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EUROPEAN UNION

Territorial Needs Assessment for the Port of Rijeka

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Contents

Introduction

The Port of Rijeka Authority is responsible for the port of Rijeka, which is a developmentoriented port with port basins specialized in types of cargo. The port includes a number of port basins: Rijeka, Sušak, Bakar and Omišalj (island of Krk) and Raša in Istria, which makes it the largest and most important national port. The reference year of the document is 2019, for which, among other things, the total cargo traffic, manoeuvres, tangents and the number of passengers are shown. The focus of this document is the part of the management area of the Port of Rijeka Authority that refers to the area of the port basins of Rijeka and Sušak, which were granted by concession to the companies Port of Rijeka j.s.c. and Adriatic Gate Terminal ltd. for the use of port infrastructure and superstructure and performing activities in the port area. These companies also represent two key stakeholders.

The GHG inventory included in the assessment of the needs of the area of this document consists of three parts of terrestrial emissions (related to relevant sources of emissions on the land side of the port area, maritime emissions (related to relevant sources of emissions on the sea side of the port area) and total emissions which include a summary of all emissions for the considered port.

To estimate terrestrial emissions, in the observed area, the energy consumption of electricity and fuel in the categories of cargo handling equipment, working machines and trucks (trucks) is analysed. As for maritime emissions, they refer to the three basic activities, namely shunting ships, anchored ships and moored ships, and depend on the characteristics of ships and the duration of these activities within the port.

A carbon footprint or carbon footprint is an analysis used to determine emission sources, track emission trends, and provide the information needed to determine where ports can focus efforts to reduce their greenhouse gas emissions. The carbon footprint of port operations is an important indicator of their relative impact on the climate.

Port Area

The history of the modern development of the port of Rijeka dates back to 1719 when free navigation across Adriatic sea was proclaimed under the leadership of Austiran monarch Karl the VI. In 1867 the construction of the port basin began and Rijeka achieved status of the main station of the Hungarian economy and in the following years it was connected with Budapest by trail. Historical world and regional events in years to come will lead to numerous ups and downs of the port's business. One of the most important years in the modern history is the year 1996 when the Port of Rijeka Authority was established by decision of the Government of the Republic of Croatia as non-profit institution for management, development and use of the port of Rijeka.

With the accession of the Republic of Croatia to the European Union, the port of Rijeka was included in basic transport TEN-T network of the EU, thus taking over the status of the main port on the Mediterranean Corridor and accession in the Baltic-Adriatic Corridor is underway.

Today, the Port of Rijeka Authority is responsible for the port of Rijeka, which is a development-oriented port with port basins specialized in types of cargo. The port includes a number of port basins: Rijeka, Sušak, Bakar and Omišalj (island of Krk) and Raša- Bršica in Istria, which makes it the largest and one of the most important national port. The focus of this document is the part of the Rijeka Port Authority management area that is related to the Rijeka and Sušak port basins, with the exception of the Porto Baroš area which, in accordance with the spatial planning documentation of the City of Rijeka, is separated from the port area. The Sušak basin also includes the Brajdica Terminal. In the Rijeka basin there are terminals specialized in passenger traffic, general cargo, cereals, phosphates and fruit, while in the Sušak basin the terminals are equipped for handling containers, general cargo and wood.

Terminals of the Rijeka basin:

Terminal for general cargo is intended for transhipment and storage of classic general cargo, but it also has specialized units for transhipment of paper, wood, metallurgical products, dangerous goods, heavy cargo, frozen and conditioned food, and cargo processing capacities. The terminal is equipped with 4 mobile cranes with a capacity of 40 - 63 t, coastal cranes with a capacity of 5 - 84 t, truck cranes with a capacity of 6 - 100 t, forklifts, trucks, tractors, trailers and has the appropriate storage infrastructure. The terminal can accommodate ships up to 30,000 DWT.

Terminal for cereals it is intended for manipulation and storage of cereals and oilseeds, and has equipment for drying, aeration, weighing, disinfection and deratization. The transhipment capacity of the terminal is 400 t / h, and it can accommodate ships up to 60,000 DWT. The maritime passenger terminal, located on the Rijeka breakwater, was opened for traffic in 2009. Within this terminal there is a modern equipped port control center for monitoring ship traffic, but also for safety and protection of the sea from pollution. The control center has a system for monitoring maritime traffic and communication with ships, which consists of an electronic nautical chart (ECDIS) on which, from the radar sensor and the automatic ship identification system (AIS), are integrated. Additional system integration consists of a VHF communication system, hydrometeorological data, video surveillance of water areas and port areas, and an information system for managing and planning business (PMIS) of maritime activities in the port area.

Zagreb Deep Sea container terminal is the most important component of the comprehensive revitalization of part of the Rijeka coastal area, which was carried out within the Rijeka Gateway project. The first phase of construction of the terminal was completed in 2019, and further construction is the responsibility of the future concessionaire. Ultimately, the terminal will have possibility for mooring the latest generation of container ships with a capacity of more than 14,000 TEU and up to 165,000 DWT, and at the same time mooring a smaller ship up to 50,000 DWT with a capacity of up to 4,000 TEU. The terminal will be connected to the main network of the TEN-T corridor by the planned state road DC403.

In the Sušak Basin, in the area of Brajdica Terminal, there is a container terminal Adriatic Gate Terminal which is primarily intended for handling containers and cargo transported in them (loading and unloading of containers, acceptance and delivery of containers from / to trucks / railways, container washing, fumigation and assistance with customs or phyto -sanitary inspection, sealing and storage of cargo, filling and emptying of containers). The expansion of the container terminal was completed in 2013 when new equipment was installed (2 Panamax high-capacity coastal cranes, 6 container bridges, 2 container bridges for railways) and increased storage space for containers to 600,000 TEU, which required the reconstruction of railway station Rijeka-Brajdica and the construction of a new intermodal terminal, which was realized in 2020. The container terminal also includes a veterinary-phytosanitary inspection station (BIP - Border Inspection Point) where the control of products imported into the EU is performed.

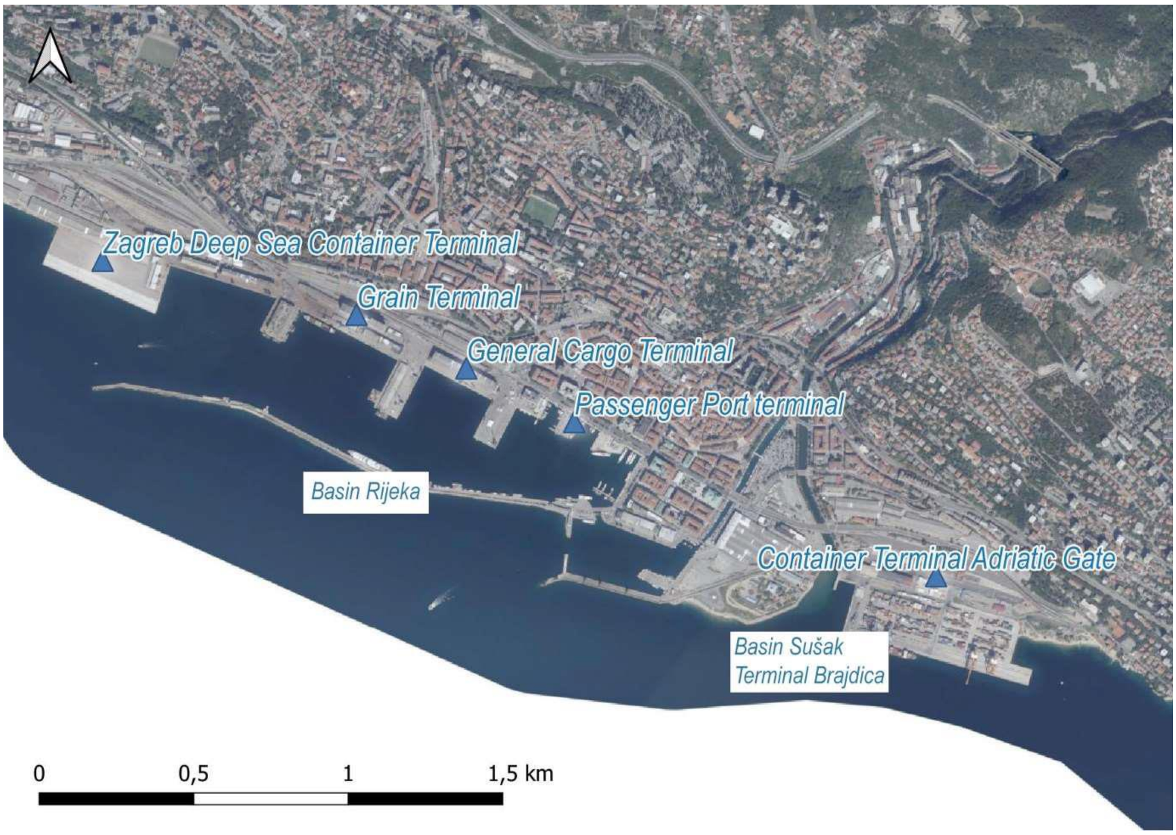

Figure 1: Terminals Rijeka and Sušak basins

At all terminals of the Rijeka Basin, the concession activity, which includes the performance of port activities, as well as other economic activities that require the use of existing and / or construction of new buildings and other substructure and superstructure facilities in the port area, is performed by Port of Rijeka j.s.c., while the Adriatic Gate Terminal of the Sušak Basin is mostly in the concession of the company Adriatic Gate Terminal d.d. (Adriatic Gate Terminal d.d. - 51%; Port of Rijeka j.s.c. - 49%). Also, a third concessionaire is being introduced, for the Zagreb Deep Sea Container Terminal (ZDSCT) area. Port of Rijeka is connected to the Trans-European Road Network (TEN-T) by road and rail infrastructure which is part of the Mediterranean Corridor of the TEN-T Basic transport network. This corridor connects the south of the Iberian Peninsula, passes through the Spanish and French Mediterranean coast through the Alps in northern Italy, then enters Slovenia and goes further, towards the Hungarian-Ukrainian border. An integral part of the Mediterranean Corridor is the route Rijeka-Zagreb-Budapest (rail and road). Port of Rijeka j.s.c. is one of a key port on the Mediterranean Corridor (TEN-T Core ports), and in order to improve the infrastructure of the port area, the Port of Rijeka Authority used CEF (Connecting Europe Facility) funds to modernize railway infrastructure and build new intermodal capacities in the port of Rijeka, reconstruction of the port for general cargo and implementation of the Port Community system information system. Ultimately, the main goal is to develop the port of Rijeka into one of the important transit ports in the northern Adriatic for European markets. Its ongoing connection to the Baltic-Adriatic TEN-T network corridor will also contribute to this.

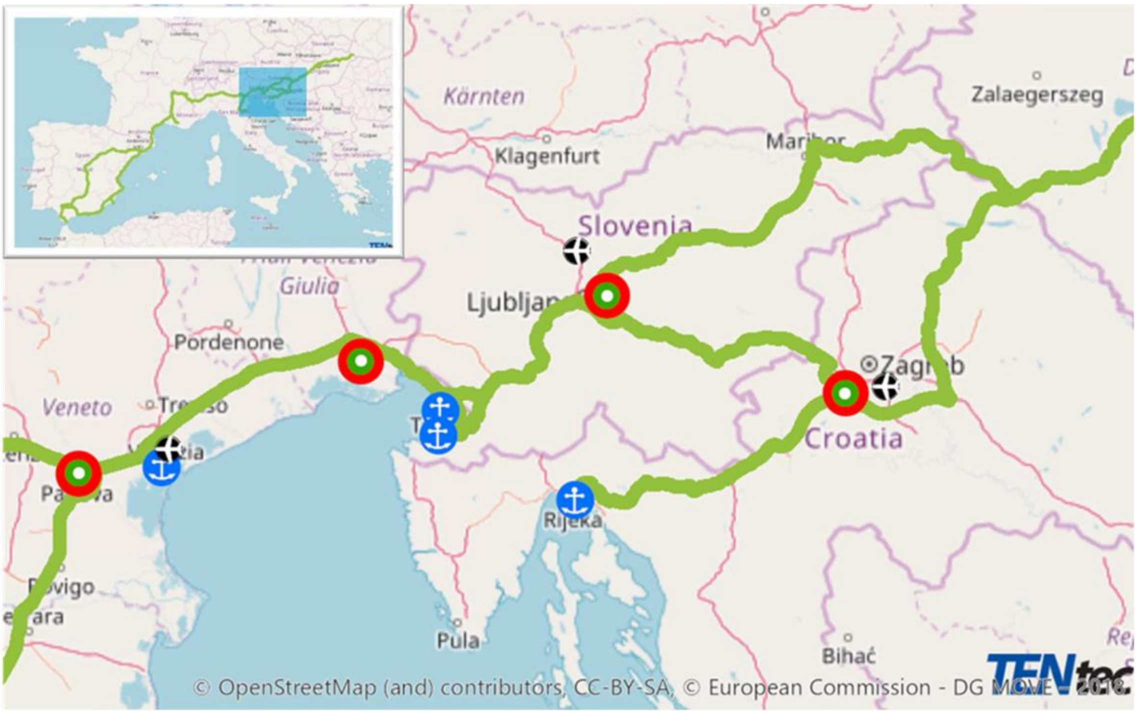

Figure 2: TEN-T Mediterranean Corridor Road Network (TENtec Interactive Map Viewer)

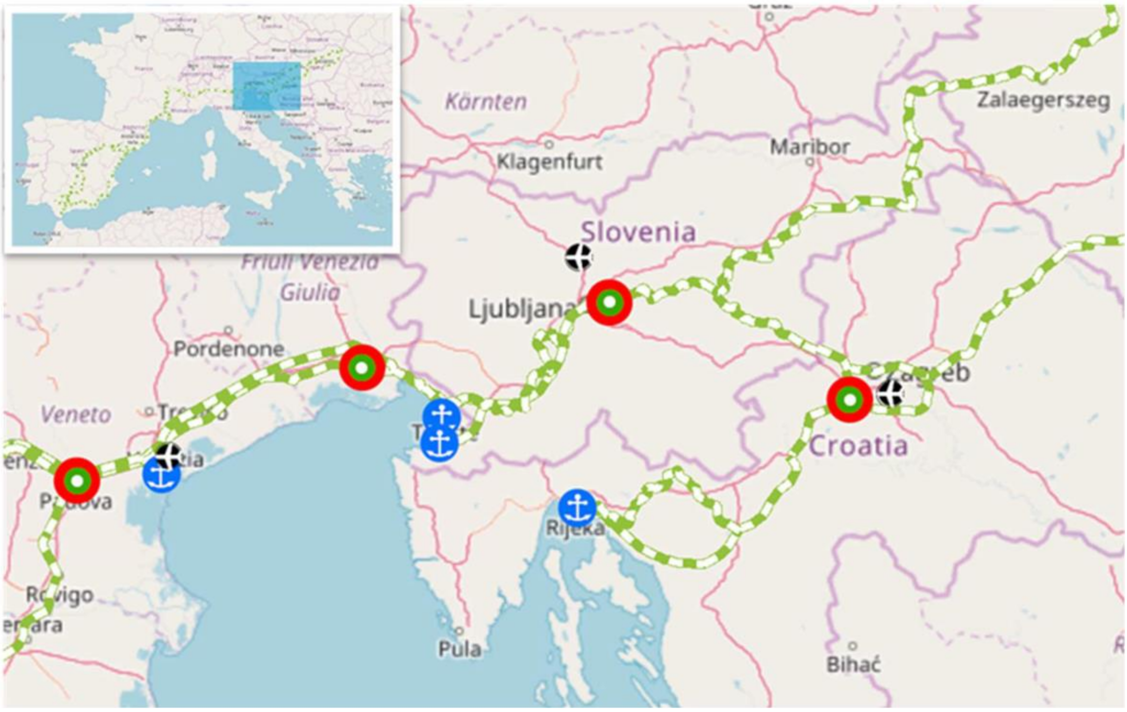

Figure 3: TEN-TMediterranean Corridor Rail Network (TENtec Interactive Map Viewer)

As the port of Rijeka is part of the northern Adriatic port cluster (Rijeka, Koper, Trieste, Venezia, Ravenna, Monfalcone and Chioggia), its gravitational area is represented by Italy, Switzerland, Germany, Austria, Croatia, Slovenia, Bosnia and Herzegovina, Serbia, Hungary, Slovakia, Czech Republic and Poland.

Also, the "Rajna-Majna-Dunav" Canal, which is the largest European inland waterway, passes through the gravitational area. For traffic passing through the Suez Canal, the northern Adriatic route has a significant advantage over the North Sea (e.g. ships heading in the direction of Europe travel shorter by 2,000 Nm). For comparison, in addition to the gravitational area of the port of Rijeka, the picture below shows the maritime route from the port of Hamburg.

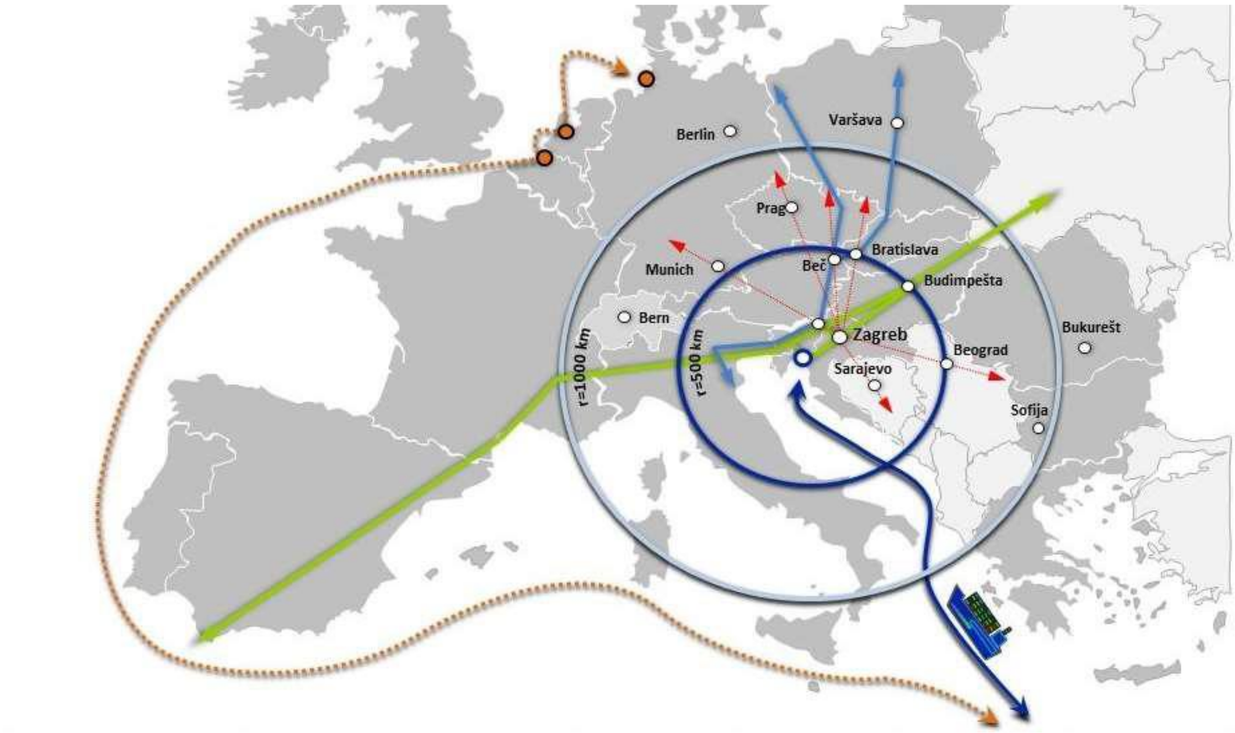

Figure 4: Gravitational area of the port of Rijeka (Source: https://lukarijeka.hr/profil-tvrtke/zemljopisni-polozaj/)

Land distances (km)					
Budapest	Bratislava	Vienna	Munich	Prague	Belgrade
504	550	490	560	810	569
Sea distances (Nm)					
Malta	Port Said	Singapore	Hong Kong	Shanghai	Busan
700	1.254	6.268	7.720	8.500	8.770

Table 1: Distances of the port of Rijeka from certain destination markets

Thanks to its exceptional geo-traffic position which enables the shortest maritime connection between the countries of Central and Eastern Europe and overseas, today, the port of Rijeka is a traffic center and the main transit port of the Republic of Croatia. Below is the total cargo traffic realized in the reference year 2019 in the area under the jurisdiction of the port of Rijeka Authority.

During all months, it is dominated by liquid cargo, which, although to a much lesser extent, is followed by general cargo. The total turnover in the year in question was 11,488,542 tons.

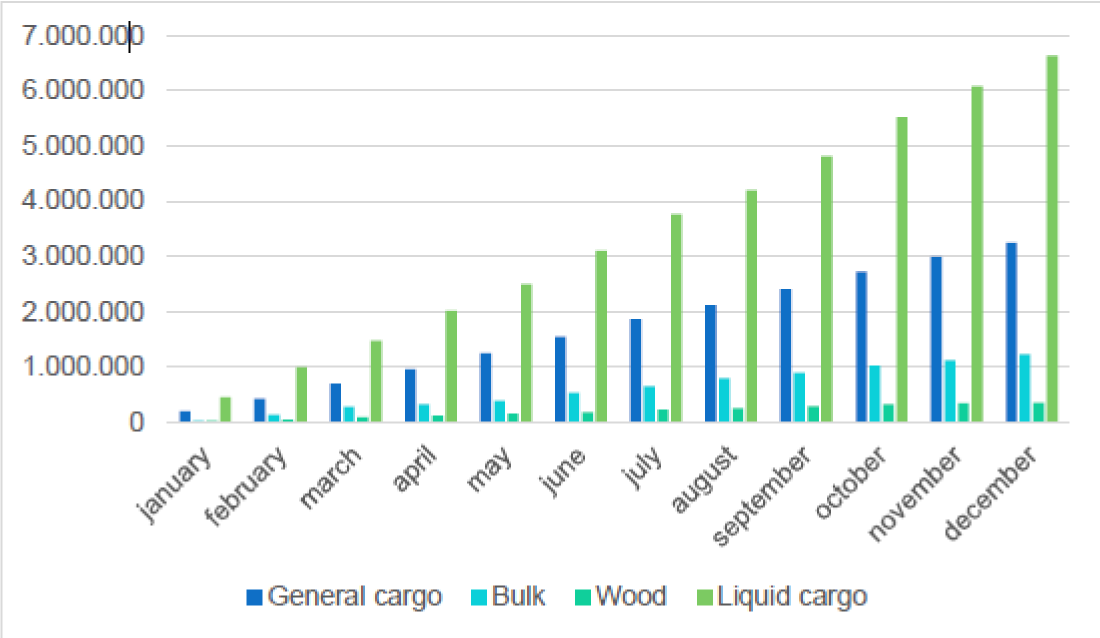

Figure 5: Monthly freight turnover (expressed in tonnes) in the port of Rijeka in 2019

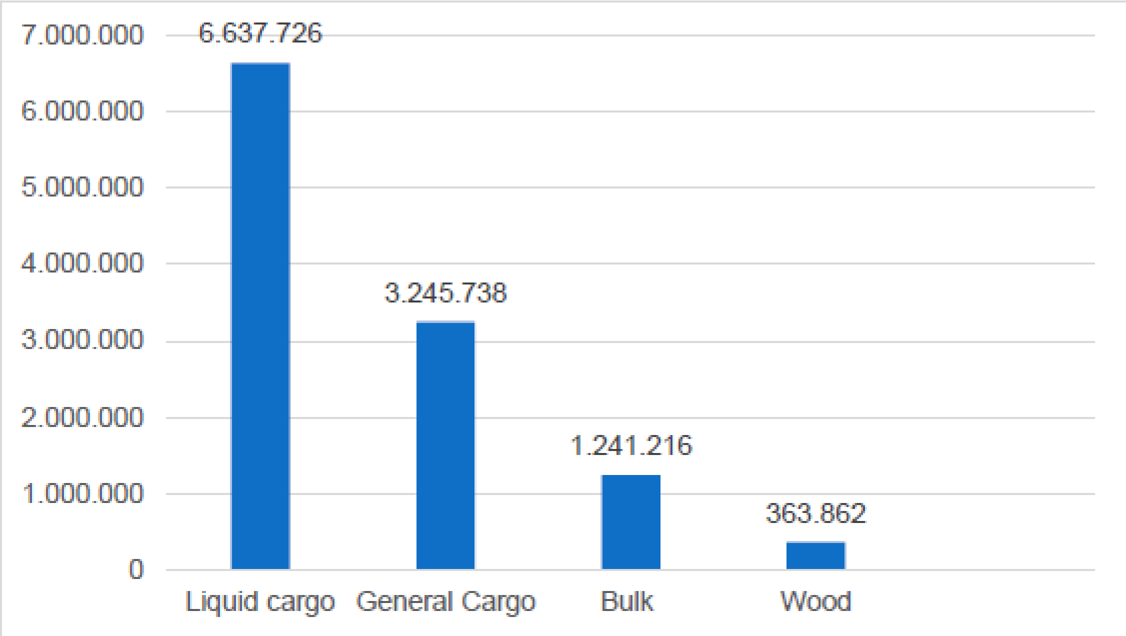

Figure 6: Total turnover of certain types of cargo (expressed in tonnes) in 2019

When it comes to ship traffic, the number of recorded manoeuvres in the area under the supervision of the Port Control Center during 2019 is 4,880, of which 3,255 manoeuvres were realized in the area under the jurisdiction of the Port of Rijeka Authority.

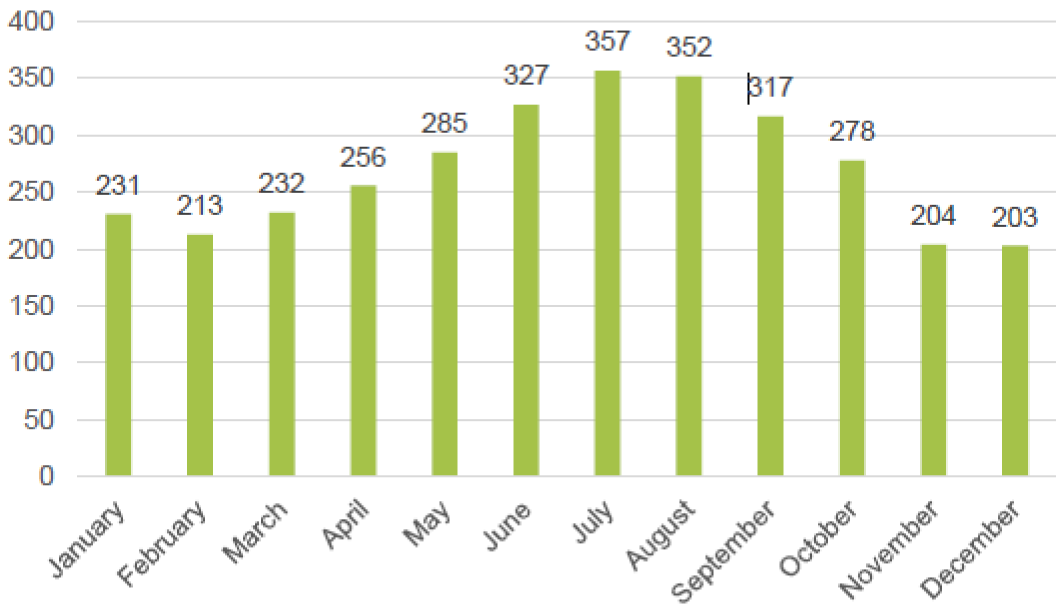

Figure 7: Total monthly number of manuvres in the area of the Port of Rijeka Authority in 2019

Furthermore, the largest traffic in the port of Rijeka was recorded in the Sušak Basin (including the Brajdica Terminal) and amounts to 1554, which represents about 48% of the total port traffic, while the share of the Rijeka Basin in total traffic is 36% (1181 manoeuvres).

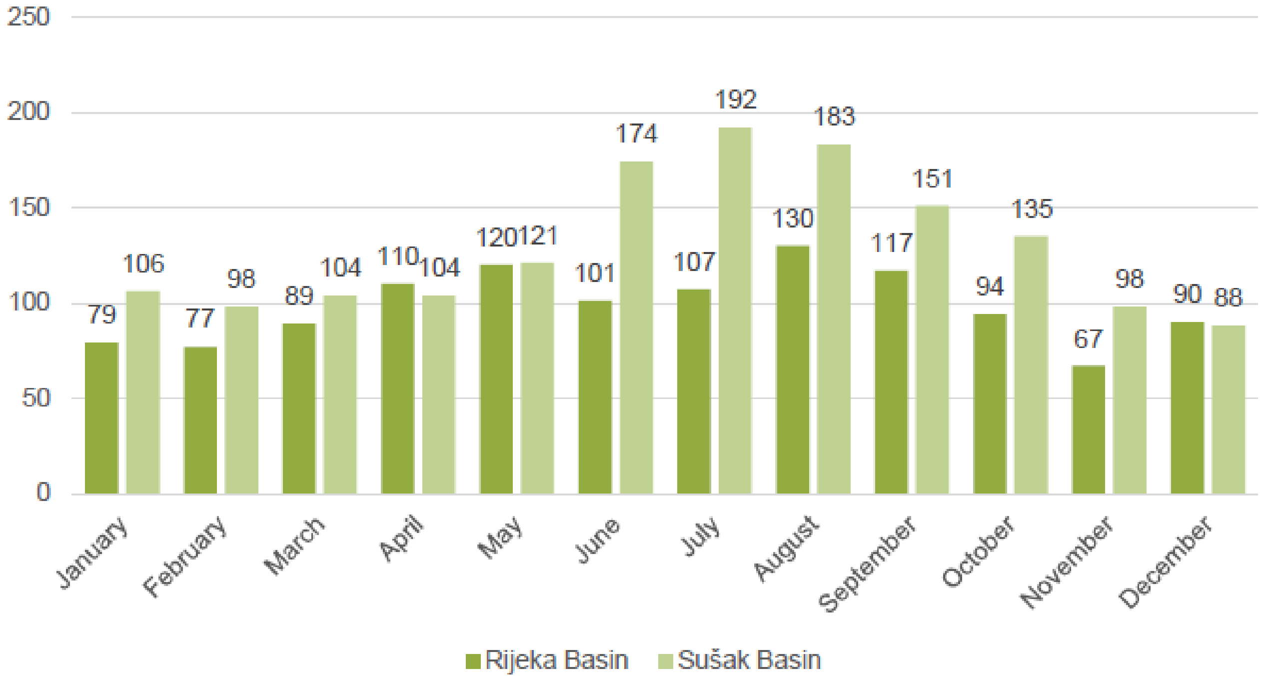

Figure 8: Monthly number of manoeuvres in Rijeka and Sušak basin in 2019

During 2019, the highest passenger traffic was achieved in the port of Rijeka in the period from 2010, amounting to 187,567 passengers. The following figure shows the passenger traffic according to the mode of transport as well as the number of passenger ships. Given the nature of the data provided, the number of passengers on yachts is not expressed.

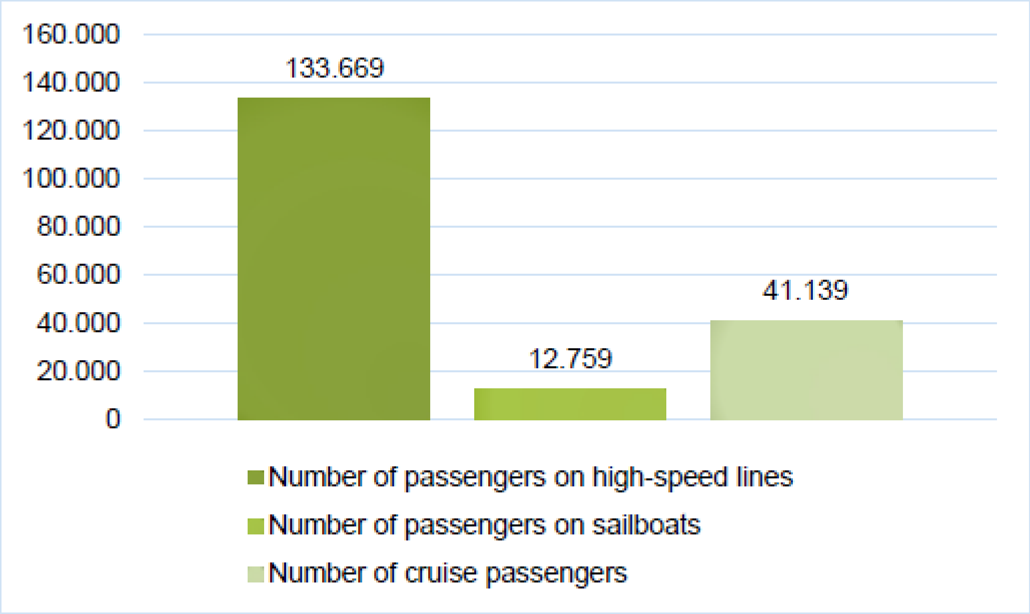

Figure 9: Number of passengers in 2019

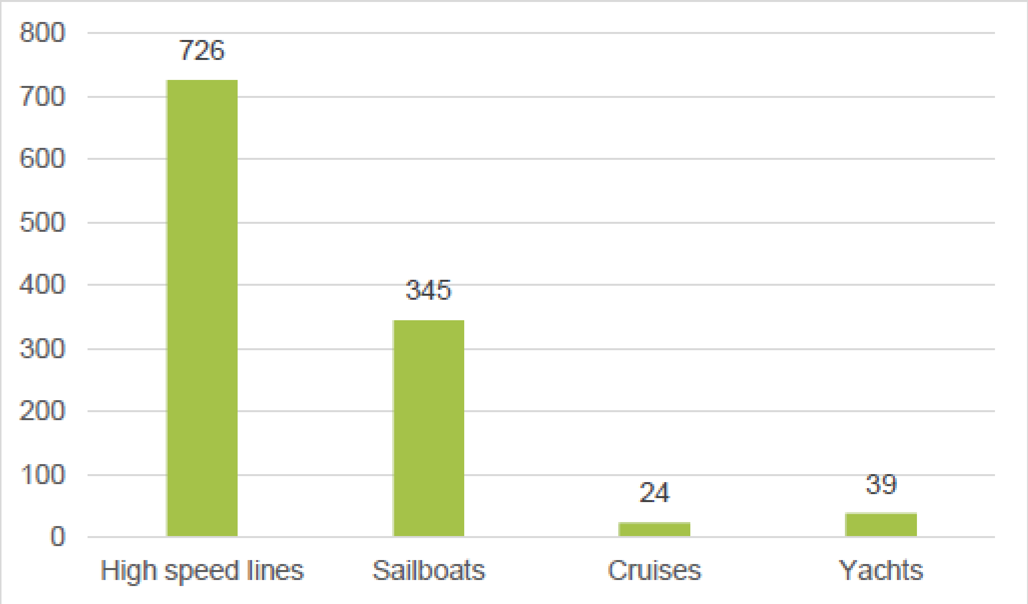

Figure 10: Number of calls for passenger ships in 2019

Mapping out stakeholders

This chapter covers the mapping of stakeholders of the Port of Rijeka Authority and exclusively refers to the participation of stakeholders in future actions that will result from the guidelines proposed by the Action Plan for the Development of Environmental Sustainability and Energy Efficiency. The purpose of the analysis and mapping is to point out the possibilities of cooperation of stakeholders that will ultimately contribute to improving the functionality of the port in terms of reduction environmental pressures, and at the same time contribute to raising green business within their activities.

The largest share of stakeholders of the Port of Rijeka Authority refers to concessionaires for performing certain activities of the port itself. According to the Maritime Property and Seaports Act (NN 158/03, 100/04, 141/06, 38/09, 123/11, 56/16, 98/19), concessionaires differ according to the concession requirements related to the need to use existing or construction of new buildings in the port area.

In the area of the Rijeka and Sušak Basins managed by the Port of Rijeka Authority, a concession for the use of port infrastructure and superstructure and the performance of activities in the port area was awarded to the companies Port of Rijeka j.s.c. and Adriatic Gate Terminal ltd. which also represent two key stakeholders. The concessionaire Luka Rijeka uses most of the area of the port of Rijeka in the field of port and other economic activities band the provision of transhipment and storage services for all types of cargo (general, bulk cargo and wood), except oil and petroleum products. Adriatic Gate Terminal ltd., which is owned by International Container Terminal Services Inc. (ICTSI), has a concession at the Container Terminal Brajdica together with the company

In the Port of Rijeka j.s.c., the largest share of concessionaires performing other economic activities in the port area is included in the category of stakeholders who at the operational level can contribute to the implementation of actions within the proposed guidelines. This primarily refers to concessionaires who, within their activities, have the possibility to act "in situ", to a significant extent participate in the land transport of the port area or participate in the promotional activities of the port.

Given the possibilities of decision-making at the local, county and national level, and having in mind the management structure of port authorities and the continued development of the port of Rijeka in accordance with the principles of environmental sustainability, relevant stakeholders have been defined. derive from the proposed guidelines.

In the following table, the stakeholders are classified according to their importance, i.e. potential interest and the level of their influence on the implementation of the guidelines for the recommended development of the port of Rijeka.

		Level of influence	
		Low	High
Interest	Low	• Port of Rijeka Authority	• City of Rijeka • Primorje Gorski Kotar County • Line ministries • Regulators and operators in the energy sector
	High	• Towing concessionaires • Ship fuel concessionaires • Ship supply concessionaires • Concessionaires for receiving and shipping waste • Passenger service concessionaires	• Port of Rijeka j.s.c. • Adriatic Gate Terminal ltd.

Table 2: Mapping stakeholders by importance

The table below provides an overview of the basic characteristics of stakeholders important for the implementation of measures in the area managed by the Port of Rijeka Authority. The table shows that the contribution of stakeholders is the largest in the field of direct implementation of future activities that will result from the proposed guidelines, while the benefit of stakeholders in most cases is reflected in reducing costs and improving green business. Existing, but also potential conflicts that may occur during the implementation of future activities, especially in the process of energy renovation of buildings, are mostly related to the harmonization of conservation conditions for protected cultural assets with the implementation of new technologies. Ultimately, raising awareness and knowledge about sustainable port development, as well as multi-stakeholder dialogue were recognized as basic strategies that would contribute to strengthening support for further port development towards a lower carbon footprint and improving the quality of environmental components.

Stakeholders roles	Importance	Stakeholders	Contribution	Stakeholders benefits	Potential and existing conflicts	Existing support	Support empowerment
Key	High	Port of Rijeka j.s.c.	• Direct implementation of future activities in the domain of the concession agreement • Partnership on projects • Support in technological and infrastructural development	• Expected reduction in operating costs in the long run • Improving the company's activities in the direction of green business	• Difficult implementation of measures on facilities that are protected as cultural property	• Partnership on projects • Performing port and other economic activities • Providing cargo handling and storage services	Raising awareness and knowledge about sustainable port development
		Adriatic Gate Terminal ltd.					
Relevant	High	City of Rijeka	• Partnership on projects	• Improved state of the environment • Raising the level of satisfaction of the population • Raising quality tourist services	• Difficult implementation of measures on facilities that are protected as cultural property	• Partnership of projects	
		Primorje Gorski Kotar County			• Harmonization of energy efficiency improvement measures with measures for the protection of cultural property		
Operational	Medium	Line ministries	• Jurisdiction in the procedures necessary for the implementation of measures (approval, consent, opinion)	• Achieving the set national strategic goals	/	/	
		Regulators and operator sin the energy sector		/	• Energy system overload / balancing difficulties		
	High	Ship fuel concession aires	• Direct implementation of future activities in the domestic concession agreement	• Expected reduction in operating costs in the long run • Improving the company's activities in the direction of green business	• Expected reduction / absence of demand for fossil fuels	• Performing other economic activities important for the port's operations	
		Ship supply concession aires			/		
		Concession aires for receiving and shipping waste					
		Towing concession aires					
	Medium	Passenger service concession aires	• Direct implementation of future activities in the domestic concession agreement	• Expected reduction in operating costs in the long run • Improving the company's activities in the direction of green business	/		
Peripheral	Low	Port of Rijeka Authority	• Direct implementation of future activities in the domestic concession agreement • Wider positive effects of the implementation of measures	• Expected reduction in operating costs in the long run • Improving the company's activities in the direction of green business	/	• Performing the tasks of navigation safety and supervision of maritime property	

Table 3: Stakeholder characteristics in relation to the requirements of the measures

Carbon footprint emissions estimation

Greenhouse gases trap heat in the atmosphere and warm the planet. The main gases responsible for the greenhouse effect include carbon dioxide, methane, nitrous oxide, and water vapor and fluorinated gases. CO_2 is the most important gas. It absorbs less heat per molecule than the greenhouse gases methane or nitrous oxide, but it's more abundant and it stays in the atmosphere much longer. Increases in atmospheric CO_2 are responsible for about 2/3 of the total energy imbalance that is causing temperature to rise. The concentration of atmospheric CO2 in 2019 sets a historical record. According to recent accessible data, CO2 emission trend is exponential, and emission is exceeded each year (Blunden & Arndt, 2020). Maritime transport emits around 940 million tonnes of CO_2 per year and is responsible for around 2.5% of global greenhouse gas (GHG) emissions (3rd IMO GHG study), and growth is projected. It is estimated that emissions from shipping could, according to the usual scenario, increase between 50% and 250% by 2050. Nevertheless, it is considered that there is a significant untapped potential for economical reduction of ship emissions, through various technical and operational measures.

As far as Europe is concerned, emissions from shipping represent around 13% of total EU greenhouse gas emissions from the transport sector (2015), and in 2013 the Commission adopted a Strategy to reduce greenhouse gas emissions from the shipping industry. The strategy consists of 3 consecutive steps:

- Monitoring, reporting and verification of CO2 emissions from large ships using EU ports
- Greenhouse gas reduction targets for the maritime transport sector
- Further measures, including market-based measures, in the medium and long term.

A carbon footprint is an analysis used to determine emission sources, track emission trends, and provide the information needed to determine where ports can focus efforts to reduce their greenhouse gas (GHG) emissions. Overall, the carbon footprint of port operations is an important indicator of their relative impact on the climate. Based on the data collected from the port area, data processing and calculation of actual emissions are carried out according to the indications of the IPCC (2006). These reference documents provide calculation approximation levels, the so-called calculation levels defined by the IPCC (2006) and the EMEP / EEA (2019) are three different levels of accuracy of the calculation or estimation of greenhouse gas emissions related to area or activity.

Tier 1: the simplest and, therefore, the most valued and least accurate. In the case of Tier 1 , a simple linear correlation between activity data and emission factor is applied. Activity data are derived from already available statistics (energy, production, traffic counting, etc.). The emission factor selected for Tier 1 must represent the "typical" or "medium" process conditions.

Tier 2: middle between Tier 1 and Tier 3. In the case of Tier 2, the same (or similar) activity data (statistical, estimated or average) are used, but more specific emission factors are used (by country or for example geographical area).

TIer 3: the most complex and accurate. The level of calculation of Tier 3 is more accurate than the previous ones, because it includes consumption data directly collected from the analysed activities, ie. detailed information on consumption and fuels or complex estimation models.

Depending on the availability of data, Tier 1 (emissions from ships) or Tier 2 (emissions from shore-side electricity consumption and road transport) were used. Factors from the report to the European Commission's Directorate-General for the Environment, Quantification of emissions from ships related to the movement of ships between ports in the European Community (Entec), were used to calculate CO2 emissions from ship traffic.

Factors for electricity, motor gasoline and diesel (in road transport) are from the Annual Energy Report: Energy in Croatia (2018), and it was published by the Ministry of Environmental Protection and Energy, which provides an energy audit to inform the domestic and foreign public on relations and trends in the Croatian energy system.

The conversion and emission factors used are shown below.

	Energy value (lit/MWh)	Emission factor (tCO_2/MWh)
Electric energy		0,106
Diesel	0,0119	0,267

Table 4: Energy values and emission factors

The GHG inventory included in the territorial needs assessment consists of three parts:

• **Terrestrial emissions**: related to relevant emission sources on land -side of the port area

• **Maritime emissions**: related to relevant emission sources on sea-side of the port area

(emissions from all ships and vessels within the port area during anchoring, manoeuvring and mooring phase)

• **Total emissions**: including a complete summary of all emissions for the considered port.

Terrestrial emissions

The categories included in total terrestrial emissions are:

- Electricity (through consumption in buildings, public lighting, cargo handling equipment and working machines)
- Cargo handling equipment (various types of cranes)
- Working machinery (motor and electric forklifts, backhoes and loaders, tractors, tugs, trucks and combined vehicles)
- Trucks

Data for electricity, cargo handling equipment, and working machines are shown in relation to the Rijeka and Sušak basins.

Electric energy

In the area of the Port Authority, there is a significant consumption of electric energy, which is used in the forms - electricity, heating and cooling. Electricity supply is done through substations that provide electricity for:

- Buildings: administrative building, approximately 12 warehouses (currently works on demolition of certain warehouses), refrigerated warehouse, workshops, buildings for inspection of goods
- Equipment and machinery (equipment for handling cargo that requires electricity, such as shore cranes, then working machines that have batteries for electricity such as electric forklifts, etc.)
- Public lighting

SUBSTATION	POWER AREA
SUBSTATION TS1- ˝Splitska˝	• Customs entry • Warehouses 26,27,29, 30 and 35 • About 15 different tenants in warehouses • Locksmith workshop, material warehouse, maintenance plant, INA garage • Outdoor lighting
SUBSTATION TS2- Warehouse 19	• Metropolis warehouses, which under cultural and industrial protection, 18,19,20 and 21 (warehouses 18,19 and 20 are not used) • Container next to warehouse 22, elevators in warehouses 21/22 • HŽ office
	• Forklift workshop • Cranes next to the pier *Praško pristanište* • Cranes at pier *Bratislavsko pristanište*
SUBSTATION TS3-Silos (+TS-3A Refirgerated warehouse)	• Warehouse 12 (Port of Rijeka j.s.c., Jadranski pomorski servis), 15, 16 i 17 • Cranes at pier Orlandov gat and near refrigerated warehouse • Refrigerated warehouse Frigo Ri
SUBSTATION TS4- De Franceschi (TS4A- Riva Boduli, Gat Karoline)	• Administrative building • Pier Gat Karoline • Customs entrance in Žabica • Crane on De Francheschi Pier • Outdoor lighting
SUBSTATION TS5 I TS5A	• Terminal Building • Breakwater • Building ex. Disinsections • Outdoor lighting
SUBSTATION T5B	• Future substation for the ship- museum Galeb
SUBSTATION TS3- Brajdica, TS3 BM, TS4 B Adriatic Gate Terminal	• Adriatic Gate Terminal

Table 5: List of substations and their power area

Below are photos of some substations.

Figure 11: Substation TS2

Figure 12: Substation TS3

Figure 13: Substation TS5

Electricity consumption was delivered as follows:

Rijeka Basin	Category	Electric energy consumption (kWh)
Terminal Rijeka	Refrigerated warehouse	60.000
	TRID (warehouse lighting, coastal cranes, heating)	979.234
	TRIG (warehouse lighting, coastal cranes, heating)	4.220.765
	Total	**5.259.999**
Terminal Silos		**256.280**
LTR and RTS service	PLTR(offices, waiting room, heating)	20.220
	PRST (offices, heating, garage)	225.742
	Total	**245.962**
Maintenance	Offices, heating, workshops	**145.953**
Mooring and unmooring service	Offices, heating	**24.084**
Transits service	Offices, heating	**4.816**
Administrative building	Offices, heating	**195.302**
	TOTAL	**6.132.396**

Table 6: Electricity consumption in Rijeka basins

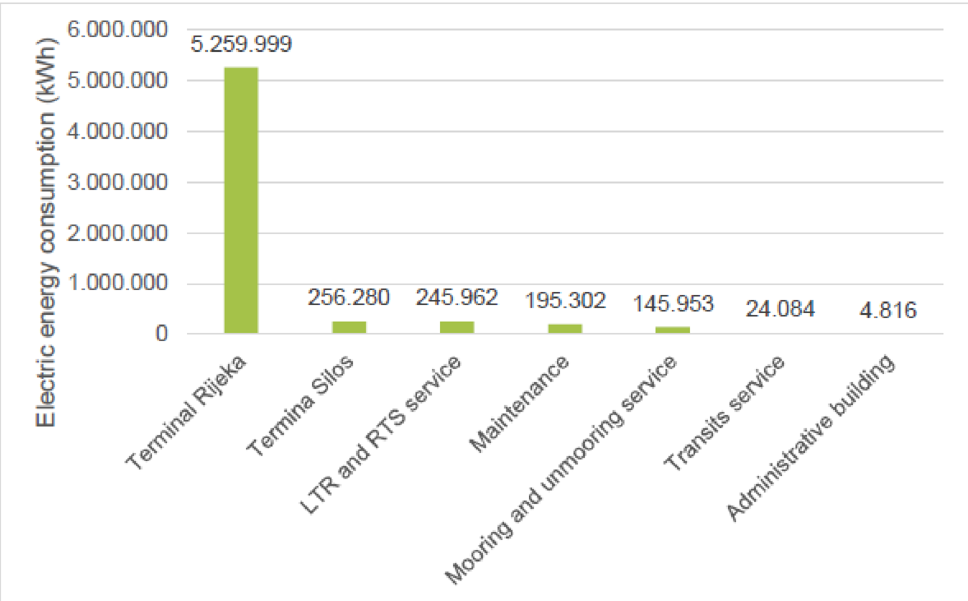

Figure 14: Electric energy consumption in the area of Rijeka Basin

It is important to note that the electricity consumption of the cranes is shown in this section, while the diesel fuel consumption is shown in the next section. The total electricity consumption in the area of the Rijeka and Sušak basins is 9,467 MWh, while the total CO2 emissions are 1,003.48 tons.

	Electric energy (MWh)	CO_2 (t)
Rijeka Basin	6.132	650,03
Sušak Basin	3.334	353,44
Total	**9.467**	**1.003,48**

Table 7: Total electric energy consumption and CO2 emissions

Port operational equipment

The basic port operational equipment for cargo handling at the piers and docks in the area of the Port Authority are cranes, of which there are a total of 30 in the analysed area, of various operating classes and capacities. The basic divisions of cranes are:

- Coastal cranes
- Coastal container cranes
- General load truck cranes
- Container truck cranes
- RTG crane (portal)

Some of the cranes are also mobile and they are distributed to all piers as needed. The listed cranes refer to:

	Category	Type of crane	Number of cranes	Number of working hours	Fuel (lit.)
Rijeka Basin (Port of Rijeka)	General load truck cranes	Demag	14	1.074	3.553
		Locatelli 2	2		
	Container truck cranes	Kalmar	1	8	234
	Coastal cranes	3 PLO6/3TE	2		
		Fantuzzi	3		
		Cranes - pier *Bratislavsko pristanište*	2		
		˝Metal˝ crane	1		
		Liebherr	2		
		Cranes- pier *De Franceschi*	3		
Brajdica (Adriatic Gate Terminal)	Container truck cranes	Kalmar	4	11.300	157.000
	Coastal container cranes	Samsung	2	6.950	-
		ZPMC ZP51T	2		
	Mobile RTG crane	(ZPMC RC/41MT)	6	20.966	460.000

Table 8: Amount of operational equipment in the Rijeka basin and in Brajdica

Photos of some cranes are shown below.

Figure 15: Container truck crane, type Kalmar

Figure 16: Coastal cranes on pier Orlandov gat, type Liebherr

Figure 17: Metal˝ crane near Silos

Figure 18: Coastal cranes on pier Bratislavsko pristanište

Figure 19: Cranes on the area of Brajdica Terminal, pier Kostrensko pristanište (source: www.portauthority.hr)

The total fuel consumption (diesel) of cargo handling equipment, and various types of cranes is 7,387 MWh, which is 1,972.43 tons of CO_2.

	Energy consumption-diesel (MWh)	CO_2 (tonnes)
Rijeka Basin	45	12,03
Sušak Basin	7.342	1.960,39
Total	**7.387**	**1.972,43**

Table 9: Energy consumption (diesel) at port operational equipment (cranes) and CO2 emissions

Service vehicles

In the area of the Port Authority, there are various service vehicles that are used for port activities and cargo handling, and they use diesel as a fuel. Motor forklifts are used for handling pallet and other heavy loads. In addition to motorized forklifts, there are also electric ones that use electricity stored in batteries located inside each vehicle. In addition to forklifts, tractors are one of the most used means of transport and handling of small loads. Backhoe loaders and loaders are among the top machines used to manipulate loose material. Trucks, tractors and combined vehicles are used for transport within the port area.

	Service vehicles	Type	Number of vehicles	Number of working hours	Fuel (lit.)
Rijeka Basin (Port of Rijeka)	Motor forklifts	Hyster	1	14.977	81.388
		Kalmar	6		
		Fantuzzi	2		
		Indos	2		
		Boss	2		
		Still	1		
		Hyster	1		
		Linde	21		
	Backhoes and loaders	Zetelmyer	2	14.437	12022
		STT	1		
		ULT	1		
		Bobcat	2		
		Caterpilar	2		
		Liebherr	2		
	Tractors	Torpedo	38	14.437	6.622
		Zetor	5		
	Tugs/trucks/vans/combined vehicles	Kalmar	2		12.778
		Truck Iveco	1		
		Truck TAM	1		
		Van Renault	1		
		Van Opel	1		
		Van Boxer	1		
Brajdica (Adriatic Gate Terminal)	Motor forklifts	Still	2	3.050	650
		Fantuzzi	1		
	Electric forklifts	Still	1		150
	Tugs/tractors	MAFI	9	226.000	33.472
		Kalmar	5		

Table 10: List of service vehicles in Rijeka basin and Brajdica

Photos of some working machines are shown below.

Figure 20: Motor forklift, type Fantuzzi

Figure 21: Electric forklift, type Linde

Figure 22: Tractors, type Torpedo

The total fuel consumption (diesel) for service vehicles is 1,758 MWh, which is 469.39 tons of CO_2.

	Fuel consumption-diesel(MWh)	CO_2 (tonnes)
Rijeka Basin	1.350	360,50
Sušak Basin	408	108,89
Total	**1.758**	**469,39**

Table 11: Fuel consumption for service vehicles and CO2 emissions

Heavy-duty vehicles

To calculate emissions due to the traffic of heavy duty vehicles (trucks) in the port area, it was necessary to collect data on the number of transits, and the estimated average route within the port in order to obtain an appropriate estimate. ISO EN 16259: 2013 was used to calculate the emission factor, ie the Methodology for the calculation and declaration of energy consumption and greenhouse gas emissions (GNG). The factor used is Et, and denotes Tankto- wells and refers to emissions only due to vehicle consumption, without considering fuel production and supply, assuming the use of diesel fuel, in a form not mixed with biofuels. In the result of the emission calculation, a percentage of 5.6% is added, as an estimate of the stopping and manoeuvring of trucks in the port area. (Jääskeläinen, 2017)

Trucks refer to trucks coming to the port area and for which it is necessary to obtain daily permits. The Port Authority has introduced a software solution for the control of the entrance of the fireplace to the port area, which simplifies the logistical process of entry and control of vehicles and drivers. In the daily permit, the truck can enter and leave the port area several times. According to statistics, the number of issued daily permits was 70,000, and due to more entries / exits, 100,000 trucks were taken as a reference number, which make an average route of 3.3 km through the port area (from the entrance to Mlaka to Brajdica). Regarding the assessment of fuel consumption, the reference values from the Ordinance on the system for monitoring, measuring and verifying energy savings (NN 33/2020) were used.

	Energy consumption - diesel (MWh)	CO_2 (tonnes)
Total	1.681	398,23

Table 12: Energy consumption (diesel) for heavy- duty vehicles and CO2 emissions

Overall terrestrial emissions

Overall terrestrial emissions are calculated for the category of electric energy, port operational equipment (cranes), service vehicles, trucks. The highest emissions are in the category of equipment for cargo handling, more than 50%, followed by emissions from electricity consumption and only then work and trucks.

Overall terrestrial emissions		
Category	tCO_2eq	%
Electric energy	1.003,48	26,11%
Port operational equipment	1.972,43	51,32%
Service vehicles	469,39	12,21%
Heavy-duty vehicles	398,23	10,36%
Total	**3.843,52**	**100,00%**

Table 13: Overall terrestrial emissions for port areas (Rijeka and Sušak basin) for year 2019

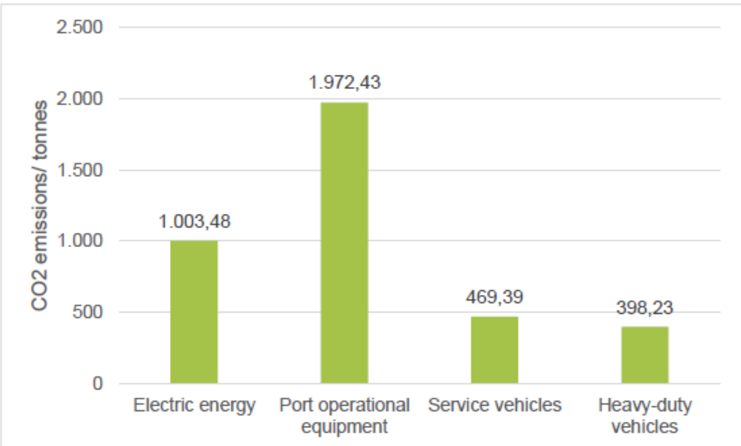

Figure 23: Overall terrestrial emissions by categories

Maritime emissions

The maritime emissions refer to emissions from the traffic of ships and other vessels in the area of the port authority. Port authorities generally publish data on ship traffic in terms of number of passengers, number of calls, tons of cargo, depending on whether they refer to passenger or cargo ships. Emission factors vary according to engine load and may be higher for engines operating at low loads, especially in port manoeuvres. For the purposes of this analysis, a certain sample of ships was selected, ie ship manoeuvres on the basis of which an estimate of energy consumption was made, and consequently of greenhouse gas emissions. The collected data needed to be analysed and correlated according to available estimates. Entec's Final Report on Quantification of Ship Emissions was used primarily as a source of estimates. The primary source of information in terms of ship traffic was the comprehensive database provided by the Lloyds Maritime Intelligence Unit (LMIU), and is the only commercial ship traffic database worldwide (more than 46,000 merchant ships docking in more than 6,000 ports). The database includes all ships larger than 500 gross tons. Daily monitoring activity includes vessels in more than 700 EU ports. The data are structured to identify:

- Ship
- Type of ship
- Ship type
- Ship size
- Flag
- Port / place details, including: port / place of arrival / departure, previous port / place, next port / place, arrival / departure or estimation dates, port / place reference ID, port / place name, country, area, place type , latitude / longitude
- Relocation type identifier and unique reference ID for each relocation

The marine areas within which maritime traffic trends were considered in this study are shown in the figure below.

Figure 24: Geographical area for Entec study (Source: Entec, Final report)

For the purposes of this study, ship movements are observed only within the port, and Enetec's port emission quantification study analysed questionnaires sent to more than 100 port carriers seeking details of port activities in the port.

There are two key elements for calculating emissions and they are:

• Time of certain maritime activities

• Basic characteristics of the ship

In the mentioned Entec study, the operators were asked for information on the hours spent for three activities:

• Manoeuvring time

• Loading/unloading time

• Hotelling time (mooring)

The term manoeuvring means when a ship is moving within or near a port, it represents a high non-stationary phase during which a ship changes speed or direction in order to quickly approach the port. Hotelling is when a ship is stopped at a berth but emits gases from the engine that produce heat and electricity for all the services needed by the crew and passengers or for the transfer and retrieval of goods, maintenance or otherwise. According to the available data, the average values for each type of ship were calculated, and they are shown below according to the type of ship that was analysed in the selected sample.

Type of ship	Average time anchored (h)	Average time in manoeuvring (h)	Average time in mooring (h)	Total time (h)
Passenger	0,8	9,6	4,0	14,4
Container	1,0	84,0	6,5	91,5
General Cargo	1,0	9,0	5,3	15,3
Bulk Carrier	1,0	17,0	21,5	39,5
Total average time	**1,0**	**29,9**	**9,3**	**40,2**

Table 14: Assumptions for the duration (hours) of activity in the port based on surveys

The estimation of total time spent in the port differs significantly depending on the type of ship, so the average values of the total time in the port for a passenger ship are 14.4 h, for a general cargo ship 15.3 h, while the same values are for container and ship for bulk cargo significantly higher, and amount to 91.5 h and 39.5 h.

Regarding maritime activities in the Rijeka port area, according to the methodology, the following will be considered:

• Time at anchor: emissions associated with ships while anchored near the port and waiting to be accessed;

• Manoeuvring time: emissions resulting from the manoeuvring phase of ships until their arrival at berth

• Mooring time: emissions produced in the actual mooring phase of the ship, including waiting and loading and unloading of cargo (eg goods and / or trailers and / or transit of passengers, etc.).

These categories, as stated, refer to a specific time, ie hours spent by the ship in a specific operation / status. Consequently, according to the submitted data, the hours were calculated as follows:

• Time at anchor: arrival at anchor - departure from anchor

• Manoeuvring time: start of piloting - end of piloting

• Mooring time: arrival at the pier - departure from the pier

Regarding the arrival of ships, a total of 251 arrivals of ships were analysed, 185 in the Sušak Basin (which includes Brajdica Terminal with 177 arrivals) and 66 in the Rijeka Basin.

Ship arrivals	Number of ships
Sušak Basin	185
Rijeka Basin	66

Table 15: Number of ship arrivals in basins

Ships that came to the Brajdica, more specifically the pier Kostrensko pristanište, predominantly form part of the arrival of ships in the Sušak Basin, and it sis shown on the map below.

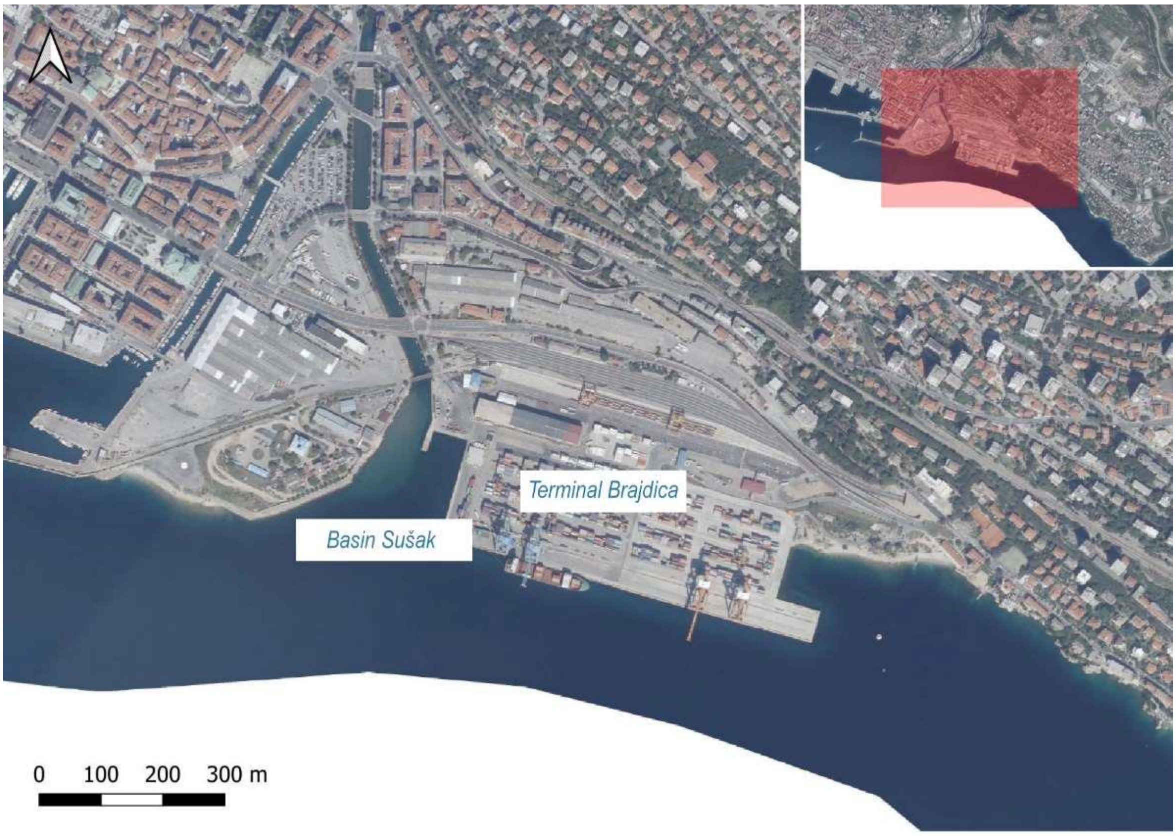

Figure 25: Sušak Basin and Terminal Brajdica

At the Rijeka Basin, there is a larger number of docks, and the analysed ships had their arrivals (66 in total) at the docks in the next number.

BASIN RIJEKA (PIERS)	Number of ships
Orlandov gat	15
Bečko pristanište	6
De Franceschi gat	14
Praško pristanište	18
Visinov gat	7
Budimpeštansko pristanište	4
Others	2
Total	66

Table 16: Number of boat arrivals at the piers within the Rijeka Basin

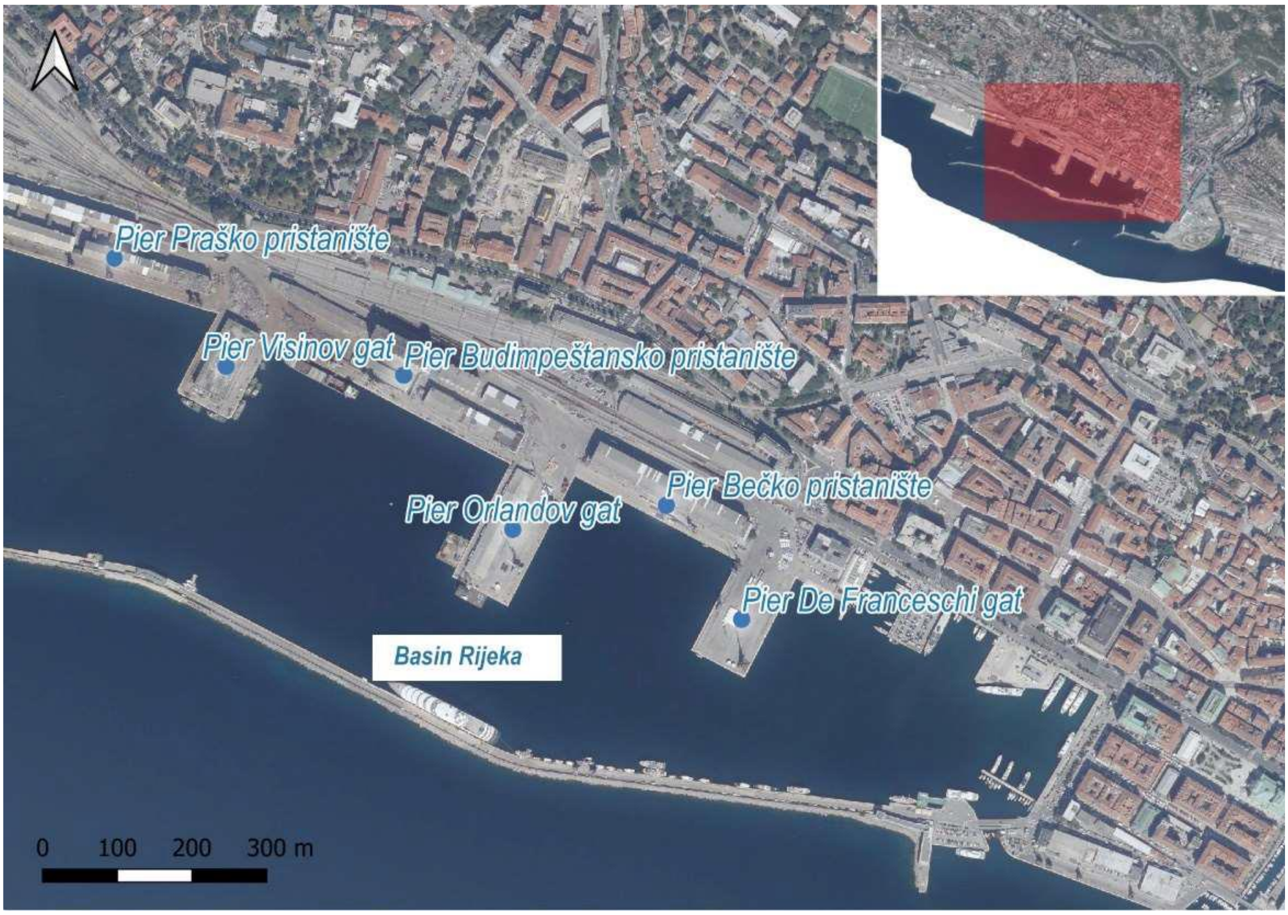

Figure 26: Rijeka basin and piers

According to the analysed ships, the total time spent is as follows:

• Anchoring period: 4,058.52 h

• Manoeuvring period: 600.32 h

• Mooring period: 13,635.68 h

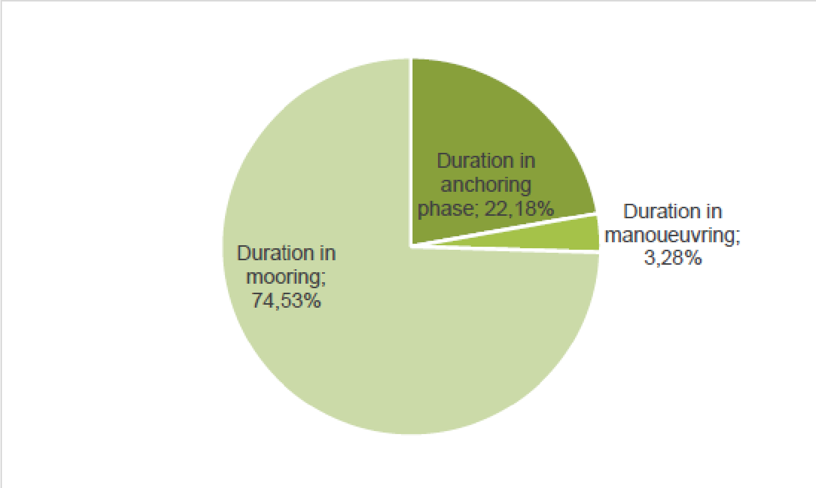

Figure 27: Share of hours in specific activity

Considering the average time for a certain activity it is 33.54 h for time at anchor, 1.24 h for time in manoeuvring, and 55.61 h for time at berth. Of course, the average time also depends on the type of ship, and for this reason the table in the table provides an overview of the average time for a certain activity depending on the type of ship.

Type of ship	Average time anchored (h)	Average time in manoeuvring (h)	Average time in mooring (h)	Total time (h)
Passenger	14,71	0,58	11,2	26,49
Container	16,55	0,71	18,1	35,36
General Cargo	48,8	2,47	132,39	183,66
Bulk Carrier	37,77	0,68	116,14	154,59
Total average time	**33,54**	**1,24**	**55,61**	90,39

Table 17: Average time in activities relative to ship type

If we compare the data from the Entec study on the average time in the port and the data collected for the port authority, then the port time differs significantly. For the port authority, the values are significantly higher, and the total average time is 90.39 h compared to 40.2 h, which is 2.25 times more hours. According to the type of ship, in the port of Rijeka passenger ships stay on average 1.89

times longer, general cargo ships 12 times longer, bulk carriers 3.91 times longer, while only container ships stay 2.59 times shorter.

Type of ship	Total time in port (Entec) (h)	Total time in port (analysed ships) (h)
Passenger	14,4	26,49
Container	91,5	35,36
General Cargo	15,3	183,66
Bulk Carrier	39,5	154,59
Total average time	**40,2**	**90,39**

Table 18: Comparison of the average time of ships in the port

Regarding the basic characteristics of ships, the sample of ships refers to a total of 89 different ones that came to the area of port management in 2019. Of this number, 55 are for general cargo, 24 container ships, 5 bulk carriers, and 4 passenger ships. The basic characteristics of ships by type in accordance with IMO terminology, which were included in the analysis, are listed below.

Passenger ship is a ship whose function is to transport passengers at sea, and a minimum of 12. The basic types of a passenger ship are cruisers, ferries, ocean liner.

Figure 28: Example of passenger ship that came in port of Rijeka, Mein Schiff 6 (Source: https://en.wikipedia.org/wiki/Mein_Schiff_6)

Container ship is a ship specially built and equipped with appropriate devices for the transport of containers. They are a common means of commercial intermodal freight transport.

Figure 29: Example of container ship that came in port of Rijeka, Maersk Houston (Source: https://www.vesseltracker.com/en/Ships/Maersk-Houston-9848950/gallery/1781170)

General cargo ship is a ship with a hull with several decks or a single-deck hull intended primarily for the transport of general cargo. General cargo represents packaged items such as chemicals, food, furniture, machinery, motor vehicles, footwear, clothing.

Figure 30: Figure 5-21. Example of general cargo ship that came in port of Rijeka, Amira Laura (Source: https://www.vesselfinder.com/vessels/AMIRA-LAURA-IMO-9053842-MMSI-572953210)

Bulk cargo ship is a ship with single or double hull intended for the transport of dry bulk cargo, built with one deck, double, and / or twisting and / or below-deck side tanks.

Figure 31:. Example of general cargo ship that came in port of Rijeka, Brave Knight (Source: https://www.fleetmon.com/vessels/brave-knight_7129336_42050/)

The ships have an average draft of 7.80 m, while their average installed power is 9,600 kW.Of course both parameters differ depending on the basic type of ship, so the average values shown in the table are:

Type of ship	Average draught (m)	Average total installed power P (kW)
Passenger	6,9	34.295
Container	11,45	23.443
General Cargo	6,21	2.349
Bulk Carrier	8,86	4.458

Table 19: Average draught values and installed power for analysed ships

Installed power is a very important criterion for calculating energy consumption in kWh, or later calculating greenhouse gas emissions.

According to the Report (Entec), ships are divided into small, medium and large according to the installed auxiliary engine (AE) and the power of the main engine (ME). The three main engine size categories are selected to represent the engine size range.

	Small	Medium	Large
Ship category passed on engine power (Kw)	ME< 6.000 kW	6.000< =ME< 15.000 kW	15.000 kW=< ME

Table 20: Ship category based on engine power

The share of installed engine capacity related to the main and auxiliary engine is shown in the table below, and it can be seen that the larger the ship, the higher the share of main engine power in the total installed power of the ship.

	Small	Medium	Large
Main engine	84%	88%	91%
Auxiliary engine	16%	12%	9%

Table 21: MCR load share (maximum continuous load) for ME and AE operation

For each of the activities there are assumptions about the operation of the engine. When the ship is at sea, the engines run at approximately 80 to 100%, but the situation is different when moving the ship within the port, and the share of engine work (main and auxiliary) is significantly less, and for manoeuvring is 20% of the main engines and 50% auxiliary engines, while the ship is at anchor and mooring assumptions is that the main engines run at 20%, while the auxiliary engines run at 40%. The assumptions about the operation of the engine for different activities are shown in the table below.

	Manoeuvring	Anchoring	Mooring
ME	20%	20%	20%
AE	50%	40%	40%

Table 22: The share of ME and AE work depending on the type of activity

It should be noted, however, that some of these engine load assumptions have certain uncertainties, especially in the use of the main engine in the port, and may affect the calculated emissions.

According to the installed power of the ship, the percentage of engine operation in individual phases and the calculated time in hours for each activity, the energy consumption in kWh was calculated.

	Energy consumption (kWh)			
Type of ship	Anchoring	Manoeuvring	Mooring	Total
Passenger	312.638,16	99.698,40	864.936,80	**1.277.273,36**
Container	3.272.043,42	1.408.356,21	12.918.614,75	**17.599.014,38**
General Cargo	2.490.670,23	191.100,08	6.208.509,49	**8.890.279,80**
Bulk Carrier	314.303,64	6.430,81	785.302,98	**1.106.037,43**
Total	**6.389.655,45**	**1.705.585,50**	**20.777.364,02**	**28.872.604,97**

Table 23: Energy consumption in kWh based on type of ship and activity

According to the above calculations, it is evident that the highest energy consumption is in the phase when the ship is in mooring phase (71.96%), then in anchoring (22.13%) and at last in manoeuvring phase (5.91%).

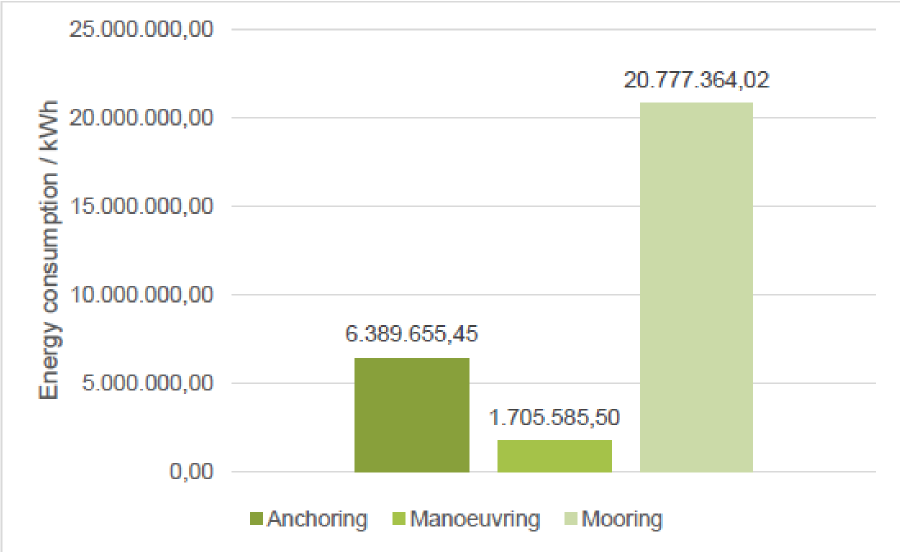

Figure 32: Energy consumption by activities

According to the submitted sample of ships, the largest consumption is in container ships (60.95%), followed by general cargo ships (30.79%), passenger ships (4.42%) and bulk carriers (3.83%).

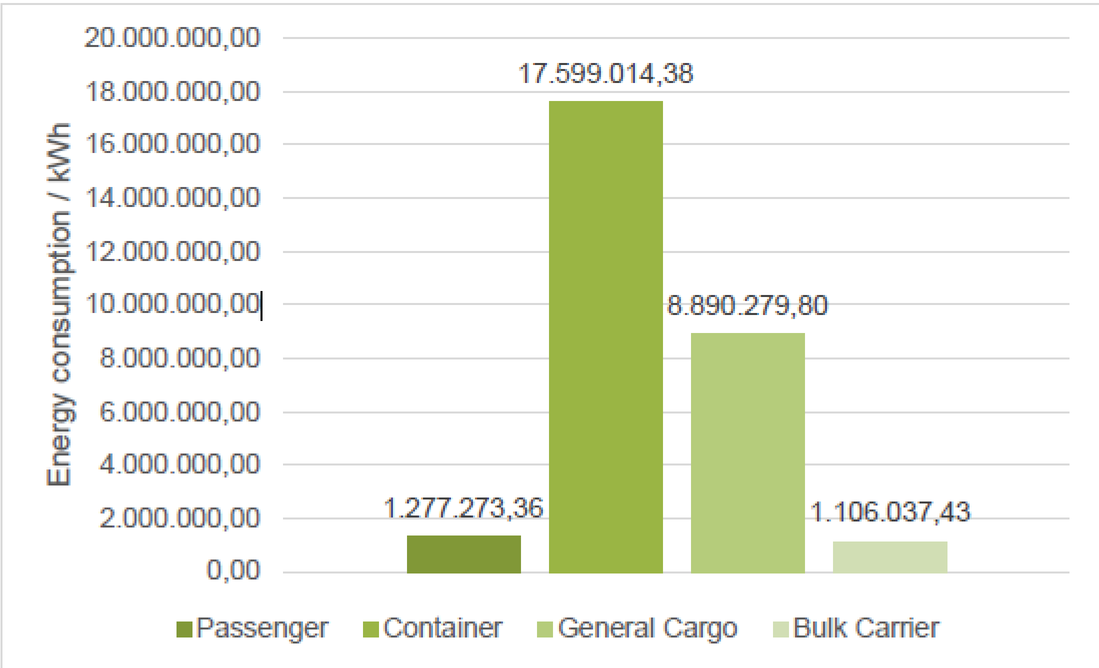

Figure 33: Energy consumption based on ship type

After defining the energy consumption, the factors for calculating the emissions were taken into account, according to the Entec report, and the values differ for the ship's activity in the port (anchoring and mooring) and for manoeuvring.

	g/kWh						kg/tonne fuel				
Type of ship	*Nox*	*SO_2*	*CO_2*	*HC*	*PM*	*sfc*	*Nox*	*SO_2*	*CO_2*	*HC*	*PM*
Passenger	11,6	12,6	750	1	1,8	236	50	54	3179	4,4	7,7
Container	13,4	11,9	715	0,9	1,4	225	60	53	3179	4,3	6,5
General Cargo	13,7	12,1	710	1	1,5	223	62	54	3179	4,4	6,7
Bulk Carrier	13,3	12,1	716	0,9	1,5	225	59	54	3179	4,1	6,5

Table 24: Emission factor values for ship activity in port (anchoring and mooring)

			g/kWh						kg/tonne fuel		
Type of ship	*Nox*	*SO_2*	*CO_2*	*HC*	*PM*	*sfc*	*Nox*	*SO_2*	*CO_2*	*HC*	*PM*
Passenger	11,6	12,6	750	1	1,8	236	50	54	3179	4,4	7,7
Container	13,5	11,4	708	1,6	2,2	223	62	52	3179	7,1	10,1
General Cargo	14	11,8	696	1,6	2,3	219	65	54	3179	7,6	10,4
Bulk Carrier	13,1	120	709	1,6	2,3	223	59	54	3179	7	10,2

Table 25: Emission factor value for manoeuvring

According to these factors, total CO2 emissions were obtained for the transport of the selected cause of ships, which amounts to a total of 20,234.61 t of CO2.

	Emissions CO_2 (tonnes)			
Type of ship	**Anchoring**	**Manoeuvring**	**Mooring**	**Total (ship type)**
Passenger	234,48	74,77	648,70	**957,95**
Container	2.277,34	999,93	8.991,36	**12.268,63**
General Cargo	1.713,27	133,75	4.377,88	**6.224,90**
Bulk Carrier	222,58	4,60	555,99	**783,17**
Total (activities)	**4.447,62**	**1.213,05**	**14.573,94**	**20.234,61**

Table 26: Overall maritime emissions based on ship type and type of activities

According to energy consumption, the largest emissions are in mooring activities (72.02%), then anchoring (5.99%) and only then manoeuvring (21.98%).

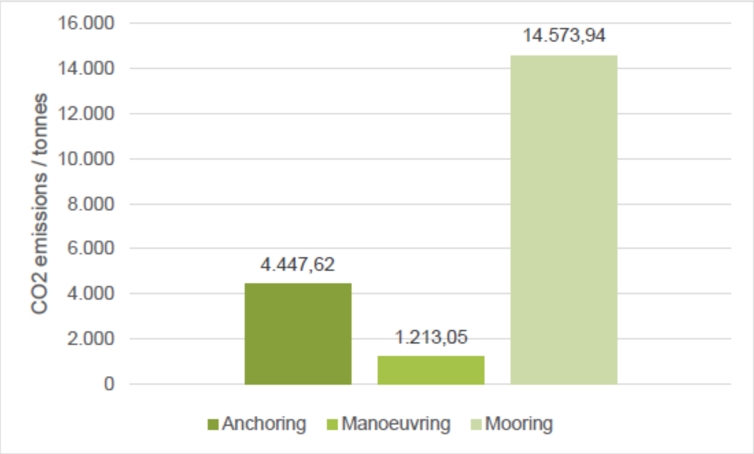

Figure 34: CO2 emissions based on type of activities

According to the submitted sample of ships, the largest consumption is in container ships (60.63%), followed by general cargo ships (30.76%), passenger ships (4.73%) and bulk carriers (3.83%).

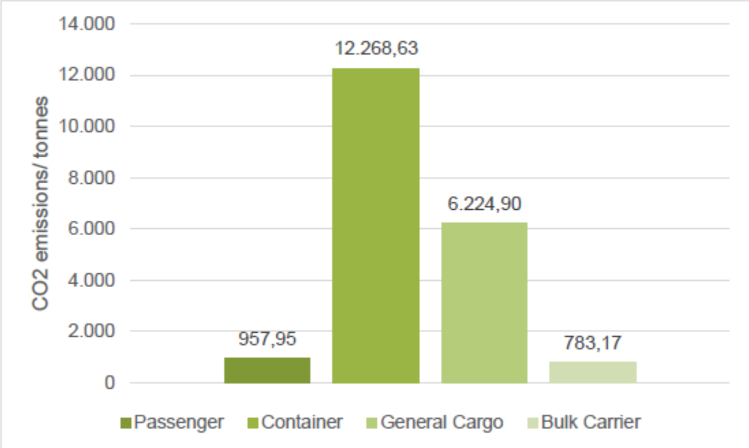

Figure 35: CO2 emissions based on ship type

In conclusion, the total marine emissions amount to 20,234.61 t CO_2, and according to thec ategories as stated in the methodology, the summary by defined activities is presented below.

Overall maritime emissions		
Category	**tCO_2eq**	**%**
Anchored ships	4.447,62	21,98%
Ships manoeuvring	1.213,05	5,99%
Moored ships	14.573,94	72,02%
Total	20.234,61	100,00%

Table 27: Overall maritime emissions for port area (Rijeka and Sušak Basin) for 2019

Emission summary

Total emissions for the analysed port area 24,128.66 t, of which the largest part, as much as 60.40% refers to moored ships, then 18.43% to ships at anchor, followed by cargo handling equipment (8.17%) , ships in manoeuvring (5.03%), and electricity 4.16%. The lowest emissions are related to vehicles (work and cargo) with 1.95% and 1.86%.

Overall emissions		
Category	tCO_2eq	%
Electric energy	1.003,48	4,17%
Port operational equipment	1.972,43	8,19%
Service vehicles	469,39	1,95%
Heavy-duty vehicles	398,23	1,65%
Anchored ships	4.447,62	18,47%
Ships manoeuvring	1.213,05	5,04%
Moored ships	14.573,94	60,53%
Total	**24.078,13**	**1,00**

Table 28: Overall port area emissions in 2019

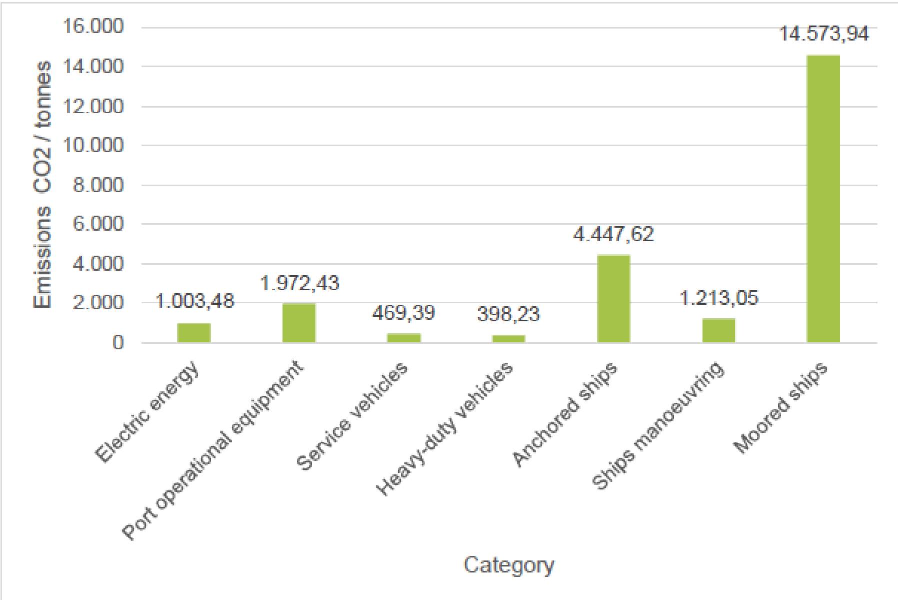

Figure 36: Category ratio in total CO2 emissions

SWOT Analysis

In accordance with the available information and data on a number of factors important for the operations of the Port of Rijeka Authority, the SWOT analysis is presented below, which was an important starting point, among other things, for identifying possible decarbonisation measures, increasing energy efficiency and overall sustainability.

STRENGTS	WEAKNESSES
• the most important intermodal center and the main cargo port of entry and exit for Central and Eastern Europe in the Republic of Croatia • exceptional position on the Mediterranean and Baltic-Adriatic TEN-T corridor • the port of Rijeka is connected by European road, rail transport corridors and common navigation and information systems • status of a port as a port of special (international) economic interest for the Republic of Croatia • the most important national port for international transport • many years of experience in the management, development and use of the port of Rijeka	• condition of electricity and other infrastructure and the need for certain modifications, upgrades and renovations (due to the frequency of the land network of 50 Hz, low transmission capacity of existing power lines) • possible questionable availability of space for necessary modifications / upgrades, etc. • a significant number of concessionaires and other stakeholders • a number of buildings in the status of protected cultural heritage (impossibility of implementation of measures and / or significant investment costs) • lack of a comprehensive, long-standing system for monitoring energy consumption • possible insufficient general capacity to implement complex port sustainability development
OPPORTUNITIES	**THREATS**
• improving the state of the environment at the site level and beyond (reducing noise, emissions of pollutants and greenhouse gases into the air, light pollution, waste, etc.) • continuation of further development of multidionics dialogue • reduction of operating costs, especially on the basis of reduced energy consumption • proximity to the LNG terminal on the island of Krk • increase in the quality of the offer • modern equipment of the whole port (mechanization, infrastructure, etc.) • promotion and development of a port as sustainable and green that advocates the public interest and the common good • expansion of port capacities and opportunities in response to the increase in demand in maritime transport, including cruising tourism	• environmental pollution • faster development of other ports • slowness of administrative processes required during the implementation of projects / measures • possible conflicts with other users or contenders for the same space and / or resources and / or infrastructure, etc. • general crises of various origins, especially those that may have an impact on the development of demand in the transport sector
✓ increase navigation safety	

Conclusion

Based on the collected and analysed data, an analysis of ecological sustainability and energy efficiency was made through the production of a carbon footprint of the observed area related to terrestrial and marine greenhouse emissions. Greenhouse gases retain heat in the atmosphere and heat the planet, and the most responsible for the greenhouse effect include carbon dioxide, which is also the most important gas, methane, nitrous oxide, and water vapor and fluorinated gases.

According to the IPCC methodology, there are three different levels of accuracy for the calculation or estimation of greenhouse gas emissions related to an area or activity, and for this document used depending on the available data Tier 1 or Tier 2.

Total greenhouse gas emissions for the port area amount to 24,128.66 t, of which the dominant part of as much as 84% refers to marine emissions, while the remaining part of 16% refers to land emissions. Within maritime emissions, the largest share or 72% refers to moored ships, followed by 18.43% to anchored ships, while manoeuvring ships account for 5.03% of total emissions. Regarding terrestrial emissions, the largest share of 51.31% refers to cargo handling equipment, followed by electricity 26.10%. The lowest share of emissions refers to vehicles (work and cargo) with 10.36% and 12.21%.

The port of Rijeka is the most important intermodal center and is the main cargo entry-exit port for Central and Eastern Europe in the Republic of Croatia, which can have its opportunity in the development of the port as sustainable and green.

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Figures

Tables