholesale of nitrogen, phosphorus and compound fertilizers, as well as other products of the chemical industry. The idea that was realized during the construction of the warehouse for storage of grain is HDV, which arrive on the warehouse territory to unload cargo of grain, and subsequently their return rate to be combined with the transfer and delivery of mineral fertilizers, needed by farmers.

The implementation of the good practice helps to reduce the number of trucks arriving and departing from the port terminal Varna - West, and this effect of reducing emissions of CO_2 affects not only the port, but also regional and national level.

7.1.4. Software for management of the check-in system, the so-called Active Portal.

Before the introduction of this software, there were confusions, as there were often cases in which HDV entered the territory of the port terminal Varna - West, that do not have their full set of documents, which makes it impossible to process their cargo. The check-in system software is connected to the port software, thus only the HDV, for which fully prepared documentation has been submitted in advance, are allowed to enter the terminal**.** The software also provides the ability to track the time of entry and exit, giving a realistic idea of the processing period and the stay of HDV in the terminal.

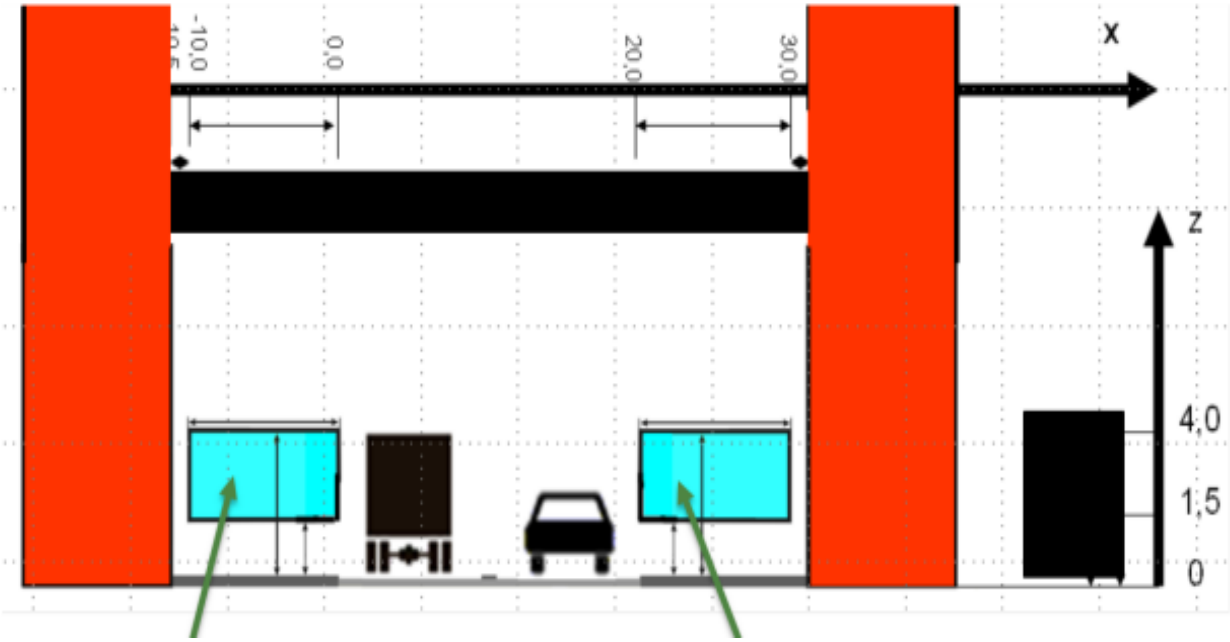

Fig. № 6. Check-in system Active Portal.

7.2. Good practices that are currently being implemented at the terminals of the port of Varna.

7.2.1. Making changes in the method of handling containers at the terminal Varna - West.

With each passing year, the number of processed containers from the port terminal Varna - West increases. The volume has increased almost three times in the last 15 years, which necessitates a reorganization in the method of receiving and handling container cargo, as in

front of the port there is an increasing concentration of HDV waiting to enter, which cannot be processed efficiently and maximally fast.

The plan to solve this problem includes a new way of stacking the containers by introducing the so-called block-stacks, improving communication, building a portal with 5 lanes, creating a dispatching group and gradually updating the service equipment. . This whole plan is consistent with the implementation of the idea of creating and operating an intermodal terminal in the port. The expected amount of the investment will amount to BGN 11.3 million.

With the introduction of a block-stacks will save two times more space than the old way of arranging containers. Work will be further accelerated and empty transhipment operations in the search and retrieval of containers will be reduced. The management of the stack and the provision of containers for expedition will be done entirely by the dispatching staff.

7.2.2. Extension of the port terminal Varna - East.

After the investments and reconstructions made in the last years of the port terminal Varna - West, the time has come for port terminal Varna - East to be renovated. The first large-scale investment in recent years is the expansion of the terminal, which is currently under construction. The proposal concerns the development of land on which the port is located, including for the construction of port facilities for handling about 750,000 tons of general cargo per year and about 1,000,000 tons of grain, which is associated with the construction of silos for loose grain cargo. It is invisined that 10 silos for bulk grain cargo will be built, in two parallel silo groups with a total maximum volume of 82,000 tons, which will have two auto-unloading and one railway unloading facility. Along with the silos, a system of rubber-belt conveyors will be built to take the cargo to the pier. The rubber-belt conveyors will be stationary until the beginning of the operational area of the shore cranes. The system of rubber belt conveyors will provide productivity of about 500 tons per hour and higher. With the construction of the above-mentioned system, the current practice of transporting grain cargo from the silos to the quay operational area with dump trucks will be stopped. With the commissioning of this innovation, it is expected that the number of HDVs (owned by the port terminal) to cover the daily needs of the cargo flow in the port will be reduced. Currently, 45 HDVs are in operation, and their number is expected to be limited to about 30.

In order to limit the concentration of HDVs in stand-by and to speed up their processing, a second car portal about 200 meters south of the existing one is planned to be built. In the current port, there is one truck scale. With the expansion of the port, it is planned to install another scale at the second car entrance.

7.3. Good practices from international ports with potential to be implemented and used by the terminals of the Port of Varna.

7.3.1. Truck Assignment System (Vehicle Reservation System).

The number of vehicle and operating time, including idle time, are the main factors that determine the amount of emissions released, therefore, the amount of emissions reduced will be proportional to the number of trucks or idle time reduced. To reduce emissions but still maintain cost-effectiveness, a system called the Truck Assignment System (TAS) or Vehicle Booking System (VBS) is proposed. TAS or VBS is used in many developed European and international ports, and some of them are the ports of Vancouver, Los Angeles, Long Beach, Incheon, Southampton and many others.

TAS (VBS) usually divides a day into several small time periods. The terminal operator announces the maximum quota for each period and then HDV drivers select a preferred period. In case the selected period is not available, drivers must choose another one until they manage to make the reservation for the port visit. To ensure impartial access for all truck companies, each company can simply reserve only one slot within a certain period of time. The truck appointment method can reduce the number of trucks arriving during pique hours. The purpose of TAS (VBS) is to minimize the total idle time at the port gate and the waiting time in the terminal. In this way, terminal operators can control the number of trucks entering and operating to match the capacity of the terminal throughout the day.

Undoubtedly, the use of TAS (VBS) has huge advantages for reducing congestion caused by HDV over port terminals, but its disadvantage should also be noted, which is the reduction of supply chain flexibility. The fixed time of entry into the port terminals and the insufficient number of time periods create difficulties for shipping companies in performing their deliveries. This shortcoming can be overcome by sharing HDV between carriers, which will greatly reduce the number of empty trips. Implementing this idea will lead to fewer HDVs

moving on the road, which means less traffic, reduced congestion and road accidents at the local, regional and national levels. The lack of information, resources and trust between carriers limits the effective use of TAS (VBS). The possibility to eliminate this danger is in the jurisdiction of the port operator, which must manage the TAS (VBS) so as to provide the necessary information regarding the time periods in the terminal, delivery schedule, etc., and carriers to be able to find reliable options for sharing HDVs**,** which will further increase the efficiency of using the platform.

7.3.2. Use of time-varying service fees for HDV to optimize port arrival.

Internationally, a large number of studies have been conducted that offer different pricing models for charges applied to HDV in order to optimize arrival at the port. These models are explained in detail and analyzed by their authors, and in the reports presented to the public, they illustrated the effectiveness of the proposed calculations and the accuracy of the models. The idea of all these models is to identify and determine the specifics of the different ports, and on this basis, depending on the period of arrival of the HDVs, a service fee is set, which is different for each time slot. Some of the proposed models are the following:

- Analytical point-wise stationary approximation model to analyze time-dependent truck queuing processes with stochastic service time distributions at gates and yards of a port terminal;
- Convex nonlinear programming model which minimizes the total truck turn time and discomfort due to shifted arrival times;
- Two-phase optimization approach - used to first compute a system-optimal truck arrival pattern, and then find a desirable pattern of time-varying tolls that leads to the optimal arrival pattern.

7.3.3. Truck licensing system.

The Port of Vancouver obliges all container companies and their trucks wishing to serve the port's marine container terminals to meet certain criteria. This means that in order to be admitted to the port, they must meet the terms of the Access Agreement under the Truck

Licensing System. The criteria they must meet include a minimum age, safety and environmental requirements. The key environmental requirement for truck approval in the Truck Licensing System addresses the age limits of trucks. For example, to be eligible to visit the port of Vancouver, HDVs must be manufactured in 2014 or later with equipment that meets all original factory-installed emission standards.

Such a system would be of great benefit to the port of Varna, as 34% of the HDVs that are external to the Varna-East port terminal and 45.26% of the HDVs that are external to the Varna-West port terminal were manufactured before 2005 and have older generation engines that are not environmentally friendly (EURO I - EURO III). Therefore, if the access of HDVs that use old engines is restricted or completely banned, this will also contribute to the reduction of CO_2 emissions.

8. Recommendations from the authors of the study to "Port of Varna" JSC.

8.1. Priority use of railway transport over HDV.

Rail transport can connect the seaport to the hinterland area, which can help reduce congestion and CO_2 emissions from urban traffic. Rail transport can save 50% of the use of HDVs, which means 50% less emissions for each kilometer traveled. Also, rail transport allows a higher weight of the transported cargo, which is another benefit of its use, and accordingly will lead to greater efficiency in the processing of cargo from port terminals.

8.2. Renovation of HDVs used in the port terminals owned by the Port of Varna.

From the data described in Table 2 and Table 4 of the present study it is evident that the Port of Varna mostly uses obsolete and depreciated HDVs. 74% of the kilometers traveled by terminal-owned HDVs at the port terminal Varna - East and 50% of the kilometers traveled by own HDV at the port terminal Varna - West are realized by old and non-environmentally friendly engines with categories EURO I - EURO III, which respectively leads to a larger amount of released harmful emissions. This problem can only be solved by upgrading the port's fleet. This is a long and lengthy process that requires large investments, will take a long time and will take place in stages. At the moment, it is advisable for the Port of Varna to review the

arrangement, which is made for the use of its own HDVs. In case an inadequate arrangement is found or in the process of analysis practices are found that can improve the activities in the port, it is recommended to limit and minimize the use of HDVs with old engines, with the higher load transferred to those with newer and more environmentally friendly engines.

9. Conclusion.

The analysis of the inventory of the emitted CO_2 emissions from HDV traffic conducted in the present study proves the relevance of the set issue. Harmful emissions from vehicle fuels will become an increasing problem in the future. Therefore, timely preventive action is needed to limit these emissions. There are numerous methods, practices and innovations in European and world practices on this topic to achieve the above-mentioned goal.

The inventory of CO_2 emissions from HDVs has improved the understanding of the link between freight activities and air pollution. The way to tackle this global problem is to publicize appropriate public policies and activities to improve air quality to help regional and local authorities, academia and those planning to tackle this problem. The combined application of a large number of measures to limit HDV traffic throughout the supply chain of goods and products would lead to the desired effect and to the achievement of satisfactory results for environmental protection.

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