The Territorial Needs Assessments for the Port of Ploče

(D.3.2.10)

Content

1. Introduction

In accordance with the Maritime Development Strategy and the Integral Maritime Policy of the Republic of Croatia for the period from 2014 to 2020 [1], the Port of Ploče has been designated as one of the six main ports, which have been declared ports of particular (international) economic interest for the Republic of Croatia, and according to the aforementioned Strategy alongside the port of Rijeka, represents the second most important cargo port.

Although the Port of Ploče is a Croatian port, it is extremely important for the economy of neighboring Bosnia and Herzegovina. About 90% of the Port of Ploče activities are transit traffic, as the port is the main approach to Bosnia and Herzegovina on the seaside and at the same time the destination of the Pan-European Corridor Vc (a port on the TEN-T Comprehensive Network). With the completion of the Vc corridor, the Port of Ploče will expand its operations to other countries in Western and Central Europe, especially Hungary.

1.1. General overview of the port area

The strategy of the development of the Port of Ploče is still aimed mainly at meeting the needs of the economy of Bosnia and Herzegovina, and by building modern infrastructure inland, the port will be able to offer its services to the markets of central European countries that it has already served before.

The Port of Ploče is a universal purpose port which means that it serves to transship almost all types of cargo that appear in international shipping. Within the port itself there are areas specializing in the service of certain types of cargo.

Thus, today the port has complete port transshipment, storage, and all accompanying port services for:

- dry bulk cargo,
- liquid cargo,
- container/general cargo.

Image 1: Satellite image of The Port of Ploče [5]

1.1.1. Container Terminal

The first phase of construction of the container terminal was completed in 2010. It invested 38.5m euros, and significant funds were invested in transshipment equipment, installed by concessionaire Luka Ploče Ltd. It is a specialized modern terminal that is also in the function of increasing the level of intramodality throughout corridor Vc.
During the first phase, a coastline was built in the length of 280 meters, 27 meters wide, with a Ro-Ro ramp and a storage capacity of 60 thousand TEU per year. The second phase of construction that will follow ultimately involves a terminal that would span 23 hectares of port area with an annual capacity of as much as 500,000 TEU.

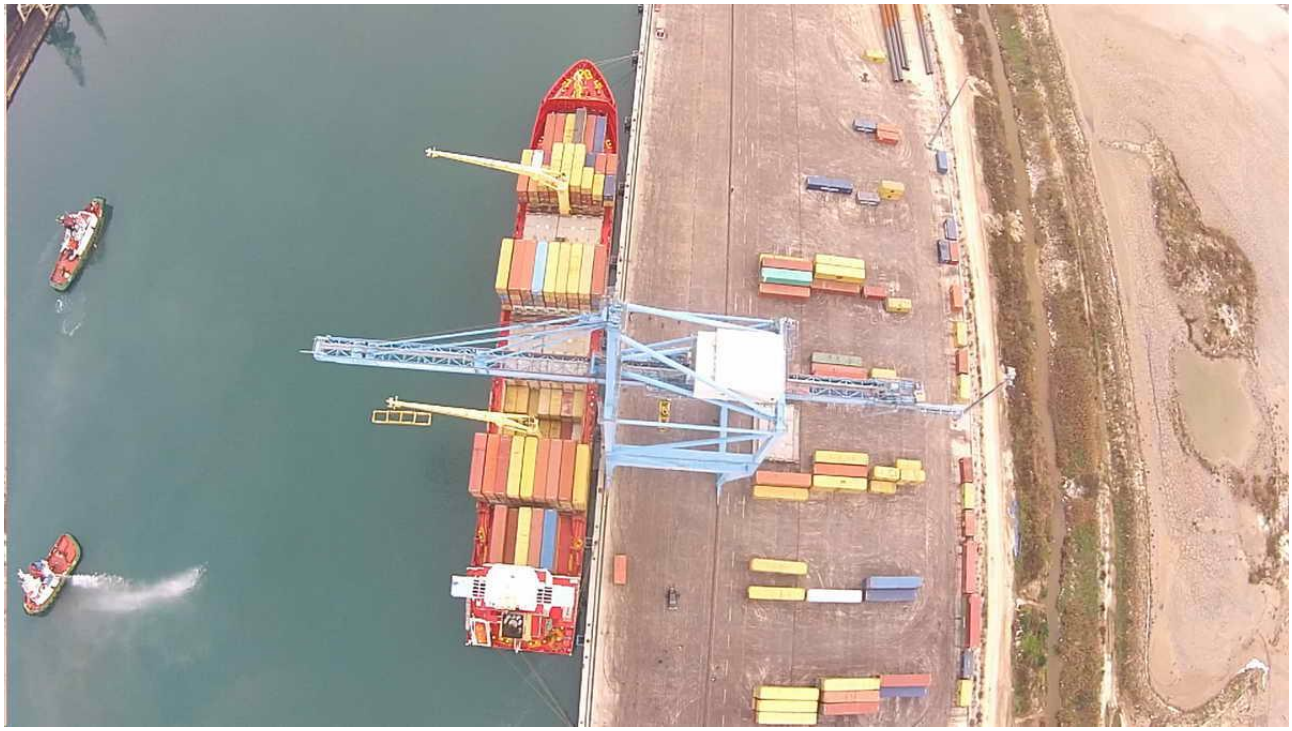

Image 2: Container Terminal [6]

The modern container terminal has strengthened the position of the Port of Ploče in the intermodal network, and the increase in container traffic creates the conditions for the realization of the second and third phases of construction and thus an increase in the capacity of the terminal.

1.1.2. Bulk Terminal

The bulk cargo terminal, technologically and financially observed, is certainly the most important sub-project within the realization of the Trade integration and transport project, for which over HRK 400 million has been contracted for construction alone. Its function refers to increasing bulk cargo capacity to more than 6 million tons per year at the final stage and improving transshipment technology, which will result in an increase in bulk cargo. Therefore, the competitiveness of the port will be increased, as well as environmental standards of cargo handling and ultimately allow for better positioning on the market, according to which the importance of the Port of Ploče in the European business environment would be recognized.

It is located on the southwestern part of the port on the coast of the Vlaška Canal, and two stages of construction are planned. The first phase of the terminal is being built with reduced transshipment equipment with a capacity of 3.6 million tons per year.

The construction of the pier of the new bulk cargo terminal is designed for the possibility of mooring ships up to 180 thousand dwt (deadweight tonnage – ship load capacity). The pier is an open reinforced concrete structure 317.5 meters long and 30 meters wide, with approximately 56 meters long and 22 meters wide access bridge connecting the docking structure with the storage zone.

Bulk cargo terminal is a component that is realized on the principle of public-private partnership between the Port Authority of Ploče and the concessionaire Luka Ploče Ltd. In mid-2016, the infrastructure was built, which is the obligation of the Port Authority of Ploče, and in 2017 the installation of transshipment equipment was carried out, as an obligation of the concessionaire and with which the terminal became operational.

Image 3: Bulk Terminal [6]

1.1.3. Liquid cargo terminal

The existing Liquid Cargo Terminal Adriatic Tank Terminals Ltd. consists of a storage area located on a floating object (barge), associated cargo handling pipelines, a filling station of truck tanks and a compartment of wagon tanks. Storage capacities for petroleum products amount to 24,000 m^3, and for other liquid cargoes (base and vegetable oils, etc.) 11,000 m^3, which totals 35,000 m^3.

Also, Adriatic Tank Terminals Ltd. has built new storage capacities for 50,000 m^3 of liquid cargo (Group 100 tanks), area of 12,844.00 m^2, and by 2023 it is planned to build at least 250,000 m^3 of liquid cargo storage capacity at the site with a total area of 158,000 m^2.

Image 4: Liquid cargo terminal [6]

1.1.4. Inbound Terminal

The construction of the Entrance Terminal has been imposed as a necessity for the purpose of developing the competitiveness of the Port of Ploče. In addition to modern space, the new Entrance Complex implies adequate equipment and IT capacities that will enable acceleration and optimization of business processes of all participants of the port community.

At the same time, it will connect all significant business factors of port business because in one place all entities involved in the business process will be located: Port Authority of Ploče, freight forwarders, control houses, police, customs, etc.

The Entry Terminal also provides for superior technological equipment, in line with the needs of the most important European businesses and the requirements necessary for the establishment of the Schengen regime in ports of particular (international) economic interest. The value of the construction itself amounted to over HRK 85 million.

Image 5: Inbound Terminal [6]

1.2. Geolocation and connectivity of the Port of Ploče

The Port of Ploče is located on the eastern coast of the Adriatic Sea at location 43° 03' N and 17°26' E and is of paramount importance to the economy of neighboring Bosnia and Herzegovina, whose national border is located only 25 km from the Port of Ploče, and for partners from Serbia-Montenegro, Hungary and other Central European countries.

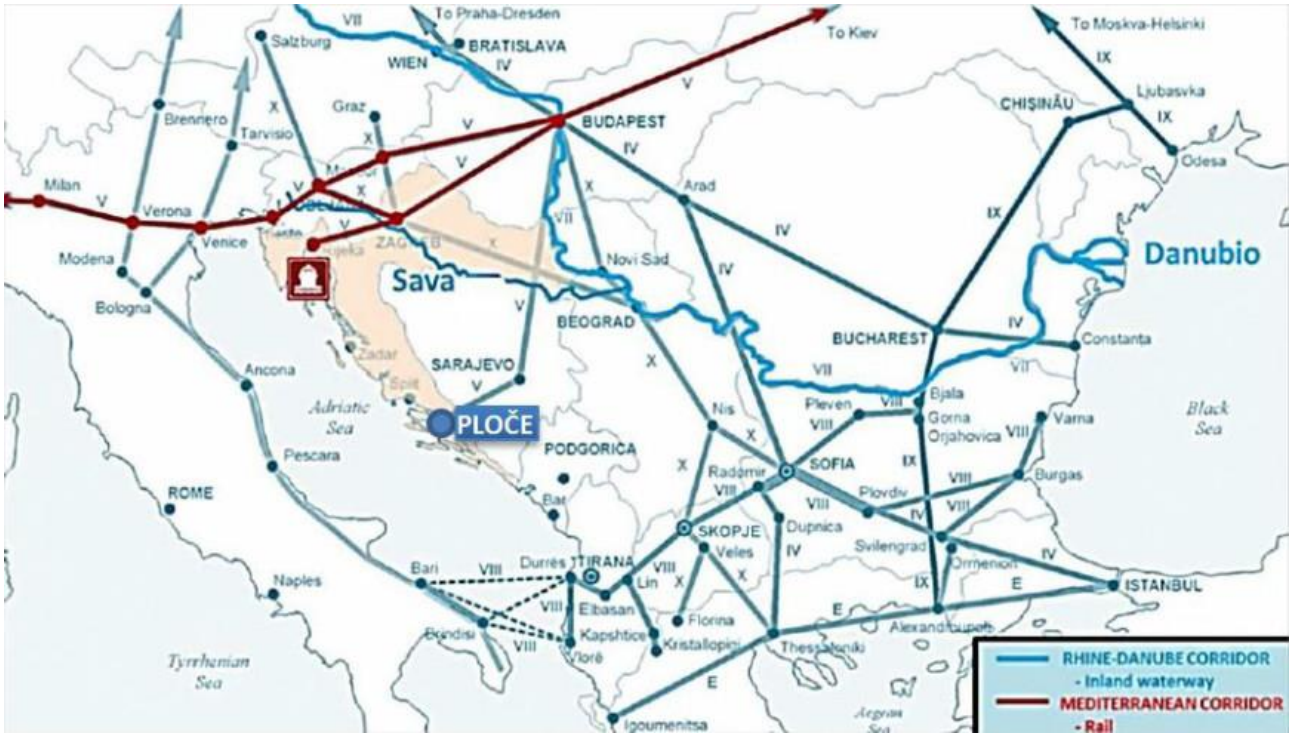

Image 6: 1.2. Geolocation and connectivity of the Port of Ploče [2]

The Port of Ploče is in a bay that closes the Pelješac peninsula on the south and southwest side, thus representing a natural breakwater. It is directly connected with its hinterland in Bosnia and Herzegovina, further to the north-eastern part of Croatia, and to the Central Europe railway line, and the road (E-73) that stretch along the route of the future branch C (Budapest - Osijek - Sarajevo-Ploče) of the Fifth Pan-European Corridor (Venice - Trieste - Budapest - Uzgorod - Lvov) and will be the seaport of this branch. This road is also one of the most important branches of the TEM/TER project and in a broader sense connects the European North (Baltic) with the Adriatic and is vital in economic connection and the traffic of people and goods.

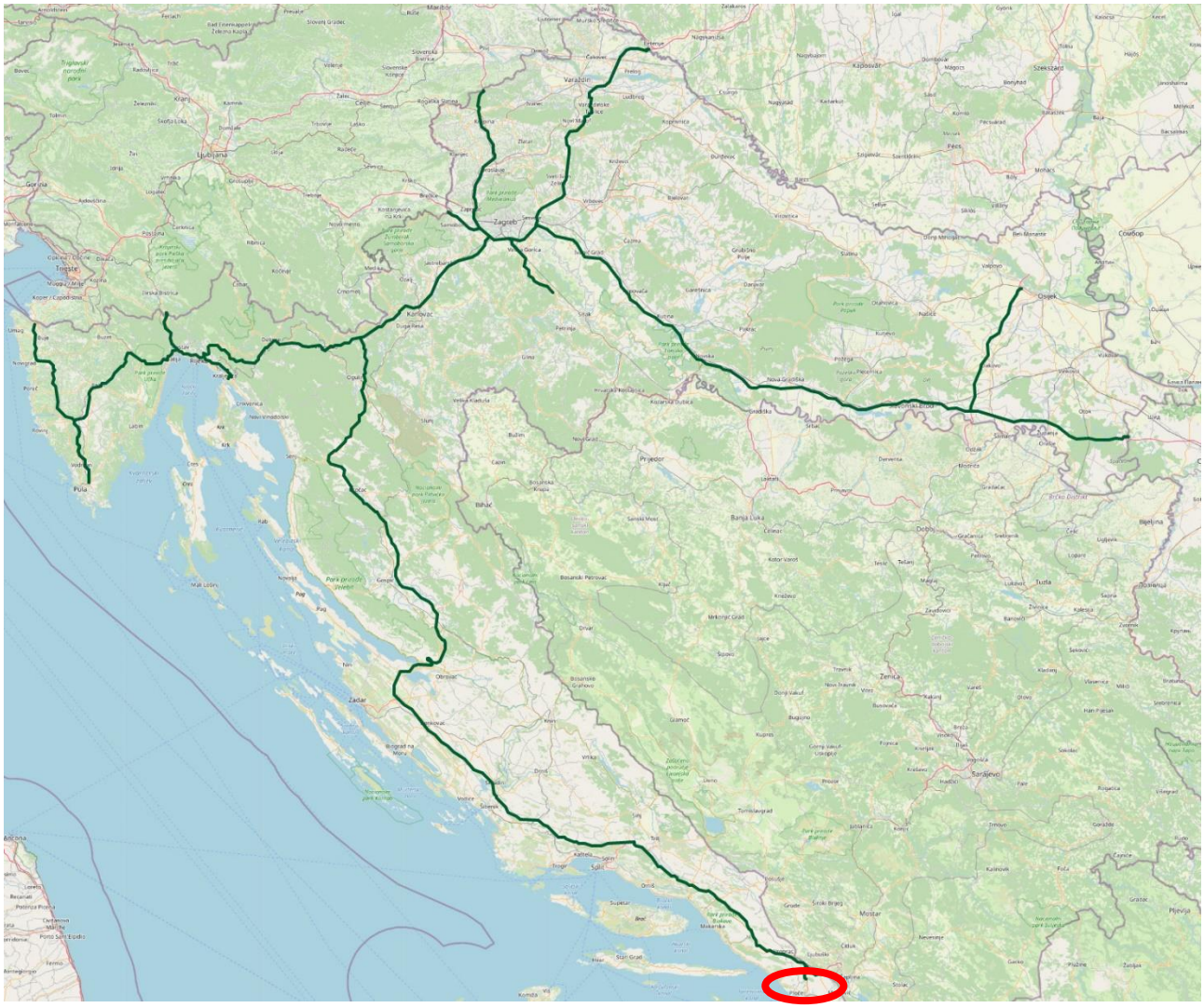

Image 7: Road connection of the Port of Ploče to the network of motorways in the Republic of Croatia [3]

Image 8: Railway network of the Republic of Croatia and connection of the Port of Ploče [4]

The Port of Ploče is also located along the Adriatic Highway (E-65), a road that stretches from Trieste through Rijeka and Split to the far south of this part of Europe. The modern motorway Zagreb – Ploče has been completed and the fastest connection with Zagreb, as well as with destinations in Central, Western and Eastern Europe, has been enabled. In the immediate surroundings of the Port of Ploče there are international airports in Split and Dubrovnik (distance approx. 120 km) and airport in Mostar, Bosnia and Herzegovina (distance 60 km).

The geolocation of the Port of Ploče provides a quality maritime connection with both cities on the Adriatic coast of Croatia and Italy and with ports of the whole world, achieved by establishing a regular feeder line connecting the Port of Ploče with significant container ports in the Mediterranean.

1.3. Environmental policies related documents

In accordance with the National Plan for the Development of Ports of Special (International) Economic Interest for the Republic of Croatia [7], to increase the focus on environmental protection and sustainability, the Port of Ploče should aim to become a 'green' port. The focus should be on further meeting the requirements of port environmental management standards (PERS) and the certified Quality Management System promoted by the European Sea Ports Organization (ESPO). The port should also introduce incentives to promote low Sulphur emissions of shipping companies. Furthermore, the port should also prepare for the introduction of low-Sulphur areas in the Adriatic/Mediterranean by 2020, where ships would be limited to the use of low-Sulphur fuels. The port should also prepare to provide clean fuel storage, perhaps even include LNG (liquefied natural gas). In the long run, the port has initiated a feasibility study on the application of "Cold Ironing", or "Shore-2-Ship" technology, and preparation for the reception and storage of LNG (liquefied natural gas) is planned. An additional advantage would be the transition from road to rail transport mode. In line with the short- and medium-term development plan, the port has already started exploring opportunities for the deployment of clean energy technologies, i.e., electricity generation from renewable sources, and is implementing measures to optimize electricity consumption.
In accordance with national legislation and World Bank policies, a comprehensive environmental impact study has been developed for the container terminal and bulk cargo terminal [8], and separately, the Environmental Impact Study of the Container Terminal of the Port of Ploče was developed [9], and the Environmental Impact Study of the Bulk Cargo Terminal of the Port of Ploče [10] were produced, from which the conclusion emerged that both interventions were environmentally friendly with the application of environmental measures and environmental monitoring programs, all in order to achieve the greatest possible preservation of environmental quality. Environmental management plans have also been developed for both terminals [11, 12].

2. Associated stakeholders

This chapter provides an overview of the main stakeholders based on their impact on the implementation and dissemination of the activities covered by this project. A particular organization shall be considered as a stakeholder where there is its direct interest and/or impact on project activities. Below are two tables, of which table 1 shows stakeholders in accordance with their interest and/or impact on the project, while table 2 provides an overview according to their level of involvement and role under this project.

		IMPACT LEVEL	
		LOW	HIGH
LEVEL OF INTEREST	HIGH	Edge stakeholders Relevance = Low	Important stakeholders (Ones we wish to include) Relevance = Middle/High
		• Crodux derivati dva d.o.o. • INA – Industrija nafte d.d. • Top logistics d.o.o. • Pločanska plovidba d.o.o. • Pomorski servis – luka Ploče d.o.o. • Adriatic tank terminals d.o.o. • Brodospas d.d. • Intermodal Transport Cluster • Media • General population	• Grad Ploče • Dubrovnik-Neretva County • Dubrovnik-Neretva County Regional Development Agency – DUNEA • Ministry of Economy and Sustainable Development of the Republic of Croatia
	LOW	Operative stakeholders (Ones needed to be included) Relevance = Middle/High	Ključni dionici (Required for actions to be achieved) Relevance = High

		• Harbormasters Office
		• Police
		  ○ Maritime
		  ○ Border
		• Customs
		• Hrvatska elektroprivreda (HEP Group)
			• Ministry of the Sea, Transport, and Infrastructure of the Republic of Croatia
			• Luka Ploče d.d.

Table 1: Portray stakeholders according to their interest and influence

STAKEHOLDER	ROLE	IMPORTANCE	CONTRIBUTION	ADVANTAGES	CONFLICTS	CURRENT SUPPORT	STRATEGIES TO IMPROVE SUPPORT
Ministry of the Sea, Transport, and Infrastructure of the Republic of Croatia	Observational; They will be involved in dissemination	High	Adopted strategies and strategic plans of the Government of the Republic of Croatia	Development of the Port of Ploče and related activities	None	Indirect	Getting acquainted with the needs of The Port of Ploče for the purpose of their inclusion in future strategic decisions and plans
Luka Ploče d.d.	Main Concessionaire	High	None	Interest in energy and environmentally efficient solutions	None	None	Communication with port authority and dissemination of information
City of Ploče	Observational; Included in dissemination	Medium/High	None	Interest in energy and environmentally efficient solutions	None	None	Communication with port authority and dissemination of information
Dubrovnik-Neretva County	Observational; Included in dissemination	Medium	None	Interest in energy and environmentally efficient solutions	None	None	Communication with port authority and dissemination of information

STAKEHOLDER	ROLE	IMPORTANCE	CONTRIBUTION	ADVANTAGES	CONFLICTS	CURRENT SUPPORT	STRATEGIES TO IMPROVE SUPPORT
Dubrovnik-Neretva County Regional Development Agency – DUNEA	Observational; Included in dissemination	Niska	None	Interest in energy and environmentally efficient solutions	None	None	Communication with port authority and dissemination of information
Ministry of Economy and Sustainable Development of the Republic of Croatia	Observational; Interest in sustainable (economic) development of the port	Medium/High	None	Interest in energy and environmentally efficient solutions	None	None	Communication with port authority and dissemination of information
Harbormasters Office	None; It is in the port authority building	Medium/High	None	They are in the port authority building and will benefit directly from the activities applied	None	None	Communication with port authority and dissemination of information
Police (Maritime & Border)	None; It is in the port authority building	Medium	None	They are in the port authority building and will benefit directly from the activities applied	None	None	Communication with port authority and dissemination of information

STAKEHOLDER	ROLE	IMPORTANCE	CONTRIBUTION	ADVANTAGES	CONFLICTS	CURRENT SUPPORT	STRATEGIES TO IMPROVE SUPPORT
Carina	None; It is in the port authority building	Medium	None	They are in the port authority building and will benefit directly from the activities applied			Communication with port authority and dissemination of information
HEP Grupa	National energy company	Medium/High	None	Return of surplus produced el. energy to HEP Group	None	None	Communication with port authority and dissemination of data
Intermodal Transport Cluster	Project partner	High	Support in project implementation	Experienced	None	Support in project implementation	Communication with port authority and dissemination of information
Adriatic tank terminals d.o.o.	None; Concessionaire at liquid cargo terminal	High	None	Interest in energy and environmentally efficient solutions	None	None	Communication with port authority and dissemination of information
Media	None; Dissemination of information	High	None	Interest in energy and environmentally	None	None	Communication with port authority

STAKEHOLDER	ROLE	IMPORTANCE	CONTRIBUTION	ADVANTAGES	CONFLICTS	CURRENT SUPPORT	STRATEGIES TO IMPROVE SUPPORT
				efficient solutions			and dissemination of information
General Population	None; Dissemination of information	Medium/High	None	Interest in energy and environmentally efficient solutions	None	None	Communication with port authority and dissemination of information

Table 2: Overview of stakeholders by level of involvement and role

3. Carbon footprint

The emissions estimate (carbon footprint) for the Port of Ploče presented in this Chapter is based on data on the accepted-shipped quantity of cargo, i.e., ships, trains, and road vehicles in 2020, presented in Table 3. The data was downloaded from the official website of the Croatian Bureau of Statistics [13], and the missing data were derived based on different categories of available data.
Important note: Croatian language uses inverse number displaying compared to English language, therefore sign "," (comma) is used to delimiter decimal part of numbers whilst sign "." (dot) is used to delimiter thousands.

2020	CARGO (Yearly)					
Type	General		Liquid	Bulk	∑	
Unit	(TEU)	(tons)	(tons)	(tons)	(tons)	(#)
Qty	14.886	178.181	765.139	1.150.509	2.093.829	
Share	8,51%		36,54%	54,95%	100,00%	
	INBOUND					
Vessels (#)	14		62	92	2.093.829	168
	OUTBOUND					
Trains (#)				702	1.150.509	702
HDVs (#)	8.943		31.057		943.320	40.000
HDVs (%)	22,36%		77,64%			100%

Table 3: Statistics about accepted and shipped cargo and transport assets in the Port of Ploče in 2020

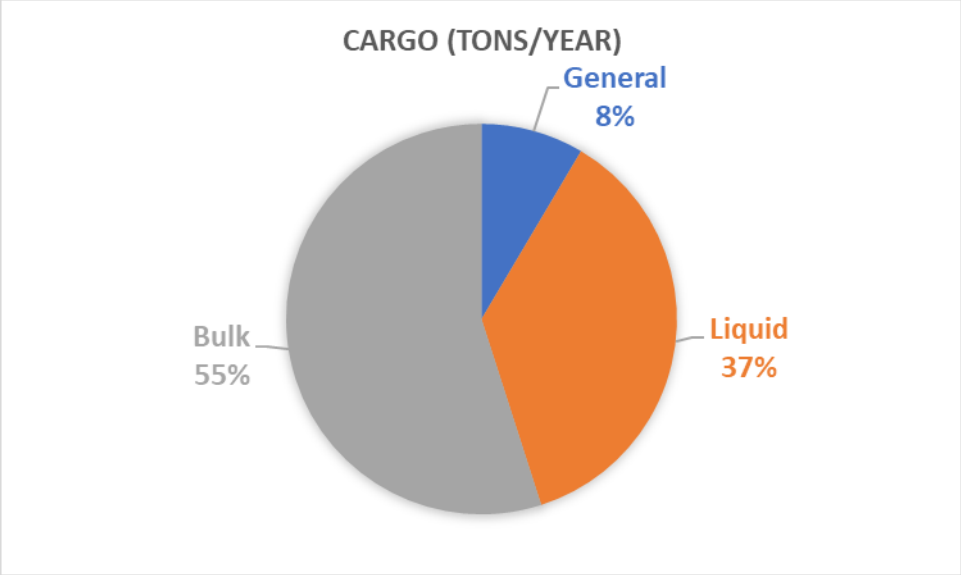

Figure 1: Distribution of accepted cargo by type in the Port of Ploče in 2020

As evidenced by the data presented in Table 3 and Figure 1, the Port of Ploče carries out activities through three types of terminals – for general, liquid, and bulk cargoes. According to the existing port infrastructure, it follows that general and ongoing cargoes from the terminal are taken by road, i.e., tugs with trailers of the appropriate category come for them, while bulk cargoes are transported by rail.

3.1. Terrestrial activities carbon footprint

3.1.1. Electricity

Due to the unavailability of other energy products as a source to produce various forms of energy, electricity is the basic energy source for the supply of fixed infrastructure in the Port of Ploče. Data on electricity consumption were obtained based on the invoice for the spent electric energy. energy, and the average CO_2 production coefficient per kWh spent el. Energy (0,121 CO_2 kg/kWh) on the territory of the Republic of Croatia, is taken from the official publication "Energy in Croatia" [14], which is produced annually for the Ministry of Economy and Sustainable Development by the Energy Institute Hrvoje Požar from Zagreb. Table 4 shows data on monthly consumption and the corresponding amount of CO2 released in kg/kWh, and a graphical representation is given in Figure 2.

2020	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	∑
kWh	79.236,00	68.819,00	67.981,00	54.726,00	51.705,00	51.490,00	52.962,00	51.342,00	47.328,00	64.451,00	66.677,00	72.442,00	**729.159,00**
CO_2 (kg)	9.587,56	8.327,10	8.225,70	6.621,85	6.256,31	6.230,29	6.408,40	6.212,38	5.726,69	7.798,57	8.067,92	8.765,48	**88.228,24**
CO_2 (tons)	9,59	8,33	8,23	6,62	6,26	6,23	6,41	6,21	5,73	7,80	8,07	8,77	**88,23**

Table 4: Statistics on electricity consumption and related CO_2 emissions in Port of Ploče in 2020

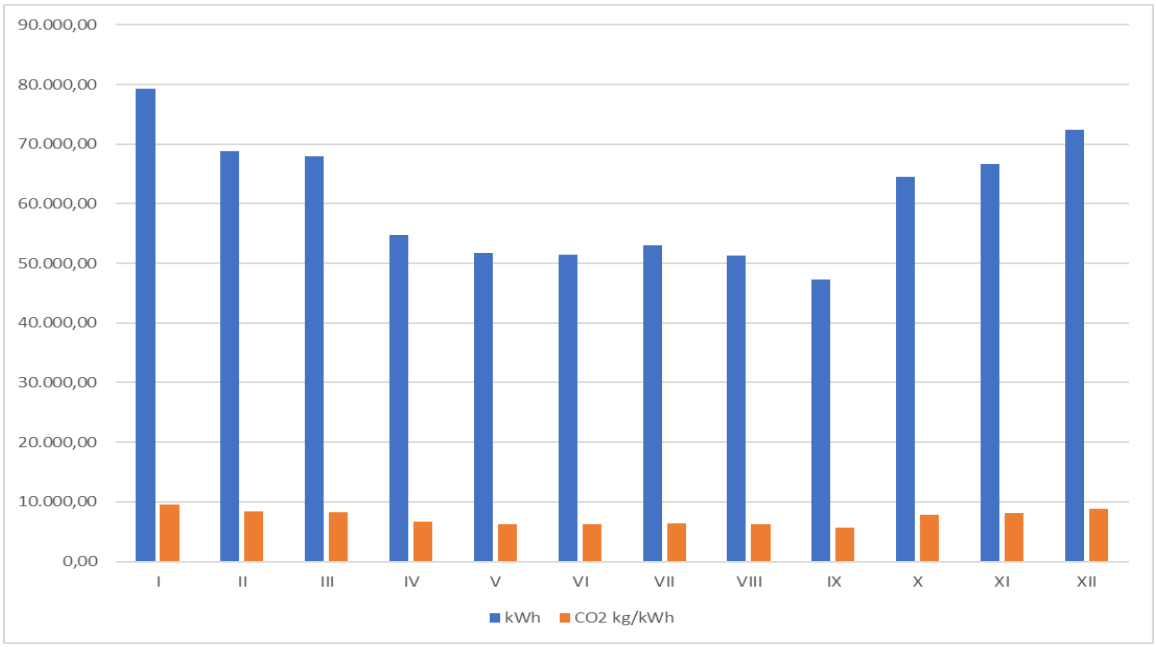

Figure 2: Statistics on electricity consumption and related CO_2 emissions in Port of Ploče in 2020

3.1.2. Airconditioning

Due to the unavailability of other energy products as a source to produce various forms of energy, electricity is the basic source of heat generation for heating purposes. Since the construction of the port authority building was completed in 2016, it is equipped with modern air conditioning systems with optimal efficiency. Based on the available data on electricity consumption, it was not possible to single out exclusively the consumption of the air conditioning system, which is why the amount of greenhouse gas emissions resulting from the use of air conditioning systems was shown in the framework of the aggregate electricity consumption in the previous sub-chapter.

3.1.3. Service vehicles

Due to the composition and specifics of the use of the fleet of the Port of Ploče Authority, it was not possible to extract data on service vehicles, and accordingly on their fuel consumption, i.e., greenhouse gas emissions. Also, the terminals in the area are under the management of concessionaires, who also could not provide separate data exclusively for service vehicles. In principle, considering the number of vehicles that can be classified as service in the port area, it can be said that their greenhouse gas emissions are negligible.

3.1.4. Cargo handling vehicles

Table 5 presents data related to port vehicles intended for the handling of different cargo types. All these vehicles are in the possession of the concessionaire, and it was not possible to obtain accurate data on fuel consumption and mileage on an annual basis. For these reasons, their annual greenhouse gas production was calculated based on data on the greenhouse gas emissions coefficient of heavy and cargo vehicles [15], and the average distance they pass in terms of their area of use.

PORT OPERATIONAL VEHICLES (POV)					
(#)	Daily			Yearly	
	(km)	(kg)	(tonne)	(kg)	(tons)
35	2	63,81	0,06	22.971,10	**22,97**

Table 5: Amount of CO_2 released by cargo handling vehicles in the Port of Ploče in 2020

3.1.5. Rail

Railway represents the primary modality of transport of bulk cargo from the Port of Ploče. To obtain accurate estimation of CO_2 discharge as possible when using the railway transport modality, since it is based on the value of the released amount of CO_2 for each of the transported cargo (tons per kilometer – tkm), an empty mass of the composition was used for inbound, and a full mass of the railway composition was used for outbound direction. In accordance with [15] a value of 0,01429 kg/tkm was used to calculate the discharge of CO_2 composition without load, while for full load composition, a value of 0,03295 kg/tkm was used. The amount of CO_2 released based on the use of rail transport modality is shown in Table 6, showing that the total amount of CO_2 released in 2020 totaled 63,46 t CO_2.

RAIL	CO_2 Emission	Daily		Yearly	
	(kg/tkm)	(kg)	(tons)	(kg)	(tons)
Inbound	0,01429	20,69	0,02	7.449,89	7,45
Outbound	0,03295	155,66	0,16	56.036,09	56,04
∑		176,35	0,18	63.485,98	**63,49**

Table 6: Amount of CO_2 released for railway transport modality in the Port of Ploče in 2020

3.1.6. Heavy Duty Vehicles (HDV)

Movement, i.e., the use of cargo (road) vehicles in the Port of Ploče appears in the function of shipping bulk and general cargo (containers). According to the records of the Port Authority of Ploče, 40 thousand trucks enter the territory of the port annually, of which 22.36% transport containers and 77.64% of liquid cargo. Given the maximum permissible mass of road vehicles, as well as the distance they travel in the port area (2 km each way) between the inbound and liquid cargo overtaking terminals, both categories of vehicles were observed collectively when calculating the amount of CO_2 released. When calculating the amount of CO_2 released by trucks, data on the coefficient of greenhouse gas emissions of heavy and cargo vehicles [15] worth 0,91155 kg/tkm were used. The total amount of CO_2 released in the Port of Ploče in 2020 by HDVs, as shown in Table 7, is 145,85 tons.

CO2 Emission (kg/tkm)	HEAVY DUTY VEHICLES (HDV)					
	Daily			Yearly		
	(#)	(kg)	(tons)	(#)	(kg)	(tons)
0,91155	111	405,13	0,41	40.000	145.848,25	**145,85**

Table 7: Amount of CO_2 released for road transport modality in the Port of Ploče in 2020

3.1.7. Overview of terrestrial activities carbon footprint

In accordance with the data presented in Tables 5 do 8, , it follows that the largest share of CO_2 discharge in the area of the Port of Ploče originates from HDVs, although the total share of container and liquid cargo in 2020 in the Port of Ploče was 45.05%, compared to 54.95% of the bulk cargo share. According to these data, there is undoubtedly a higher efficiency of the use of rail versus road transport modality according to the criterion of the released amount of CO_2.

TERRESTRIAL OPERATIONS CO_2 EMMISSIONS OVERVIEW				
CO_2	POV	RAIL	HDV	∑
(tons)	22,97	63,49	145,85	**232,31**
(%)	9,89%	27,33%	62,78%	100,00%

Table 8: Overview of released CO_2 for terrestrial operations in the Port of Ploče in 2020

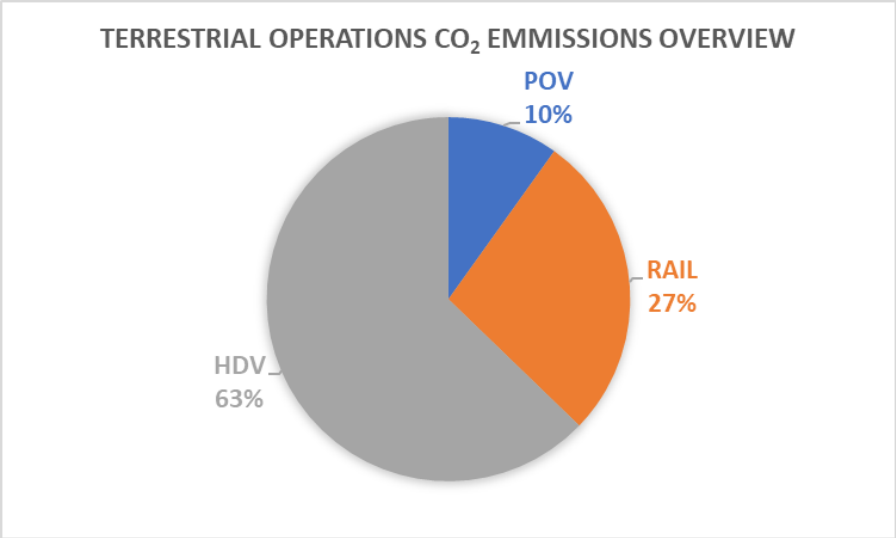

Figure 3: Overview (share) of released CO_2 for terrestrial operations in the Port of Ploče in 2020

3.2. Maritime activities carbon footprint

3.2.1. Vessel docking

Under this sub-chapter, ship docking operations are divided into the entry, maneuvering and anchoring/hoteling phase for each of the above stages of docking ships in the Port of Ploče, a calculation of released CO_2 was made, given the average size and type of ship docking in the Port of Ploče. According to the data presented in Table 3, a total of 168 ships entered the Port of Ploče in 2020, of which 8,51% of general cargo ships, 36,54% of tankers and 54,95% of bulk carriers. The average size of the ship expressed in the carrying capacity of the ship (dwt), the average power of the main and auxiliary propulsion machines, and the ratio of their power are shown in Table 9. The power data of the main machine is taken from the "Third IMO GHG Study 2014, Annex 2: Details for Section 1.3: inventory results" [16], and the power ratio of the main and auxiliary propulsion machines is taken from the "Defra, UK Ship Emissions Inventory, Final Report" [17], on the basis of which the power of auxiliary propulsion machines for a particular vessel type was determined.

VESSEL		P - Δ ENGINE POWER (kW)		
Type	Δ Size Category (dwt)	Main Engine (ME)	Auxiliary Engine (AE)	ME:AE
Bulk	35,000-59,999	8.922	1.874	0,21
Tanker	60,000-79,999	12.091	3.265	0,27
Container	2,000-2,999	21.668	4.767	0,22
Tug	1,342	2.900		

Table 9: Categorization of main and auxiliary engines for vessels called at Port of Ploče in 2020

Table 10 shows the duration of individual docking phases of different types of vessels including tugboats in the Port of Ploče.

	t - Δ VESSEL OPERATION TIME (h)		
Operation	Reduced speed zone	Manoeuvreing	Anchoring
Bulk	1	1	48
Tanker	1	1	48
Container	1	1	12
Tug	1	1	

Table 10: The duration (in hours) of individual phases of docking of ships in the Port of Ploče

According to literature [18] auxiliary engine load factors (LF_{AE}) are shown in for individual stages of vessel docking. Additionally, according to forementioned literature main engine load factor was defined as LF_{ME} = 0,2 for all vessel types except for tugboats for which main engine load was defined as LF_{ME} = 0,8.

	LF_{AE} - AUXILIARY ENGINE LOAD FACTOR		
Type	Reduced speed zone	Manoeuvreing	Anchoring
Bulk	0,27	0,45	0,22
Tanker	1,27	1,45	0,67
Container	0,25	0,5	0,17

Table 11: Auxiliary engine load factors (LF_{AE}) for various vessel types during various docking stages

According to literature [18], Table 12 shows main and auxiliary engine CO_2 (g/kWh) emission factors regarding their build year.

	EF - EMISSION FACTORS (g/kWh)			
Type	Main Engine (EF_{ME})		Auxiliary Engine (EF_{AE})	
Build Year	< 2000	> 2000	< 2000	> 2000
All Vessels	10,6	8,8	17	14,1

Table 12: Main and auxiliary vessel engine CO_2 (g/kWh) emission factors regarding their build year

In accordance with „2021 Guidelines on the method of calculation of the Attained Energy Efficiency Existing Ship Index (EEXI)“ [19], specific fuel consumption values (SFC) were defined for main SFC_{ME} = 190 g/kWh and auxiliary SFC_{AE} = 215 g/kWh vessel engines.
Ultimately, quantity of released CO_2 (EM_{vessel}) for all docking phases of all vessel types were calculated based on the following expression [18]:

$$EM_{vessel} = t(RSZ/M/A) \cdot [(P_{ME} \cdot LF_{ME} \cdot EF_{ME}) + (P_{AE} \cdot LF_{AE} \cdot EF_{AE})] \quad (1)$$

, where:

t(RSZ) – Reduced Speed Zone navigation time,
t(M) – Maneuvering time,
t(A) – Anchoring/Hoteling time.

Tugboat CO_2 (EM_{tug}) emissions were calculated based on simplified version of expression (1), as they do not have/use auxiliary engines according to the following expression:

$$EM_{tug} = t \cdot (P_{ME} \cdot LF_{ME} \cdot EF_{ME}) \quad (2)$$

Based upon expressions (1) i (2) total CO_2 emission value from maritime operations were calculated for all vessel types in year 2020 totaling 2.266,45 tons CO_2.

VESSELS	CO_2 EMISSIONS (tons)					
Operation / Vessel	Reduced speed zone (RSZ)	Manoeuvreing (M)	Anchoring (A)	Per		Σ
				Port call	Year	
Bulk	0,45	0,52	4,25	5,22	480,42	2.266,45
Tanker	1,35	1,48	22,57	25,40	1.574,84	
Container	1,08	1,34	2,09	4,51	63,09	
Tug	0,44	0,44		0,88	148,11	

Table 13: The total amount of maritime operations related CO_2 emissions in the Port of Ploče in 2020

3.2.2. Overview of maritime operations carbon footprint

According to Table 13 and Figure 4, it is apparent that the largest share of CO_2 emissions associated with maritime operations were caused by tankers. The fact is not surprising regarding the data shown in Table 11, showing tanker-related operations have a higher main and auxiliary engine load factor, along with longer retention time at the port, which consequently results in a higher amount of emitted CO_2. Additionally, tanker vessels have higher auxiliary engine loads during anchoring/hoteling phase because of usage of liquid cargo pumps for cargo discharging.

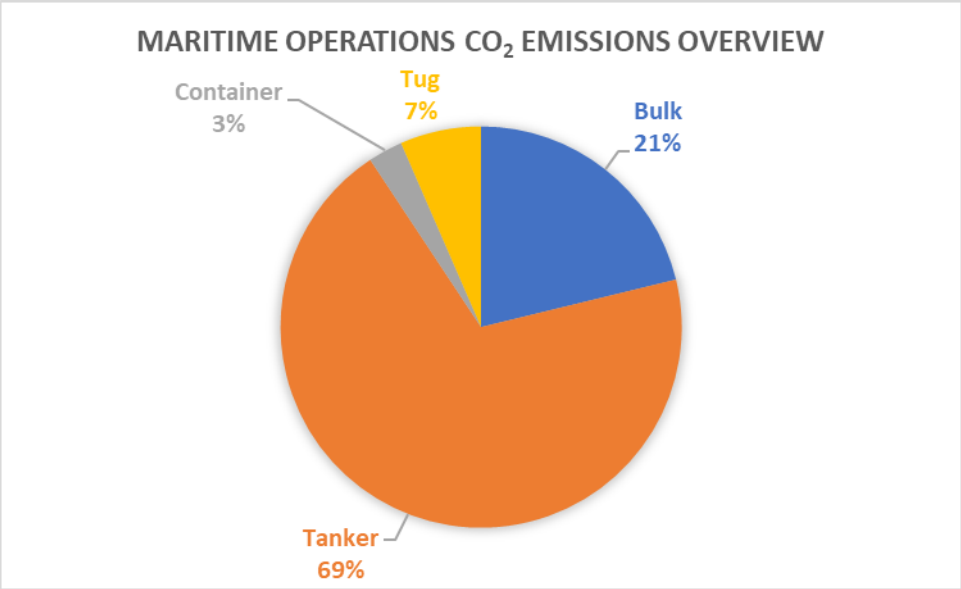

Figure 4: Maritime operations CO_2 emissions share by vessel type in the Port of Ploče in 2020

3.3. Carbon footprint overview

In accordance with the presented data in the previous sub-chapters, and Table 14, it is evident that the highest share of CO_2 emissions in terms of cargo shipment in the Port of Ploče in 2020 comes from HDVs, that is, in terms of cargo delivery from tankers.

Looking at the possibility of reducing forementioned emissions in terms of cargo handling – naval operations could certainly have one to the greatest contributions from the implementation of "Cold Ironing", i.e. "Shore-2-Ship" technology that enables the power supply and smooth functioning of all ship systems during the ship's berthing from the coast, while completely lacking the need for the operation of vessel auxiliary engines, and therefore all related CO_2 emissions would disappear completely.

The data presented in Table 8 undoubtedly shows that changing the modality of shipping liquid cargo from road to rail would have the greatest positive impact on the level, i.e., the reduction of CO_2 emissions. In this case, additional reduction in CO_2 emissions could be achieved by electrification of railway infrastructure in the Port of Ploče.

CO_2	Electricity	POV	RAIL	HDV	VESSELS	∑
(tons)	88,23	22,97	63,49	145,85	2.266,45	**2.586,99**
(%)	3,41%	0,89%	2,45%	5,64%	87,61%	100,00%

Table 14: Overview of total CO_2 emissions for the Port of Ploče in 2020

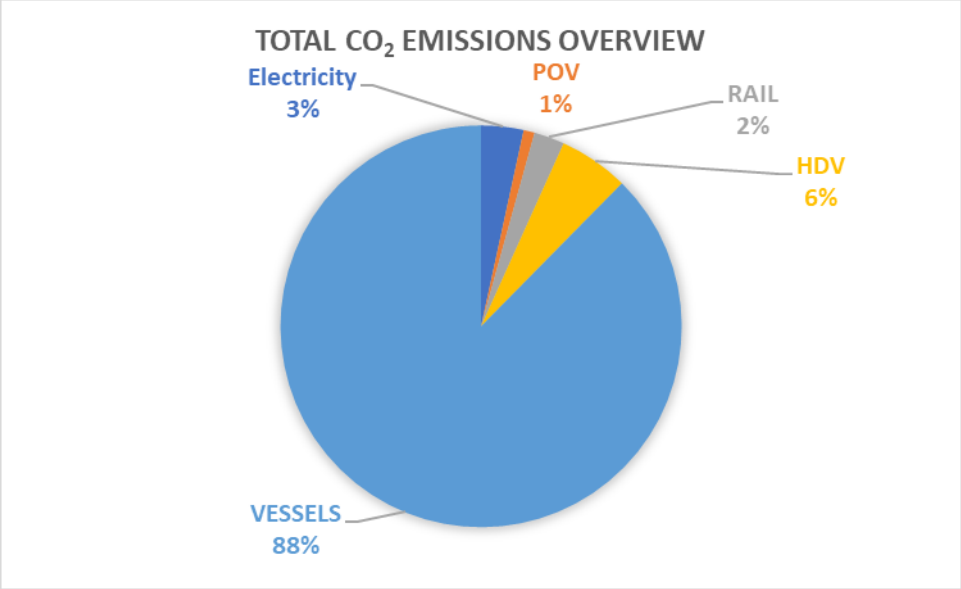

Figure 5: Sources of CO_2 emissions for the Port of Ploče in 2020

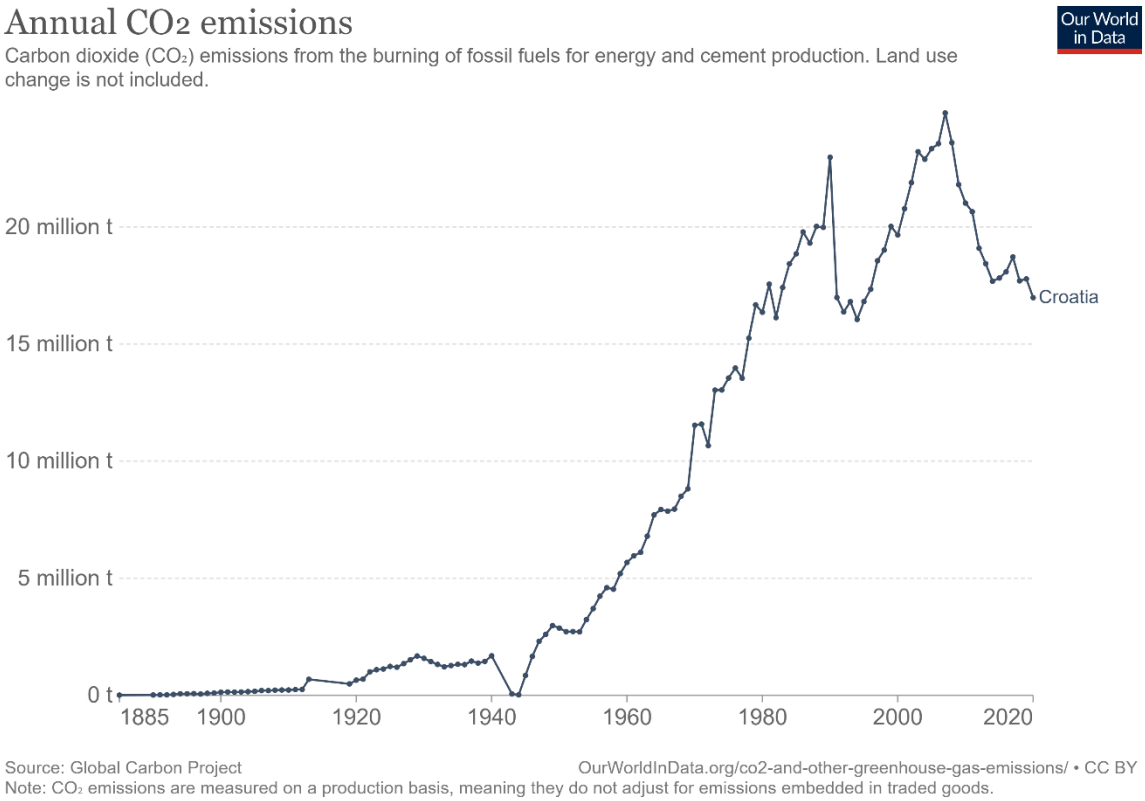

Figure 6: Annual level of CO_2 emissions in the Republic of Croatia in 2020 [20]

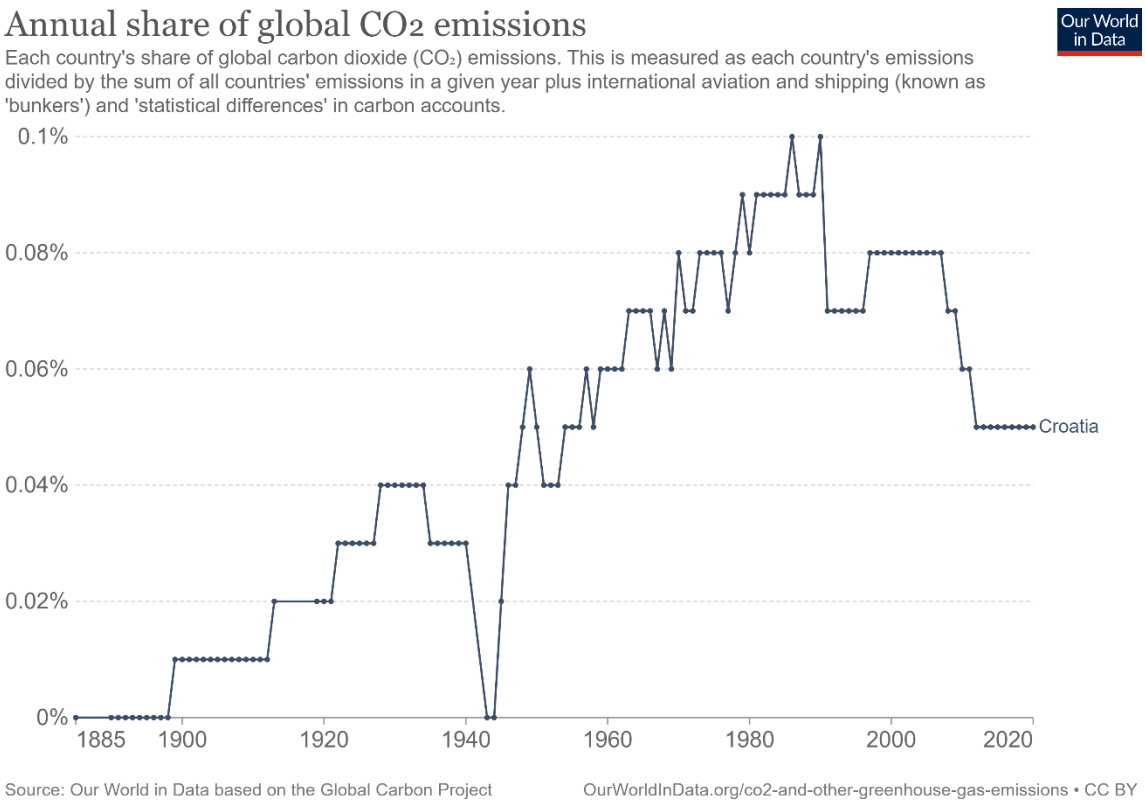

Figure 7: CO_2 emissions in the Republic of Croatia on world scale in 2020 [20]

Considering the data shown in figures 6 i 7, about 16,5 million tons of CO_2 released from the Territory of the Republic of Croatia in 2020, accounts for 0,06% of global CO_2 emissions. Furthermore, conclusion can be drawn about 2.586,99 tons of emitted CO_2 in the Port of Ploče in 2020, ranks it as area with a low level of CO_2 emissions.

4. SWOT Analysis

	ADVANTAGES	WEAKNESSES
INTERNAL	• Initiation of the process of using renewable energy sources • Environmental management plans adopted • Geographical location • Intermodal connectivity • Technical and technological modernization of the port • Main cargo import port for Bosnia and Herzegovina • Bulk, liquid, and container/general cargo operations • Second most important cargo port in the Republic of Croatia	• Lack of LED lightning • Untapped possibilities of production el. energy from renewable sources, in particular solar energy • Inefficient air conditioning system of the server room • Lack of "Cold Ironing"/”Shore-2-Ship” technology

	OPPORTUNITIES	THREATS

EXTERNAL	• Introduction of new energy-efficient and environmental solutions:
	  ○ Setting up photovoltaic cells – production of el. energy
	  ○ Improving the air conditioning system of the server room
	  ○ "Cold Ironing"/"Shore-2-Ship"
	  ○ electrification of port handling equipment
	  ○ Rail electrification
	• Further growth and development of the port
	• Good relationship with the main concessionaire in the port
	• Introduction of new environmentally friendly cargoes
	• Using EU funding for financing planned activities and projects
		• Increase in cargo handling activities could cause negative consequences upon environment

5. Conclusion

As mentioned above, looking at the data shown in Figures 6 i 7, it follows that 16,5 million tons of CO_2 were emitted from the territory of the Republic of Croatia in 2020, accounting for 0,06% of global CO_2 emissions. Additionally, according to the forementioned data, it follows that the total amount of CO_2 emissions in the Port of Ploče in 2020 was 2,586.99 tons, therefore allowing Port of Ploče to be classified as an area with low CO_2 emissions. However, also based on the CO_2 release calculation carried out, it is evident that there are possibilities to further improve, i.e., reduce CO_2 emissions in both terrestrial and maritime part of the port activities.

Inbound cargo operations can be optimized by introducing "Cold Ironing", or "Shore-2-Ship" technology, whereby the need for the operation of auxiliary vessel engines would disappear, i.e., CO_2 emissions would be eliminated during the vessel's anchoring/hoteling phase in the port. Potential challenges in the implementation of this technology may only be posed by the vessels which would possibly not be able to take advantage of "Shore-2-Ship" technology. Nevertheless, regarding a general trend of introducing and application of stricter environmental regulations at European Union level, which necessarily affect local and national regulations, but also taking in consideration ever more stringent regulations globally affecting the entire shipping industry it will become more and more present even in smaller and medium sized ports.

Outbound cargo operations at the Port of Ploče could be optimized, i.e., by electrifying the railway infrastructure in the port area, but of course the same applies for electrification of the entire railway network to Bosnia and Herzegovina as the primary user of the services of the Port of Ploče. According to the results obtained from the CO_2 emissions, it is evident the railway has lower CO_2 emission rates compared to HDVs. But for modal shift of liquid cargo transport could be made possible, it is necessary to align it with the needs of the cargo users. Possible solution would be setting up a liquid cargo handling terminal as close to the port's entry terminal as possible, thereby avoiding unnecessary entry of (heavy) trucks into the area of the Port of Ploče.

Finally, regarding buildings and other infrastructure elements (e.g. public lighting) under the management of the Port Authority of Ploče, activities have been identified and started (e.g. the introduction of LEDs instead of metal-halide public lighting replacement, replacement of inadequate air conditioning systems in the administrative building, etc.) of their optimization in terms of reducing electricity consumption, which will also directly affect in reduction of CO_2 emissions, as well as other greenhouse gases. The convenience of the geographical location of the port is also recognized, which allows the installation of a system to produce electricity from renewable sources, i.e., solar energy. All these activities are recognized and listed in the accompanying action plan attached to this document.

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