Action plan for the establishment of new touristic routes based on green technology vessels

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1 Contents

2 Introduction

2.1 METRO project (Interreg Italy-Croatia 2014.-2020.)

METRO project aims to improve the environmental sustainability in the field of maritime transport, with a specific focus on touristic connections in the North Adriatic area. Also, to improve the quality, safety and environmental sustainability of marine and coastal transport services and nodes by promoting multimodality in the programme area. This objective will be pursued both from the technological point of view (development of hybrid solutions to be adopted in vessels used for passenger's transportation), and from the logistic one (study on the adaptation of power supply infrastructures in small harbours, definition of new routes to be established among north Adriatic ports).

Targeted groups within the project are general public, local, regional and national public authorities, enterprise, transport operators including operators of multimodal logistics hubs, infrastructure providers, education and training organizations and universities and research institutes.

The project addresses various challenges that affect the Programme area, such as the need for more integrated, efficient and sustainable maritime connections between the eligible territories, the necessity to reduce traffic congestion caused by seasonal tourism flows, and the need to tackle the continuous lack of competitiveness of companies in shipbuilding.

Start of the project was on January 1st 2019 and it's scheduled to finish on December 31st 2021 with total budget of 2.959.605 euros.

The lead partner of project is high education research center University of Trieste with other partners Wartsila Italia, Port Network Authority of the Eastern Adriatic Sea, Tehnomont shipyard ltd, Istrian Development Agency (IDA), University of Rijeka – Faculty of Engineering and Faculty of Maritime Studies.

2.2 Action plan: aim and description

The action plan is a document that includes data from the analyses that have already been done within the project. It is explanation of the necessary steps for implementing new touristic routes into the real word.

3 Maritime passenger transport in North Adriatic

Development of road infrastructure and a constantly increasing number of vehicles has also had a positive influence on the development of maritime passenger transport. Passenger transport on ferries, therefore, led to an important expansion of ferries and RO-PAX fleet and circulating but also to an important development of port infrastructure. In the last few years, the world fleet of ferry ships has grown in three directions: the construction of comfortable ferries relatively fast, intended for the night and fairly long routes; superfast ferries used exclusively for daytime travel and RO-PAX ferries designed primarily for the transport of commercial vehicles and for passengers and private vehicles.

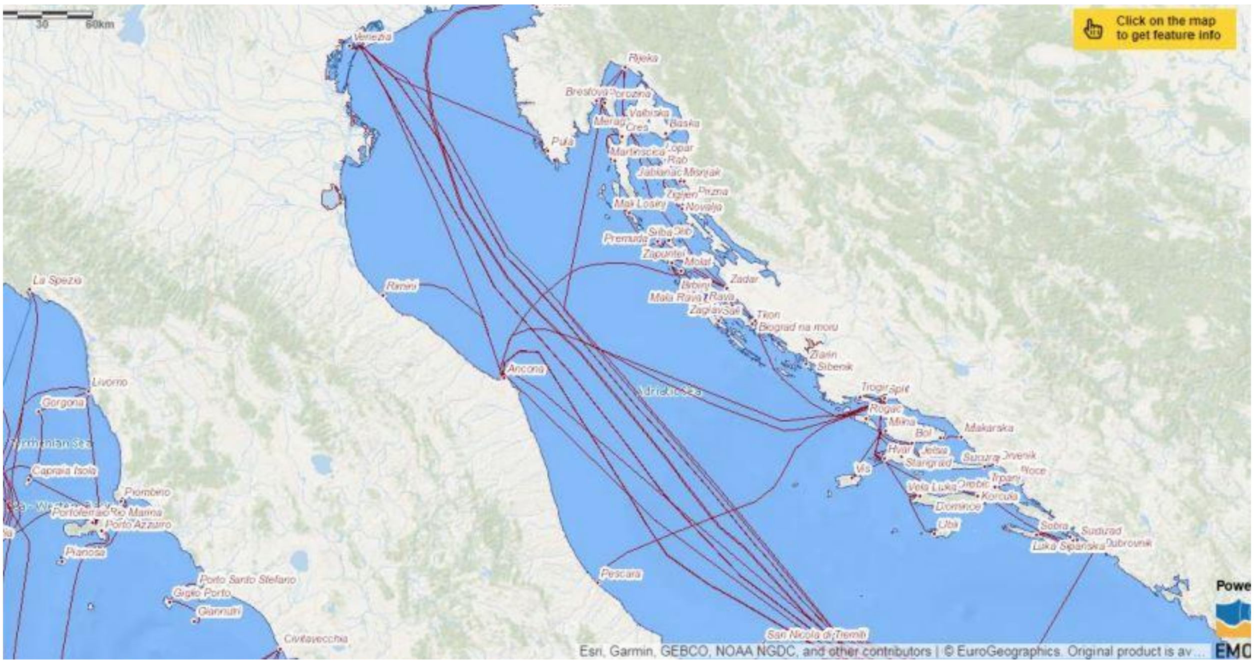
In the short term, ports adapted to manage new types of ferries by providing themselves with modern technology for the sorting of large numbers of people and numerous types of vehicles. This is particularly important in the arrivals and departures of superfast catamarans due to their very short stopover in the ports. In such cases, the operations of disembarkation and embarkation of passengers are similar to those of an airport. In Croatia, the traffic with ferry ships began to develop about twenty years ago. Due to the geographical location of Dalmatia and the numerous islands, the port of Split has become the largest port on the Adriatic for passenger transport by ferry boats.

The Adriatic area, thanks to the particular conformation and the kilometers of coastline available, sees the sea-land relationship and integration as an essential element to take into account in its future development. In the Adriatic area, the state of the existing and possible connections leads to favor the sea compared to other alternatives that would require excessive infrastructure loads. The topic of relief is that of the “freeways of the sea” that represent service of marine transport alternative to ordinary practicability on road. The choice of maritime transport over road transport is, however, conditioned by several factors which are well known by a shipowner: For maritime transport to be competitive with road transport the minimum distance should be 600 km, but there is nothing to prevent the creation of maritime links at shorter distances that can best meet the needs of the market. Although the focus of the job is the leisure and not commercial component for the shipowners the presence of stable traffic of this second component is a determining factor.

The Adriatic Sea is a tourist area on which there are more than 150 destinations. It is an ideal place to move for tourism or logistics, and the port of Ancona represents an important connection hub for its geographical position, in fact, over a million passengers, are handled annually. Due to the strategic position, the port of Ancona represents an important location for the Adriatic-Ionian dynamics in terms of passenger flows and for the tourism of the entire Adriatic region.

3.1 Existing maritime routes in North Adriatic area

3-1 Existing maritame routes - North Adriatic area



Source: [European Atlas of the Seas (europa.eu)]()

The port of Split is the area's leader (almost 5 million domestic and international passengers in 2018) with Igoumenitsa and Zadar to follow (2.8 and 2.4 million). Between the Italian ports, Bari is in 5 positions with 1,2 million passengers; immediately after it is positioned Ancona, exceeding the threshold of the million. Rereading but the classifies for the single international traffic are the two Italian ports of Bari and Ancona with Igoumenitsa and Durres to follow. Shifting the attention on a horizon of 10 years and focusing on the international ferry traffic in the area, it has recorded substantial stability between 2008 and 2011 followed by a net decrease between 2011 and 2012. the main ports of call of the Adriatic (13), then in 2008 they recorded approximately 7 million passengers, from 2012 they have enlivened little more than 5,5 million people, figure in decrement until 2015 (5,1 million), therefore in increase until the last years in which the enlivened passengers have been almost 6 million.

There are 14 companies that in 2018 have operated in the Adriatic-Ionian area, 10 of which are dedicated to the transport by ferry; the remaining 4 have operated with hydrofoils and catamarans.

3-2 Ferries, Croatia-Italy

Ferries from Croatia to Italy

- Bar (Montenegro) to Bari Ferries
- Bol (Brac) to Pescara Ferries
- Cesenatico to Pesaro Ferries
- Dubrovnik to Bari Ferries
- Hvar to Pescara Ferries
- Hvar to Termoli Ferries
- Mali Losinj to Cesenatico Ferries
- Mali Losinj to Pesaro Ferries
- Mali Losinj to Trieste Ferries
- Mali Losinj to Venice (Venezia) Ferries
- Novalja to Pesaro Ferries
- Pesaro to Cesenatico Ferries
- Piran to Trieste Ferries
- Piran to Venice (Venezia) Ferries
- Ploce to Termoli Ferries
- Porec to Trieste Ferries
- Porec to Venice (Venezia) Ferries
- Pula to Trieste Ferries
- Pula to Venice (Venezia) Ferries
- Rab to Cesenatico Ferries
- Rab to Pesaro Ferries
- Rabac to Venice (Venezia) Ferries
- Rovinj to Cesenatico Ferries
- Rovinj to Trieste Ferries
- Rovinj to Venice (Venezia) Ferries
- Split to Ancona Ferries
- Stari Grad (Hvar) to Ancona Ferries
- Umag to Venice (Venezia) Ferries
- Vela Luka to Pescara Ferries
- Zadar to Ancona Ferries
- Zadar to Cesenatico Ferries
- Zadar to Pesaro Ferries

3-3 Ferries, Italy-Croatia

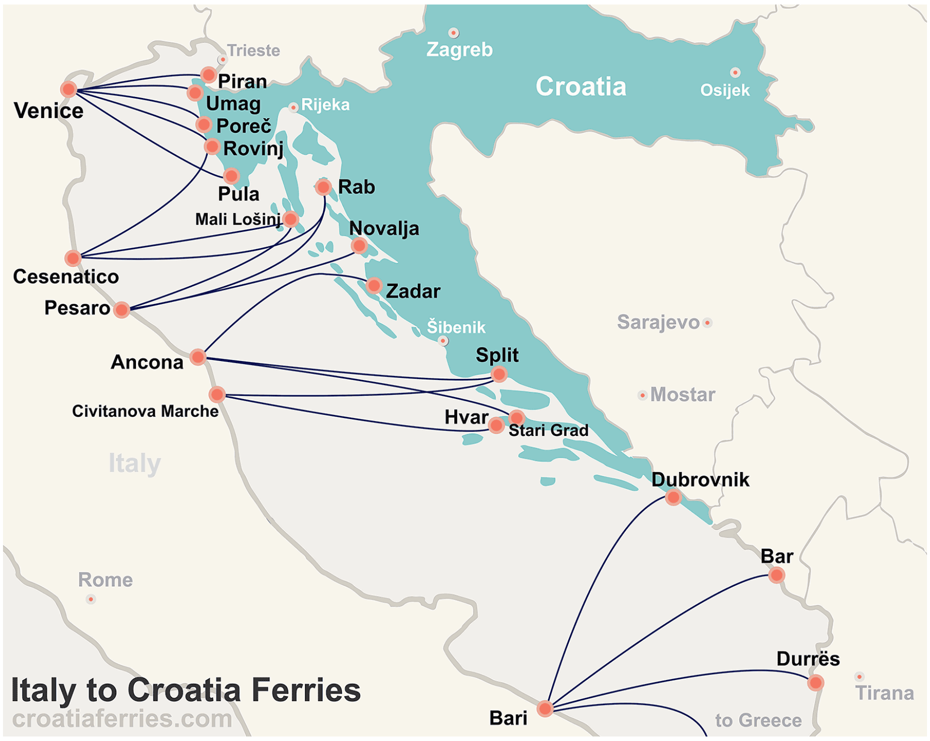
Ferries from Italy to Croatia

- Ancona to Split Ferries
- Ancona to Stari Grad (Hvar) Ferries
- Ancona to Zadar Ferries
- Bari to Bar (Montenegro) Ferries
- Bari to Dubrovnik Ferries
- Cesenatico to Mali Losinj Ferries
- Cesenatico to Pesaro Ferries
- Cesenatico to Rab Ferries
- Cesenatico to Rovinj Ferries
- Cesenatico to Zadar Ferries
- Pesaro to Cesenatico Ferries
- Pesaro to Mali Losinj Ferries
- Pesaro to Novalja Ferries
- Pesaro to Rab Ferries
- Pesaro to Zadar Ferries
- Pescara to Bol (Brac) Ferries
- Pescara to Hvar Ferries
- Pescara to Vela Luka Ferries
- Termoli to Hvar Ferries
- Termoli to Ploce Ferries
- Trieste to Mali Losinj Ferries
- Trieste to Piran Ferries
- Trieste to Porec Ferries
- Trieste to Pula Ferries
- Trieste to Rovinj Ferries
- Venice (Venezia) to Mali Losinj Ferries
- Venice (Venezia) to Piran Ferries
- Venice (Venezia) to Porec Ferries
- Venice (Venezia) to Pula Ferries
- Venice (Venezia) to Rabac Ferries
- Venice (Venezia) to Rovinj Ferries
- Venice (Venezia) to Umag Ferries

Source: www.croatiaferries.com

3.1.1 Routes

3-4 Italy to Croatia Ferries



Source: www.croatiaferries.com

Ferry routes include ferries from Ancona, Bari, Casenatico, Pesaro and Venice in Italy to Dubrovnik, Split, Zadar, Piran, Umag, Poreč, Rovinj, Pula, Mali Lošinj, Rab, Pag (Novalja) and Hvar in Croatia. There are also connecting ferry routes to Bar (Montenegro) and Durres (Albania). This kind of traffic is highly dependet on external factors, such as weather, petrol costs and travel alternatives.

3.1.1.1 Maritime routes between port of Ancona and port of Split

The analysis the Ro-Pax routes offered between Italian port of Ancona and Croatian port of Split, and other route operated by RO-PAX ferries from Ancona to Zadar and from Bari to Dubrovnik. These routes showed in figure, are managed by the Jadrolinija and SNAV.

3-5 RO-PAX flows Jadrolinija Ancona-Split

Source: METRO 5.2. Analysis: Passengers and Goods flow dynamics, Analysis of port capacity for target ships & ships energy consumption

Ro- Pax most frequent route is Ancona – Split (328) managed with one line whole year by the Jadrolinija, and with one line from April to September by the SNAV.

Ancona port connects the highest number of destinations with 2 lines to Split and 1 line to Zara, and has the highest number of departures, equal to 15 in the high season.

Low season - includes months from December to March and there is 1 active line from port of Ancona to port of Split that has an average of 2 departures per week, equal to 8% of the total departures. This maritime route is managed by the Jadrolinija, and it's the only active maritime routes for the whole year.

Transition time includes months from April to June and from September to November. For the first months, starts to operate SNAV with Ancona – Split routes, whereas Jadrolinija starts to offer all their 4 routes. Routes increase from 1 to 5 and average of weekly departures per month increase from 6 to 12, leading to increase from 28 to 56 the total monthly departures. From September to November, decrease routes, from 5 to 3, and average of weekly departures per month from 10 to 4, leading to decrease from 45 to 19 the total monthly departures.

High season – includes July and August, period in which increase the average of weekly departures per month from 16 to 20, reaching 23 departures and keeping them for 2 weeks. On this period 97 departures are reached. It represents 39% of the total annual departures.

3-6 Table of Departures from Ancona to Split

Month	Weekly departures						Monthly departures	% departures of a total	Weighted average of a weekly departures	Seasonality
January	2	2	2	2	1		9	2%	2	Low season
February	1	2	2	2	1		8	2%	2	Low season
March	1	2	2	2	3		10	2%	2	Low season
April	0	5	5	7	9	2	28	6%	6	Transition time
May	6	8	9	11	6		40	9%	8	Transition time
June	5	13	13	13	12		56	13%	12	Transition time
July	0	15	16	17	20	6	74	17%	16	High season
August	17	23	23	21	13		97	22%	20	High season
September	1	11	10	11	12		45	10%	10	Transition time
October	12	10	8	7	2		39	9%	9	Transition time
November	2	4	4	4	5		19	4%	4	Transition time
December	0	2	2	2	2	0	8	2%	2	Low season
	Total annual departures						433	100%		

Source: METRO 5.2. Analysis: Passengers and Goods flow dynamics, Analysis of port capacity for target ships & ships energy consumption

3.1.2 Vessels

For travelling by car there are only three options to get to Croatia from Italy by car or any other vechile except by bicycle:

- Car ferry between Ancona and Split
- Car ferry between Ancona and Zadar
- Car ferry between Bari to Dubrovnik

Car ferries between Ancona and Split sail all year round while Ancona to Zadar and Bari to Dubrovnik sail usually April to October.

Foot passenger ferries sail mid-April to October between the east, Adriatic coast of Italy (Cesenatico, Civitanova Marche and Pesaro ports) and Istria, the peninsula on the north coast of Croatia.

In that period, fast ferries are also regularly sailing from Trieste, Venice, Cesenatico and Pesaro to popular places in Istria - Umag, Porec, Rovinj and Pula as well as to islands of Rab, Pag (Novalja) and Losinj (Mali

Losinj) and Zadar, the town in central Dalmatia.The journey takes between 3 and 6 hours depending on the route. Some of these passenger ferries also take bicycles. None of them takes cars.

3.1.3 Passenger flow

3-7 Passengers & Calls for the Adriatic Ports, 2018.

Total Port Passengers and Calls	Year:2018		
Port	**Country**	**Passengers**	**Calls**
Split	HR	4.817.828	12.389
Igoumenitsa	GRE	2.677.303	12.583
Zara	HR	2.387.482	18.087
Corfù	GRE	1.472.618	12.695
Bari	ITA	1.222.940	2.258
Ancona	ITA	1.037.999	2.432
Durazzo	ALB	879.905	1.012
Dubrovnik	HR	569.776	2.177
Patras	GRE	521.349	1.265
Brindisi	ITA	492.113	1.036
Sibenik	HR	284.816	2.784
Venezia	ITA	203.996	565
Rijeka	HR	127.282	622
		Total: 16.695.407	**Total: 69.905**

Source: METRO 5.2. Analysis: Passengers and Goods flow dynamics, Analysis of port capacity for target ships & ships energy consumption

The passenger transport sector is strongly subject to seasonal fluctuations, with a significant peak in the summer months, especially in July and August.

Transport of passengers from the Italian coast to the Croatian coast and vice versa is very much subject to seasonal fluctuations, due to the fact that the destinations reachable by RO-PAX ferries are normally aimed at tourist holidays in seaside resorts, and consequently during the winter months these will be used drastically less.

Owners of the ferries used have tried to adapt the number of calls to the seasonal trends, keeping however active the service also during the winter period in which the passenger flows turn out minimal, and significantly enhancing the service during the warmer months so as to adapt supply to demand.

4 North Adriatic ‘green’ tourism

4.1 Tourism data

4-1 Port of Trieste, number of ferry and cruise passengers in 2018. and 2019.

TIME PERIOD GOING FROM	01/01/2018 to 31/12/2018			01/01/2019 to 31/12/2019			Difference	
	IN	OUT	TOTAL	IN	OUT	TOTAL	TOTAL	%
NUMBER OF LOCAL AND FERRY PASSENGERS	21.418	21.306	42.724	6.237	7.539	13.776	-28.948	-67,76%
Local (< 20 miles journey)	0	0	0	0	0	0	0	
Ferry passengers	21.418	21.306	42.724	6.237	7.539	13.776	-28.948	-67,76%
CRUISE PASSENGERS			68.815			190.960	+122.145	+177,50%
Home Port	23.380	23.323	46.703	79.571	78.511	158.082	+111.379	+238,48%
Transits			22.112			32.878	+10.766	+48,69%

Source: Presentation, METRO_ITA_HR_Action_Plan_Units

The “Analysis of the current state and potentials for development of the innovative services” also shows the numbers of tourist arrivals in Port of Pula, Rovinj, Poreč, Umag, Novigrad and Rabac.

4-2 Number of passengers in Port of Pula in 2019.

Type/Direction	Arrived	Departed	Total
Domestic	469053	472712	941765
International	21096	18890	39986
Total	**490149**	**491602**	**981751**

Source: METRO 5.4. Analysis of the current state and potentials for development of the innovative services

4-3 Type of ships passengers travelled at Port of Pula in 2019.

Type of ships passengers travelled	Arrived	Departed	Total
Passengers (excl. passengers on cruise ships)	487494	491600	979094
Passengers on cruise ships starting/finishing the journey	1	2	3
Passengers on cruise ships visiting	2654	0	2654
Total	**490149**	**491602**	**981751**

Source: METRO 5.4. Analysis of the current state and potentials for development of the innovative services

4-4 Number of passengers in Port of Rovinj in 2019.

Type/Direction	Arrived	Departed	Total
Domestic	48989	57729	106718
International	27058	20484	47542
Total	**76047**	**78213**	**154260**

Source: METRO 5.4. Analysis of the current state and potentials for development of the innovative services

4-5 Type of ships passengers travelled at Port of Rovinj in 2019

Type of ships passengers travelled	Arrived	Departed	Total
Passengers (excl. passengers on cruise ships)	70194	78213	148407
Passengers on cruise ships starting/finishing the journey	0	0	0
Passengers on cruise ships visiting	5853	0	5853
Total	**76047**	**78213**	**154260**

Source: METRO 5.4. Analysis of the current state and potentials for development of the innovative services

4-6 Number of passengers at Port of Poreč in 2019.

Type/Direction	Arrived	Departed	Total
Domestic	111951	106907	218858
International	48339	49088	97427
Total	**160290**	**155995**	**316285**

Source: METRO 5.4. Analysis of the current state and potentials for development of the innovative services

4-7 Type of ships passengers travelled at Port of Poreč in 2019.

Type of ships passengers travelled	Arrived	Departed	Total
Passengers (excl. passengers on cruise ships)	160114	155995	316109
Passengers on cruise ships starting/finishing the journey	0	0	0
Passengers on cruise ships visiting	176	0	176
Total	**160290**	**155995**	**316285**

Source: METRO 5.4. Analysis of the current state and potentials for development of the innovative services

4-8 Number of passengers at Port of Umag in 2019.

Type/Direction	Arrived	Departed	Total
Domestic	9512	9400	18912
International	4357	4380	8737
Total	**13869**	**13780**	**27649**

Source: METRO 5.4. Analysis of the current state and potentials for development of the innovative services

4-9 Type of ships passengers travelled at Port of Umag in 2019

Type of ships passengers travelled	Arrived	Departed	Total
Passengers (excl. passengers on cruise ships)	13869	13780	27649
Passengers on cruise ships starting/finishing the journey	0	0	0
Passengers on cruise ships visiting	0	0	0
Total	**13869**	**13780**	**27649**

Source: METRO 5.4. Analysis of the current state and potentials for development of the innovative services

4-10 Number of passengers at Port of Novigrad in 2019

Type/Direction	Arrived	Departed	Total
Domestic	2359	2364	4723
International	0	0	0
Total	2359	2364	4723

Source: METRO 5.4. Analysis of the current state and potentials for development of the innovative services

4-11 Type of ships passengers travelled at Port of Novigrad in 2019

Type of ships passengers travelled	Arrived	Departed	Total
Passengers (excl. passengers on cruise ships)	2359	2364	4723
Passengers on cruise ships starting/finishing the journey	0	0	0
Passengers on cruise ships visiting	0	0	0
Total	**2359**	**2364**	**4723**

Source: METRO 5.4. Analysis of the current state and potentials for development of the innovative services

4.2 Analysis of a set of potential ports and 'green' facilities

The purpose of analysis of the current state and potentials for development of the innovative services within METRO is to define existing and potential innovative services in Istrian ports (Pula, Rovinj, Poreč, Novigrad, Umag and Rabac) and its accompanying infrastructure for the purpose of developing multimodal and sustainable transport modes with the aim of reducing CO2 emissions, especially with regard to the use of e-bikes, e-scoters, hybrid cars and motorbikes, e-ships for coastal tourism, etc.

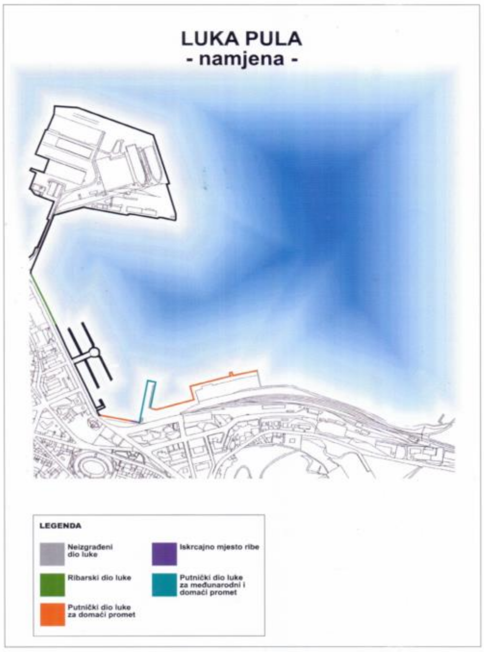
Also, the analysis will help to explore the potential for integration (intermodality) between maritime, road, railway, and biking transport in Region of Istria, with special emphasis on the possibility of introducing the "Tw" project, an electric tram along Pula's seafront. Furthermore, it will provide possibilities and needs for the information throughout application of smart card/app system and similar tools in Istrian ports. Also, it will provide the information on the intensity of cooperation of Istrian ports with local institutions and companies in the field of maritime transport and other transport sectors in the Istrian Region, with the aim of installing and introducing multimodal transport modes in Istrian ports.

Analysis of the existing and potential future innovative products and services in Istrian ports (Pula, Rovinj, Poreč, Novigrad, Umag and Rabac) as well as the related infrastructure with the goals of developing the multimodal and sustainable transport models that will result in smaller emission of CO2 emissions, having in focus e-bicycles, hybrid cars and motorbikes, electric ships for tourism purposes and other.

4.2.1 PORT OF PULA

Port of Pula is port located in the Bay of Pula. It is on the west side of City of Pula, at the Riva and close to famous amphitheater called Arena. The figure below shows how the Port of Pula is divided depending on the purpose for which it is used with each color representing specific part of port. Starting from the right, the orange part, that is passenger part, is used for passengers which are on domestic trips. Passenger part for international and domestic traffic is colored in blue and next to it there is a small landing place for fishery boats colored in purple. The black color on map represents unbuilt parts and between them is stationed fishing part of port highlighted with green color. The number of municipal berths that are open for public transport at Port of Pula were 90 in 2018.

4-12 Division of Port of Pula by purpose



Source: https://www.lup.hr/luka-pula/

Port of Pula maintenance and service facilities covers gas station for boats, but it does not have e-charger for electric boats. The port has parking lot and there are few more parking lots nearby. Close to port there is bus station for public transportation. City of Pula (Pulapromet) has implemented smart cards for public transport which acts as e-wallet on which you add money and then buy tickets for public transport at exclusive prices. In the city of Pula there are few places where you can rent a e-bike but none of them are located at the Port of Pula. Also, Pula is 1 of 15 cities that cooperate with HŽ (Croatian railways) which allows them to have smart cards with all kinds of exclusive prices for travelling with trains. According to that, Railway station of Pula is near the Port of Pula which offers great opportunity of connecting these ways of transport. Furthermore, through ICARUS project, which aims to develop a green type of transport, HŽ will enable wagons of regular railway lines in County of Istria for the transportation of bicycles which will significantly contribute to connecting and multimodality, as well as additional promotion and tourism valorization and development of new products on the territory of the entire Istria County.

4-13 Top 10 enviromental priorites of European ports for 2020

Source: https://www.ecoports.com/publications

4.2.2 'Green' Port facilities

A "Green Port", also known as an ecological port, represents the model of a sustainable port development, which not only meet demands of the environment but also increases the port's economic interests. The concept of building a "green port" should be set as a priority in the construction of harbours and coastal areas. Furthermore, it is necessary, within the port management, to include and implement the concept of "green ports" in ports development planning. From a development perspective, environmental resources are scarce, but they make up the basis for an economic development. Therefore, the inclusion of the concept of "green ports" in ports development planning requires a coordinated distribution in phases according to current possibilities of seaports. As already mentioned above, the inclusion of this term in ports development planning is significant for technological improvements in the production of energy efficiency (technological innovation, new innovated equipment, etc.) which enables the coordination of environmental protection and sustainable economic development.

Model of "Green Port" development is based on three aspects of work and port systems planning that include energy conservation, environmental protection and environmental care. The idea of developing "Green Port" should be converted into activities. The mentioned activities should be exercised on the basis of factors that have an influence on the definition of the concept of "Green Port" development.

Impact of green ports:

Accelerated deployment of sustainable alternative fuels (including advanced biofuels, green hydrogen, ammonia) and electromobility in transport, as well as energy storage and waste heat recovery in ports;

- On-site clean energy / fuel production and distribution (particularly green hydrogen and electricity) and increased alternative (bio-) fuel supply, with re-fuelling and re-charging capabilities;
- Zero-emission port operations by 2030;
- Reduced waterborne and other transport emissions, as well as improved air quality, biodiversity, circular economy and reduction of noise in ports;
- Energy-efficient and smart port operations and buildings, green and smart logistics, integration with other low-emission transport modes;
- Reduced emissions for cities and urban mobility, as well as improved city integration for ports;
- Significant, direct and immediate contribution to the achievement of the European Green Deal, as well as other EU transport policy objectives, while strengthening the competitiveness of the EU transport sector.

Measures of transforming the seaports into the so called model of "Green Port" are numerous. It is important to take such measures as to achieve a balance between ports, transport and transhipment activities, storage activities, human needs and the environment. All the elements related to the construction and operation of seaport activities should be focused on the efficient use of resources, minimization of negative impacts on the regional environment, raising the level of environmental management and improvement of environmental quality in seaports and its surrounding areas.

4.2.3 'Green' tourism in the ports

The data is written in the "Analysis of the current state and potentials for development of the innovative services".

4.2.3.1 PULA

City of Pula (Pulapromet) has implemented smart cards for public transport which acts as e-wallet on which you add money and then buy tickets for public transport at exclusive prices. In the city of Pula there are few places where you can rent a e-bike but none of them are located at the Port of Pula. Also, Pula is 1 of 15 cities that cooperate with HŽ (Croatian railways) which allows them to have smart cards with all kinds of exclusive prices for travelling with trains. According to that, Railway station of Pula is near the Port of Pula which offers great opportunity of connecting these ways of transport. Furthermore, through ICARUS project, which aims to develop a green type of transport, HŽ will enable wagons of regular railway lines in County of Istria for the transportation of bicycles which will significantly contribute to connecting and multimodality, as well as additional promotion and tourism valorization and development of new products on the territory of the entire Istria County.

4-14 Map of city bus lines and E-bike stations in Pula

Source: Pulapromet's official web site and City of Pula's official web site

Figure 4-14 shows map of city bus lines and position of e-bike stations. There are 9 lines that connects all parts of city, from north to south and from east to west. Every line goes through the center of City of Pula. Furthermore, map shows points of sale for public transport where you can buy ticket or smart card, marked by BUSCARD mark. Yellow stars represent positions of city e-bike stations where you can rent a E-bike. There are 8 stations in City of Pula, one at bus station, two near the Arena, another one at city market, opposite the entrance ramp on Verudela, at the Stoja returnee, at Zlatne Stijene and near the school court. There are 29 bikes that can be rented by buying code with smartphone. Price for 1 hour is 4 kunas, 30 kunas for a day and 100 kunas for a whole week. Users of e-bikes can rent them at one station and leave them at another one and because of that this position of E-bike stations, represents great way of connecting 2 ways of transport (by bus and cycling).

The Port of Pula authority participatesin the INTERREG Italy-Croatia project ADRIGREEN. The main goal of the ADRIGREEN project is to improve the connection between the ports and airports of Italy and Croatia with other transport modes with the intention of increasing passenger traffic during the summer season and to improve the environmental performance of the Adriatic Maritime and Air systems.

Another important project in which the Luka Pula Authority participates is the INTERPASS project. The project is realized in a consortium of 8 project partners and one associate member consisting of:

- 3 airports (Dubrovnik, Pula, Apulia)
- 4 Port authorities (Dubrovnik, Pula, South Adriatic, Corfu)
- 1 scientific partner (Technological Institute of Epirus)

The main goal of the INTERPASS project is to improve the connection of seaports with airports in the Adriatic Ionian region in order to enable numerous tourists and passengers to arrive at the desired Adriatic Ionian region destinations during the peak season. At Port of Pula's web site, they mentioned ACI marine Pula which uses smart cards in their marine. Smart cards allow marine reception to have faster and more accurate service and they also have other exclusive offers in every ACI marine.

4.2.3.2 ROVINJ

When talking about multimodal and sustainable transport, City of Rovinj has 3 places where you can charge your e-bike, at Resort Amarin and Resort Villas Rubin, and at hotel Eden. Also, city has several charging stations for hybrid cars. There are no city bikes available for rent but there are numerous renta-bike firms that also offers city tours on bikes.

The Port of Rovinj is also a part of project MIMOSA which includes cooperation between Italy and Croatia, and is being implemented with the aim of improving the offer of sustainable multimodal solutions and services in public passenger transport and promoting a new approach to passenger mobility between countries.

City of Rovinj has developed cycling roads that should be supported with city e-bike (and rent e-bike) stations as a part of more sustainable and multimodal transport solution. Also, there should be considered interconnections of different types of transport with unique smart cards which would offer exclusive offers for different types of transport (rent of e-bikes, trains, catamarans). Furthermore, there is a big area of cruising tourism that is not covered, and which offer great opportunity for strengthening of many other aspects in local economy. As public transport is available only during tourist season, ensuring public e-bikes for rent would provide more sustainable and cheaper transport solutions for tourists that are visiting city outside of season.

4.2.3.3 POREČ

City of Poreč does not have public transport but through EU project SUTRA has acquired mini-electric bus for purpose of public transport. The project aims to develop an innovative mobility concept for passenger transport that would reduce traffic congestion in urban center, improve air quality and locally reduce CO2 emissions.

Besides that, city is well equipped with e-bikes and e-bikes charging stations that offers opportunity for sustainable and multimodal transport in Poreč. In addition, city has several e-car charging stations. While city is well equipped with e-charging stations, none of them are not yet at Port of Poreč.

For those who have their own e-Bike there are 8 charging stations in Poreč at:

- Valamar Riviera Head Office, Stancija
- Pinia Residence, Beach Bar Luna
- Valamar Diamant Hotel
- Hotel Laguna Parentium
- Villa, Village & Apartments Laguna Galijot
- Camping Bijela Uvala
- Naturist Camping Ulika
- Zelena Laguna Resort, Laguna Lounge

For better development and promotion of multimodal and sustainable transport Port od Poreč should keep in mind possibility of e-bike stations at the port.

4.2.3.4 UMAG and NOVIGRAD

The Port of Umag-Novigrad Authority is a partner of the international EU project FRAMESPORT (Framework Initiative fostering the sustainable development of Adriatic small ports). The project will contribute to strengthening the role of the port administration and increasing institutional and technical intervention fields and networks.
Park&Ride system is the first public bike service in the City of Umag, involving more than 70 bikes for renting. You can use it in the area of the City of Umag and Camping Park Umag. There are 6 locations where you can rent your mechanical or E-bike.

4.2.3.5 RABAC

Valamar Riviera has developed their cycling tourism in Rabac, through Bike Center Rabac. Bike Center Rabac is located on the eastern coast of Istria in Croatia's most popular bike destination - Rabac.

Despite important role that Rabac has in cycling community, City of Rabac has only 1 E-bike charging station in Valamar Sanfior Hotel&Casa and no city rent (e-)bike stations.

4.2.4 'Green' mobility in the ports and hinterland (i.e., green car / bike /)

Most of the Istrian ports recognized importance of connecting different types of transport by entering in numerous EU projects that for the aim have develop of multimodal transport, mostly in partnership with Italy. Furthermore, cites also recognized importance of sustainable and ecological transport by introducing e-bikes and e-charging stations (for bikes and cars).

However, these types of transport do not exist at ports and here lays opportunity for further development of multimodal and sustainable transport. In addition, none of the ports have e-charging station for boats that could help in developing of elite tourism. When speaking about public transport it is not well developed in most of the cites and here also lays another opportunity to develop sustainable and ecological transport with low (or zero) CO2 emission. Improvement in availability and accessibility of the ports by connecting them with the intermodal land infrastructure is needed. Such development is recognized in "Tw" project in City of Pula. Within the "Tw" project plan, there is intention to refurbish old railway on Pula's Riva throughout its revitalization and upgrade, integrating in addition to the existing bus transport into urban mobility another form of ecological transport – tram transport. This would reduce traffic jams, noise, and CO2 emissions in the city center and on the City of Pula Riva, especially during the summer months. In addition to reducing congestion and pollution, the introduction of a tram line would connect port terminals with other facilities in the city, such as a tourist resort, parking lots, airport and thus contribute to the multimodality of transport in City of Pula. This kind of connection achieves synergy among all modes of public transport: cars, buses, ships, bicycles, trams, trains, planes, etc., which opens the possibility to integrate bus and parking tickets and extend the scope of smart cards to economic branches outside of public transport. Usage of smart cards, such as in City of Pula, should be introduced into every city and port with aim of connecting different types of transports and economics branches. Furthermore, whole region would benefit from development of an integrated IT platform and service for public transport trip planning. Local government should play active role in all of these activities.

Trieste (Italy) – PORTIS Living Lab city – is supporting car-free lifestyles by extending walking and cycling routes. Areas of particular focus are Porto Vecchio – Trieste's old commercial port – and the city's outskirts: this should enable more people to reach the city centre sustainably.

5 New ‘green’ maritime routes in North Adriatic

5.1 Brestova – Porozina - ‘green’ ferry route

Port of Porozina is a port on the northwest side of the island of Cres. The port consists of the pier, a port plateau and an area for mooring boats. The main pier accommodates ro-ro passenger ships to the port of Brestova. It is 80 meters long, with depths up to four meters alongside. The mooring capacity of the port is sufficient for berthing up to three ro-ro passenger ships of various length (two ships ready for loading or unloading), the largest being up to 100 m. The port plateau covers an area of 0.3 ha. The area reserved for boats is in the eastern part of the port, with berths for 80 boats approximately. The port is equipped with water and electricity. Port equipment also includes mooring devices, fenders, navigation lights and lighting. The ramp is adjustable (linkspan type), i.e. it can change the height above sea level.

Port of Brestova is a ro-ro passenger terminal located south of the mountain Učka, on the eastern side of the Istrian peninsula. The port provides only one berth for ships up to 100 m in length. During inclement weather, both in case of strong NE or SW winds, ships, particularly those with a length close to 100 m, are not safely berthed in the port. There are no urban sites in the immediate vicinity (small village Brestova is located uphill).

On average, there are up to nine voyages per day between Porozina and Brestova, while during the low season, there are eight voyages per day. Passage time is 20 minutes. Ro-ro passenger lines to and from Brestova are currently served by Jadrolinija, a Croatian state-owned shipping company, serving predominantly local lines between islands and the mainland.

The distance between the two ports is 2,74 miles. Ro-ro passenger ships connecting these two ports are ships using ballast water only exceptionally, mainly to adjust the loading/unloading ramp above the sea level and minimize the slope cars and other vehicles have to overcome. Consequently, the ballast water capacity assumed is about 70 tons per tank, loaded in forepeak and afterpeak tanks.

This is one of the routes that has been used as a starting point for designing the new green vessels during the METRO Project. Specifically, a double ended ferry (see picture below) has been designed for reducing the environmental impact of this passenger route. The vessel is intended for restricted waters operation in Croatia during all the year. The propulsion is based on diesel electrical solution, with onboard energy storage systems that can be recharged from the shore during the night and during berthing periods throughout the daily operations. A short summary of the vessel data is depicted in Section 5.1.4 of this document, while all the design data is available among the Project documentation.

5-1 Double-ended ro-ro passenger designed for Porozina-Brestova line

Source: METRO Analyses of ro-ro passenger and cross border routes, Prepared by: Faculty of Maritime Studies, University of Rijeka

5.1.1 Current passenger and vehicle flow

5-1 Passenger flow Brestova-Porozina 2017. and 2018.

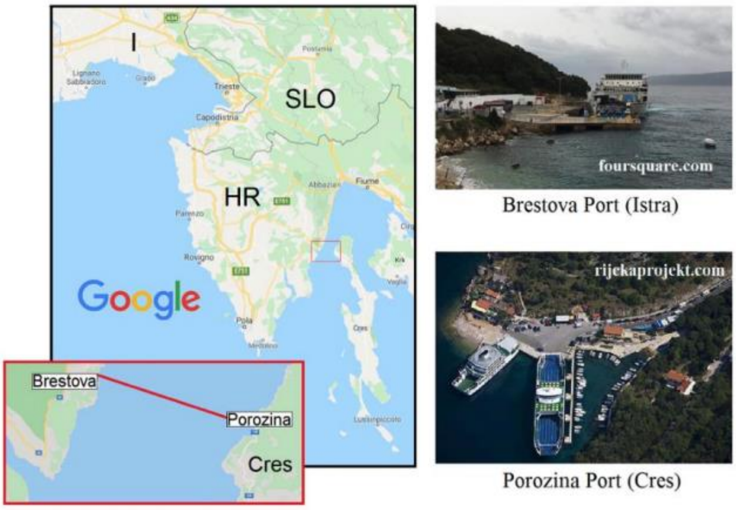
MARITIME ROUTE	FERRY	Passengers 2017.	Passengers 2018.
BRESTOVA-POROZINA	Jadrolinija	589.337	602.591

Source: agencija-zolpp.hr

Number of passes through that are operated by the MV Bol and the MV Brestova every year: month of January, February, March, April, May, October, November, and December are operated 8 runs per day, 4 for each vessel and during the summer period are operated 12 runs per day, six for each ship. Resting upon this hypothesis it is possible to define the total number of run that any ship has done during a year: 1776.

The Brestova Porozina route can handle over 1.650.000 passengers from the mainland to the island of Cres and over 430.000 cars. The flow of passengers reaches its peak in the summer months, where, in the period from June to September, the Brestova-Porozina line is equipped to move up to 850.000 people, about 170.000 people per month.

5-2 Port of Brestova-Porozina



Source: METRO 5.2. Analysis: Passengers and Goods flow dynamics, Analysis of port capacity for target ships & ships energy consumption

5.1.2 Current port infrastructure in Brestova and Porozina

These two small ports are both located in Croatia, respectively in the Istra region and on the island of Cres (Primorsko-goranska region). Although the route is less than 3 nautical miles, it is actually very important for the local economy. Indeed, the majority of tourists to Cres (notable touristic location) arrives at the island by following two possible sea paths. The route Brestova-Porizina and a second one from Krk island, which is linked to the land by a bridge. Focusing on the first possibility, the Cres Island is reached thanks to a car transportation towards Brestova in Istra and then the ferry boat to the island. As the life on Cres is essentially based on tourism, it is evident the importance of one solution for improving the environmental impact of transportation. In this regard, the METRO project acquires a great impact, not only for research institution involved in but also for the Croatian tourism.

As the METRO project's goal is an integrated strategy between ships and ports to reduce pollutant emissions, a paramount role is the one spent by the port electrical power infrastructure. If the onboard energy storage systems can strongly decrease the vessel's environmental impact during sailing, specular approach must be applied when mooring at the port. In such a case, only a well-designed recharging infrastructure can provide the green energy for refilling the batteries. In this context, two are the aspects to be considered. On one hand, the source for recharging the onboard storage, possibly carbon-free. On the other one, the time for recovering the full battery capacity, thus at the final stage the power of the electrical infrastructure. Larger the power, smaller the time, then forcing the interest towards Medium-High Voltage infrastructures for lowering the current in the power cables. As well understood, the port electrical infrastructure deserves a great attention when designing solutions for increasing the environment friendliness in maritime transport. For such a reason the two ports are treated in the following, together with some interesting considerations about future desirable developments.

5-3 Route and Transit time Brestova - Porozina

Voyage particulars	Sailing Speed	Distance	Duration - Navigation in open sea	Duration - Maneuvering	Duration - Total navigation	Duration - Berth
Both ships	11 kts	2,7 M	15 min	10 min	35 min	15min/4hrs

Source: METRO 5.2. Analysis: Passengers and Goods flow dynamics, Analysis of port capacity for target ships & ships energy consumption

5-4 Vessel for route Brestova Porozina

Main Particulars	**M/V *Bol*:**	**M/V *Brestova*:**
LOA	95.4 m	58.17 m
Breadth	20 m	16.8 m
Draught	2,3 m	2,7 m
GT	2330	2315
DWT	1.000 t	482 t
Build	2006	1985
Capacity vehicles/passengers	176 / 600	70 / 338
Engines	4 x MAN D28482LE402 TSP F240, total: 1.412 kW	2 x YANMAR T 260 ET, total: 2.200 kW
Speed	12 kts	12 kts

Source: METRO 5.2. Analysis: Passengers and Goods flow dynamics, Analysis of port capacity for target ships & ships energy consumption

5-5 MV Bol and MV Porozina

Source: METRO 5.2. Analysis: Passengers and Goods flow dynamics, Analysis of port capacity for target ships & ships energy consumption

5.1.2.1 BRESTOVA PORT

The first information regards the distribution system operator (DSO), which is HEP in Croatia in both cases. Then, some data about the present port grid can be provided. At present, a single step-down AC transformer is installed in the port premises, for providing the low voltage (400 V) at the existing loads, starting from an existing medium voltage (20 kV) supply. The rated power of the transformer is 50 kVA, which is nowadays oversized considering the installed loads. Indeed, all the transformer power is practically available as the loads are limited to a lighthouse, a restaurant, and a ticket shop. It is well evident how the requested power from these loads is smaller compared to the transformer rated power. For giving the present consumption at a glance, it is possible to hypothesize 5% of total installed power. This number constitutes an estimation, as the power request from these loads during summer time is not known at present. In the existing housing, the largest transformer that can be installed can reach up to 250 kVA. Conversely, the existing distribution power line can hold up to 2 MVA. However, such a high power requires also the building of a new substation for the transformer and its apparatuses.

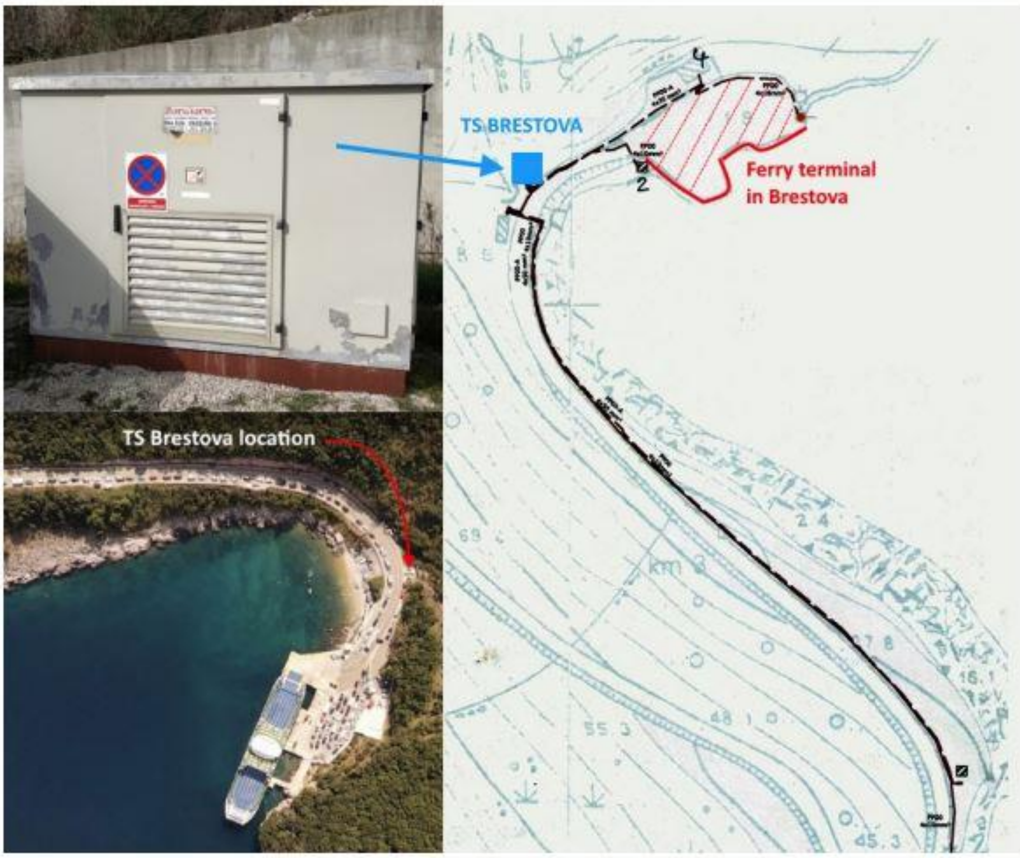
Existing distribution grid in Brestova

Port of Brestova is dislocated from nearest populated places; 4.5km from Zagore (electrical power supply from TS Sisol) and 6.6km from Brseč (electrical power supply from TS Klančac). Existing 50kVA MV/LV transformer in Brestova is used only for supplying the port infrastructure. Transformer is placed in metal container which is located approximately 50 meters from the pier.

As there are no significant electrical consumers in port (restaurant, lighthouse, public lightning and ticket shop) measured average electrical consumption is low. As per current situation available power on LV side is between 40 and 45 kW.

Maximum transformer power rating that can be installed in existing container is 250 kVA. Installation of larger transformers (400 kVA to 1000 kVA) will require a new TS (preferably KTS type). TS Brestova is connected to MV network with radial structure and there is no possibility of power supply from other direction, therefore it can be expected that long power outages may occur in case of power line faults or maintenance. Existing MV supply line has enough capacity for loads up to 2 MW.

5-6 Existing 50kVA TS (20/0.4kV) and its location in Brestova



Source: METRO 4.2. Analysis, Ground electricity infrastructures and grids

5-7 Existing power consumption in Brestova

Source: METRO 4.2. Analysis, Ground electricity infrastructures and grids

5.1.2.2 POROZINA PORT

The Porozina port existing power system allows to provide a maximum active power of about 50 kW, by taking into account the existing LV supply by means of the DSO cable. The latter starts from the Porozina transformer substation, whose maximum power is approximately 100 kW. Therefore, the final cable is the limiting factor. However, the DSO (HEP) is planning for an overhaul to the electrical infrastructure in the Porozina area. In particular, it is planned to build two new transformer substations, one connected to the same MV cable supplying the existing one and one supplied by a new cable. The port will be then supplied by Porozina2 substation (type KTS, 20/0.4 kV), which will provide up to 400 kW. In the case that even such solution demonstrates to be capable of providing an insufficient power level, an additional possibility is available. Indeed, the port can build his own substation connected to the existing 20 kV cable line (supplied by a 35/20 kV transformer substation in Cres). Such line is characterized by an Al cable (150 mm2), plus a final section of Al/Fe (35 mm2). The latter part is intended for future replacement, since it is the limiting factor fur such a line. The power deliverable by means of the Al/Fe 3x35 mm2 cable at 20 kV is approximately 4.5 MW, while the actual load is less than 1 MW, thus allowing for a significant power availability in case of a dedicated power supply to the port.

Existing distribution grid in Porozina

Port of Porozina is located in small populated area with 25-30 permanent residents, but with developed holiday neighbourhood, which is mostly populated during the summer tourist season. Existing MV/LV transformer is pole mounted, has a capacity of 250 kVA and is located 300 meters from the ferry pier. Total available power reserve during summer season at LV side does not exceed 50 kW.

According to the developing plan for the island of Cres, the construction of new 400 kVA TS is planned near the location of the existing one. Since the projected peak power of new TS is 315 kW the expected available power for battery charging will still be very low.

Existing MV power supply lines from 35/10 kV TS Cres can hold up to 4.5 MW of total power and current load is around 1MW. Same as in Brestova, it is connected to the radial MV network with no possibility of redundant power supply.

5-8 Existing 250kVA TS and its location in Porozina

Source: METRO 4.2. Analysis, Ground electricity infrastructures and grids

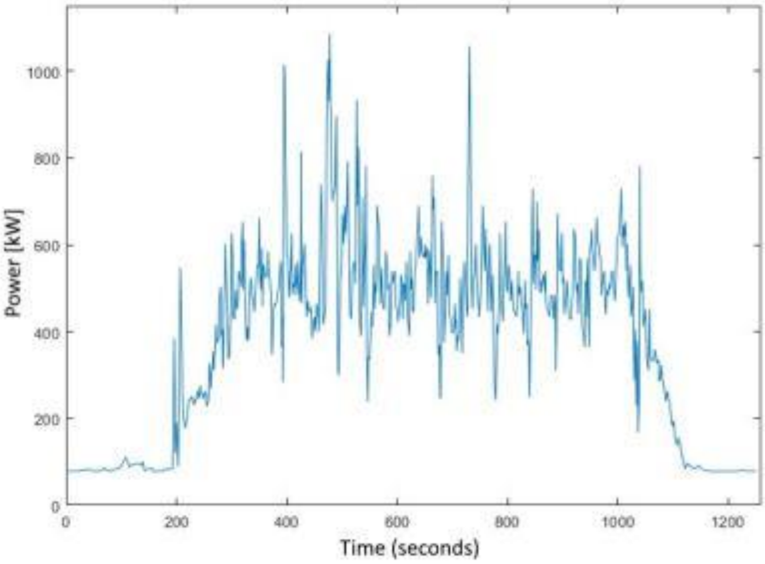
5.1.3 Required port infrastructure for establishment of new 'green' route Brestova - Porozina

From the current state of distribution grid infrastructure in Brestova and Porozina, and future urban development plans for surrounding area, required port infrastructure are:

• In both ports, due to the radial network topology prolonged power outages may occur in case of system faults or environmentally caused effects (bad weather, lightning, etc.)
• Both ports will require on shore energy storage system to support distribution grid during battery charging and also to alow ferry charging during distribution grid power outages.
• Existing MV power lines in both ports will have enough capacity for shore connections up to 1MW even after planned upgrades will be completed.
• In port of Brestova same TS can be used for shore connection and public (port) infrastructure supply.
• Due to the low power reserve, even with the installation of the new TS and available energy capacity upgrade, port of Porozina will still require separate TS for shore connection system.
• Existing MV connection point for TS Porozina is placed about 300 meters from the port. If TS is to be located there (which is the most convenient solution) there may be a voltage drop problem on LV lines for shore connection supply.
• In both ports, any standard TS type up to 1000 kVA can be physically placed on existing locations if needed.

Estimated power requirements and Proposed topology for ferry charging station in Brestova in Porozina
Based on inputs from WP3 (double-ended ferry design) and WP5 (route analysis) and power measurements on board ferry between Brestova and Porozina following power requirements are estimated:
• Capacity of battery ES on board ferry: 500kWh
• Peak charging power: 500 kW
• Power required for cold ironing (ferry consumption while in port): 250 kW

5-9 Power measrement on board ferry during voyage between Brestova and Porozina



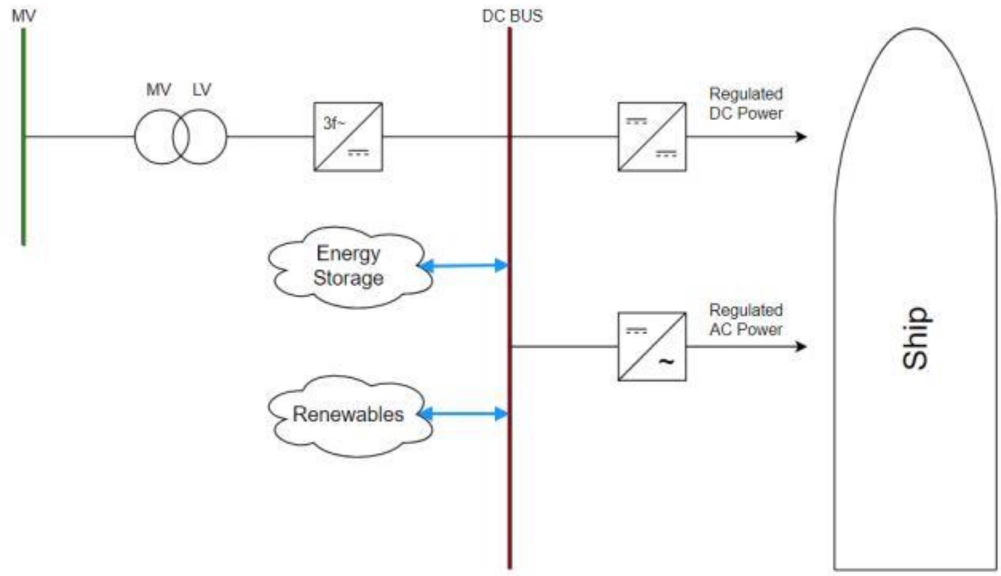
Source: METRO 4.2. Analysis, Ground electricity infrastructures and grids

Proposed hybrid double-ended ferry between Brestova and Porozina will use batteries as a primary power source during manoeuvring when entering/leaving port, and internal combustion engines during navigation.

Power system topology has not yet been determined but the proposed capacity of battery ES should be enough for planned exploitation profile. Ferry will be connected to shore side power during every stay in port. It is planned that equal charging stations will be placed in both ports.
The guiding thought during design of shore side charging infrastructure in Brestova and Porozina is to allow battery charging regardless of vessel power system topology and provide both AC and DC power when require.

Experience gained from exploitation of existing ferry charging stations, mostly in Norway and Sweden, has shown that on shore energy storage systems and renewable energy sources are key technologies for increasing energy efficiency and reliability of shore side power supply systems for ships. For this reason, it is also important to design shore side power infrastructure in such way to facilitate the easiest possible connection of such sources.
In order to meet the above conditions, a shore connection/charging system with a common DC bus is selected as a most suitable solution.

5-10 Shore connection/charging system with a common DC bus



Source: METRO 4.2. Analysis, Ground electricity infrastructures and grids

There are many advantages of using the proposed topology of which the most significant are listed:

• Use of common DC bus can provide more efficient interconnection of system with different frequencies

• When compared to AC bus, DC bus requires less power conversion stages for connections and interconnections of equipment

• Parallel operation of multiple power sources is much easier on DC system because there is no need for synchronization

• Rectifier can be placed in the same substation, together with MV/LV transformer, which reduce the length of 0.4 kV supply cables and consequently reduces possible voltage drop problems at high loads (this is especially applicable for port of Porozina)

• It is much easier to maintain required voltage level on DC system

• There is no harmonic, reactive power and skin effect issues on DC bus

• It is easier to design electrical protections because modern power electronic converters can almost instantaneously limit the current and power flow when required (e.g. system overload, short circuit, earth fault

• By using higher DC bus voltage (750-1000 V) charging current, voltage drops and copper losses are reduced compared to 0.4 kV AC distributio

• Battery storage system and renewable energy sources can be connected to DC bus via simple bidirectional DC-DC converters, which also facilitates power flow management

• During power outages on supply distribution grid, important consumers within port facility can be supplied from battery energy storage
• In future, with expected rapid grow of cars, trucks and busses, it will be much easier to realize charging stations for such vehicles and increase the port revenue by selling the energy from own micro grid.

5.1.4 Double ended ferry designed within METRO project

One of the goals of the project METRO (Maritime Environment-friendly TRanspOrt systems) is the development of new hybrid double-ended ferry that is assumed to operate in the Northern Adriatic Sea. For the purposes of the EU Interreg project METRO (Maritime Environment-friendly TRanspOrt systems) it is necessary to estimate a double-ended ferry that is assumed to operate in Northern Adriatic Sea. The main idea is the implementation of hybrid technologies to get more environmentally sustainable ships. The double-ended ferry is intended for short routes between Croatian coast and islands.

The following data were gathered as basic parameters: length overall, breadth, draft, main engine power, speed, gross tonnage, deadweight as well as passenger and car capacity. In addition to these data, the database partly contains some other data (for example route lengths, ferry lane meters, number of passenger and cargo decks, etc.), but these data were not analyzed due to their incompleteness or unreliability.

Given that a quite sufficient number of ferries were gathered, the database provides very good guidelines for a new hybrid ferry design. Based on the data analyzed and formulas developed within the study, the basic parameters of four ferries within the range of lengths that could fit well into the Northern Adriatic area were preliminary selected. The selection of these basic parameters represents the first step in the process of development of new hybrid doubleended ferry within the project METRO.

The vessel is double ended car & passenger ferry intended for restricted waters year around operation in Croatia. The propulsion is based on diesel electrical solution designed in terms of arrangement and electrical system for battery hybrid plug-in solution.

Basic information about the ferry:

1. Hull material – Steel
2. Basic functions – Passenger ferry

DIMENSIONS

Length	overall 101.90 m
Length	between perpendiculars 92.70 m
Breadth	moulded 20.00 m
Hull depth to lower car deck (midship)	1.05 m
Hull depth to upper car deck (midship)	3.80 m

Draught	max 2.50 m
Draught	design 2.30 m
Air draught abt.	25.0 m
Deadweight (at max. draught) abt.	1000 t
Deadweight (at design draught) abt.	660 t
Gross tonnage	4860 GT

PERFORMANCES

Design speed (Design draught, 15%SM)	10.0 kts
Maximum speed (Design draught)	12.0 kts

CARGO SPACE CAPACITIES:

CARS	1.80 x 4.25 m, 0.4 m gap in between
MAIN DECK	130 PCU
LOWER DECK	40 PCU
TRAILERS	2.5 x 18.0 m, 0.6 m gap in between 22 units

CREW AND PASSENGERS

CREW	12 crew members
NO. OF CREW CABINS	4 off “single” and 4 off “double
PASSENGERS	600 pax
LOUNGE	320 seats
OPEN DECKS	300 seats

For cargo and passengers loading/unloading, hydraulically operated ramps are arranged at each end. Two fixed driving ramps are arranged to access the lower hold

The propulsion is based on a diesel electrical hybrid solution with a battery system. The vessel shall be able to operate in pure battery mode, with the possibility to charge the batteries from a suitable quick connecting shore power system when the vessel is at quay. Power generating plant consists of diesel gensets and batteries.

Main diesel gensets: 2x1000 kW
Battery pack capacity 700 kWh
Azimuth thrusters 4x370 kW

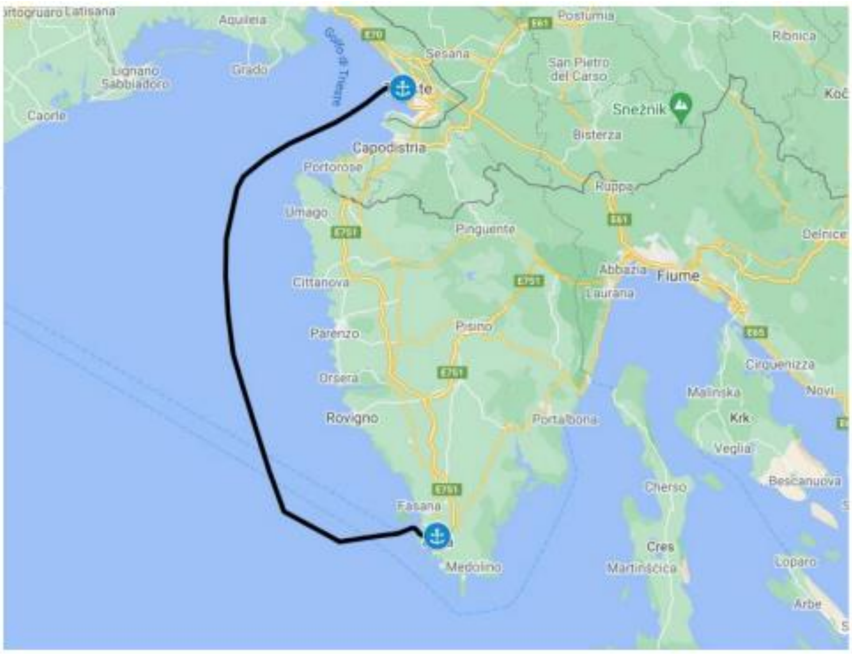
5.2 Trieste – Pula - short ‘green’ RO-PAX route

The other route that used as a starting point for designing the new green vessels during the METRO Project was the Ancona-Split one. Specifically, an environmentally-friendly RO-PAX vessel has been designed, endowed with a hybrid mechanical-electrical propulsion solution, where the propulsion motors can provide power to the vessel’s electrical loads through a power take off function during navigation. An onboard energy storage system, coupled with the generation capability of the propulsion motors, allows removing the onboard generators, optimize the engines loading, and thus lower vessel’s emissions. At berth the vessel uses a shore connection system to supply the onboard loads and recharge the onboard energy storage system, ensuring zero emissions in the port. A short summary of the vessel data is depicted in Section 5.2.3 of this document, while all the design data is available among the Project documentation.

Having designed a green RO-PAX ship for a specific route, it was interesting to evaluate if such vessel can be applied to other relevant routes in the North-Adriatic area. Therefore, an analysis has been done to evaluate possible routes, resulting in the one that is here evaluated: the Trieste-Pula one.

Routes to Croatia were present in the past. Nowadays passengers’ traffic from Trieste to Croatia is limited and dropped in the years. A potential demand is existing but not expressed. Trieste Port Authority plans for cold ironing and decarbonization can be an asset in developing green routes.

5-11 Route Port of Trieste - Port of Pula



Source: Google Maps

5-12 Port of Trieste

Source: Google Earth

5-13 Port of Trieste, passengers terminals

Source: Google Earth

5.2.1 Current port infrastructure - Trieste and Pula

5.2.1.1 PORT OF TRIESTE

For its strategic position, the port of Trieste represents a hub of primary importance inside of the dynamics of the transport goods and passengers in reference not only to north-Eastern Italy, but represents a strategic center for commercial relations with European continental countries such as Germany, Austria, Hungary, and the Czech Republic.

For several years the port of Trieste, through the society participated Trieste Terminal Passeggeri, is conveying a considerable flow of the different types of ships from the cruise, that dock directly to the "Stazione Marittima", the cruise terminal in the heart of the city, adjacent to Piazza Unità, the city center.

On the weekend of the summer months, the Port of Trieste was able to manage until 5 ships from the cruise in mooring, income, or escape from the port.

Moreover, the port of Trieste has been operating for several years with hydrofoils on international routes such as Trieste-Lussinpiccolo, passing through the ports of Rovinj, Poreč, and Piran.

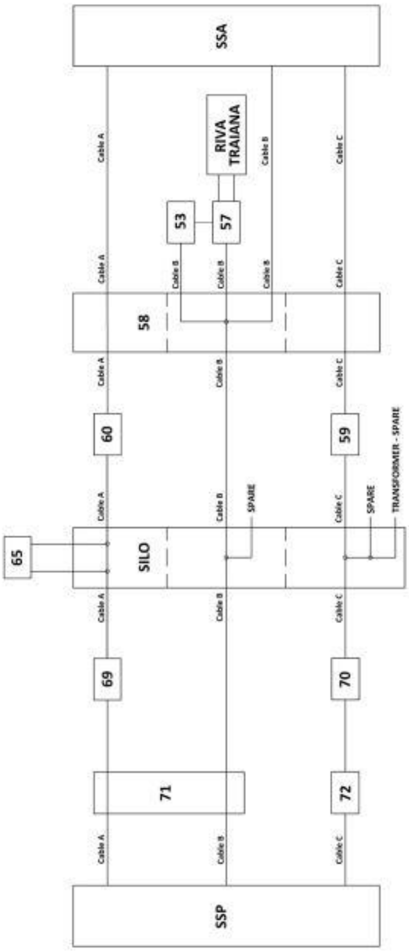
The current infrastructure in an endowment to the port of Trieste involves that this can simultaneously manage a wide number of hydrofoils, ferries, RO-PAX, and ships from the cruise. the docks that the harbor authority could put on of the plan METRO turn out all electrified and, in a position, to operating ambivalent way is on ferries of small dimension that on RO-PAX with the largest dimensions and with adequate road access to disembarkation and embarkation operations. For its strategic position the port of Trieste today represents the first Italian port for enlivened volumes of goods and a center of fundamental interchange with the neighboring countries of East Europe.

The new Port of Trieste has a 6 kV Medium Voltage AC (MVAC) distribution system designed between the 70’s and the 80’s. Electrical network has been installed to feed all the electrical utilities installed in the Trieste new harbor area, figure 5-13 shows all the Trieste terminals to. The Trieste port area is located in Italy along the north-east end of the Adriatic Sea, thus in the heart of Europe near Slovenia and Croatia. The new port behaves as a hub between the commercial flows coming from the TEN-T Mediterranean Sea routes and the Mediterranean/Adriatic-Baltic terrestrial corridors. As the exchanges between European Union and deep East are increasing day-by-day, the port of Trieste is coming back to a key role in the international commercial traffic, thus largely increasing the development opportunities for the city.

5-14 Part of the Trieste New port Area and Trieste Terminals, a) Part of the Trieste New Port Area (2); b) Trieste Terminals

Source: METRO Analysis 4.1.: Charging stations and peer infrastructure

5-15 Port of Trieste Electrical Distribution System (Pier V, Pier VI and common areas) (2)



Source: METRO Analysis 4.1.: Charging stations and peer infrastructure

The port is located in the western seaside of the city, seamless respect to the historical center and touristic areas. By considering the proximity to the city center area, the reduction in port emissions becomes of primarily importance. There are 12 km of docks and piers organized in 58 operating moorings, which can effectively accommodate a large variety of ships (e.g. multipurpose vessels, ro-ro, ferries, etc.). The 6 kV MVAC electrical port grid is a complex system, build using three main MV power lines, which start from two primary transformer stations connected to the 27.5 kV public grid. These two stations are the SSP (main port transformer station) and the SSA (backup transformer station, used in case of maintenance on SSP or in case of faults), which have both 6.5 MVA transformers and are connected to two different feeders from the DSO (to assure redundancy). In the port there are 12 MV/LV substations, identified by the name of the pier where they are installed (most of the piers have a numerical name, while two of them have a proper noun). The total apparent power used by the port is approximately 800 kVA, but it can reach up to 1 MVA in some operative conditions.

Thus, the main stations have a utilization factor that is approximately equal to 16% of the rated value (since only one of them is used at a time, normally the SSP). As the available power capability is relevant, interesting can be the scenarios of port development (e.g. cold ironing, recharging infrastructure, electrical hub).

As an example, the shore connection can be useful in decarbonizing the port site for the Italy-Turkey maritime route. In such a case, a possible power requirement level for these ships can be 540 kW, thus leading to shore connection hubs of 750 kVA (considering a 0.8 power factor and a 0.9 oversizing coefficient). By using such values, in pictures above it has been demonstrated the possibility of installing these two cold ironing platforms endowed with AC-AC power converters, by means of power flow analysis. As both nodes' voltages and load currents are in accordance to the specification during the grid operation, the two shore connections are proved to be effective and manageable, thus enhancing the port decarbonization.

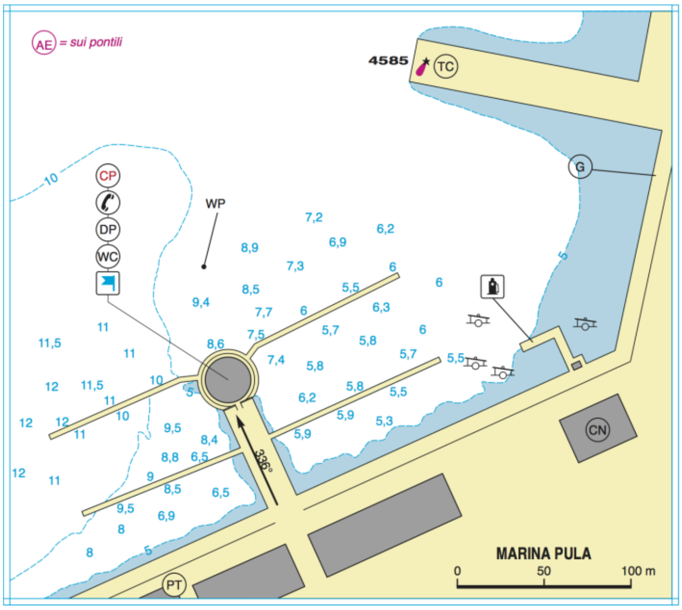
5.2.1.2 PORT OF PULA

The Port of Pula it is divided into 12 different port areas, where the so-called Riječki gat Pula Harbour plays one of the most important roles for the tourism in the city, offering a direct access to the city center through more than 300 meters of coastline for vessel and a 50 meters long pier. 'Riječki gat' is located only at 10-minute walking distance from Pula city center, therefore, close to the main attractions of the town like the famous Amphitheatre, and it works as a mooring quay for passenger catamaran and vessel in connection between the nearest islands and to the municipality of Venice, which is linked to Pula with 5 calls per week.

The Port of Pula is facing an expansion and renovation process. In particular, an important infrastructural project is planned for the construction of a new cruise terminal in the south-western part of the Port, finalized to increase the passengers flow of the port of Pula by establishing well-defined commercial areas within the port: a section dedicated to international ferries, a freight port, a cruise port area and port infrastructures oriented towards local transport. In this context, the main challenge consists in the development of new solutions that combine effectiveness, energy efficiency and environmental sustainability, by adopting measures aimed at supporting the infrastructural development and connectivity of the entire regional territory.

Nonetheless, also the seabed deep represents a not negligible aspect for the final approach of a passenger vessel. It is clear that the sea floor could represent an important problem for the mooring of Ro-Ro Pax ships due to the draught of the vessel estimated of 7 meters. The nautical chart suggests that Pier 'Riječki gat’ struggles to reach this constant deep due to the tidal effect. That is why some investments for the operations of dredging of the seabed and stretching of the pier become important, in order to allow the mooring to the truistic port of Pula to different kind of Passengers Vessels.

5-16 Port of Pula



Source: Pagineazzurre.com

5-17: Port of Pula - RO-PAX Quay

Source: METRO 5.2. Analysis: Passengers and Goods flow dynamics, Analysis of port capacity for target ships & ships energy consumption

5.2.2 Required port infrastructure for establishment of new 'green' route Trieste – Pula

5.2.2.1 PORT OF TRIESTE

To increase the Return on Investment the two platforms can additionally be used separately, when feeding refrigerated containers or recharging possible Electric Vehicles. Since the port must be sized not only for actual routes, but also for the possible future ones, a higher shore power level in respect to the above presented one may be useful to cope with new ships' needs. Thus, to include all the possible RO-RO ferries that can be berthed in the port, it is possible to consider a 1 MVA ship power as a suitable design value. Therefore, shore connection apparatuses sized for 1.5 MVA should be sufficient to cover all the possible future needs for such ships.

Not only the cold ironing can improve the environmental impact in the industrial port, but also this technology can be adopted in the city moorings for large cruise vessels. In this context, these large vessels are nowadays moored and bunkered on Molo Bersaglieri, in the city center near the main square "Piazza dell'Unità di Italia". As a matter of fact, during the cruise vessel stop in the city port, the pollutant emissions are today consequent as the main diesel engines run to feed the base onboard loads. It is evident how a shore connection in Molo Bersaglieri could be able to solve this city pollution. During the last years, several are the proposals in this regard. One of the most feasible foresees the installation of two multi-MW shore connections on the Molo Bersaglieri. By taking into account the large requested power during cold ironing (i.e. 10-20 MW for each platform), the High Voltage supply is consequent thus opening interesting scenario of grid development.

5.2.2.2 PORT OF PULA

Riječki gat of Port of Pula is the passenger ships arrival terminal due to its strategical location close to the city center. Despite a quay of over 150 meters usable for handle passengers and vehicles traffic, for what concern the infrastructure for establishment of a new 'green', it is necessary to consider the lack of an electric transformation cabin, adjacent to the Port mooring area for passenger ferries. That is why the Passenger terminal of Port of Pula needs some important investments in electrification of the quay, indispensable to be able to handle the operations on hybrid Ferries Ro-Pax as proposed in this ambitious project. Some investments have been already made to improve both the pedestrians and motor vehicles connection from the Port Area to the Urban Center.

The electrification of Riječki gat of Port of Pula thus becomes the major investment to support to allow the docking of hybrid and battery-powered Ro-Pax Ferries. There are two essential reasons that must be considered in this proposal of the electrification of the quay: the first one regards the charging of the batteries of the ships, and the second one it is about the possibility of limiting the use of the main and auxiliary engines once ships are mooring to the dock, with an important reduction of air emission polluting and noise pollution.

Further investments could also involve the installation of a floating temporary quay, aimed to extend the Riječki gat Pier of the Cruise Terminal. A floating pier linked to the mooring of Passenger Ferries could be extremely useful to address the problem of the depth of the seabed at the quay. The analysis of the depth of the marine backdrop, suggests in fact that this can represent a critical factor for the final approach of RO-Pax Ferries in Port of Pula, also linked the effect of the tides. Therefore, beyond to some activities of dredging of the seabed, the possibility to lengthen the dock using a floating pier could be and economic and efficient alternative.

5.2.3 Hybrid RO-PAX ferry designed within METRO project

The vessel is Ro-Ro passenger ferry intended for short international voyages year around operation for regular service between ports in Croatia and Italy in Adriatic Sea. Equipment and systems shall be made as modern, energy efficient, environmentally friendly and suitable for transportation of passengers and wheeled cargoes.

Basic information about the ferry:

1. Hull material - Steel
2. Basic functions - Ro-Ro Passenger Vessel

DIMENSIONS

Lenght	overall 129.00 m
Lenght	between perpendiculars 123.00 m
Breadth	moulded 23.60 m
Hull depth to freeboard deck (midship)	8.00 m
Draught, scantling	5.60 m
Draught, design	5.25 m
Deadweight (at scantling draught) abt.	2240 t
Deadweight (at design draught) abt.	1400 t
Gross tonnage	15040 GT

PERFORMANCE

Design speed (Design draught, 15%SM)	15.5 kts
Maximum speed (Design draught) ab.t	18.0 kts

CARGO SPACE CAPACITIES

CARS	1.80 x 4.20 m, 0.4 m gap in between
MAIN DECK	181 PCU
CAR DECK	161 PCU
TRAILERS	2.5 x 18.0 m, 0.6 m gap in between 38 units

CREW AND PASSENGERS

CREW	75 crew members
SHIP'S CREW SINGLE CABINS	27 berths
HOTEL STAFF SINGLE CABINS	24 berths
HOTEL STAFF DOUBLE CABINS	24 berths
PASSENGERS	1336 passengers
PASSENGERS 4-BERTHS CABINS	400 berths
SITTING LOUNGES	513 seats
PUBLIC SPACES	423 seats

The Vessel is designed with stern and bow ramp for facilitated loading/unloading of ro-ro cargo and passengers in fully enclosed main cargo hold. Hoistable car deck shall be designed for stowage of cars only, with the end panels acting as access ramps. 6 reefer plugs shall be fitted on Main Deck.

The ship is driven by a dual fuel engine machinery propulsion unit consisting of two (2) medium speed, four stroke, non-reversible main engines, coupled to reduction gears, propulsion shafts and controllable pitch propellers. Two (2) shaft generators and one (1) emergency diesel generator unit to be provided, as well as battery pack for pure battery operation (manoeuvring, low speed and emergency – PTI operation) and hybrid "peak shaving" operation, used to store energy when the power demand is reduced and to restitute the energy when such demand is high, while running main engines at constant speed and at optimized load.

Main diesel gensets: 2x4000 kW
Battery pack capacity 4800 kWh
Shaft generators 2x1500 kW

In the proposal of this new route therefore it would be necessary also to include of the important infrastructural intense activities for the port of Pula that include the lengthening of the pier River, using perhaps a part of floating dock, the dredging of the seabed and a further analysis of the vehicular traffic, in order to avoid congestion of the traffic on the promenade of the Croatian city.

6 Costs and benefits of establishment of new touristic routes based on green technology vessels

According to Technomont information, price of material and equipment is not stabile on world market and it is very difficult to say that prices will be on same level next week or month.

Rough estimation price for DOUBLE ENDED FERRY is on level of 15 to 20 mil EUR, and for RO-PAX is on level of 45 to 60 mil EUR (depends on what kind of equipment will be installed on vessel and interior quality level).

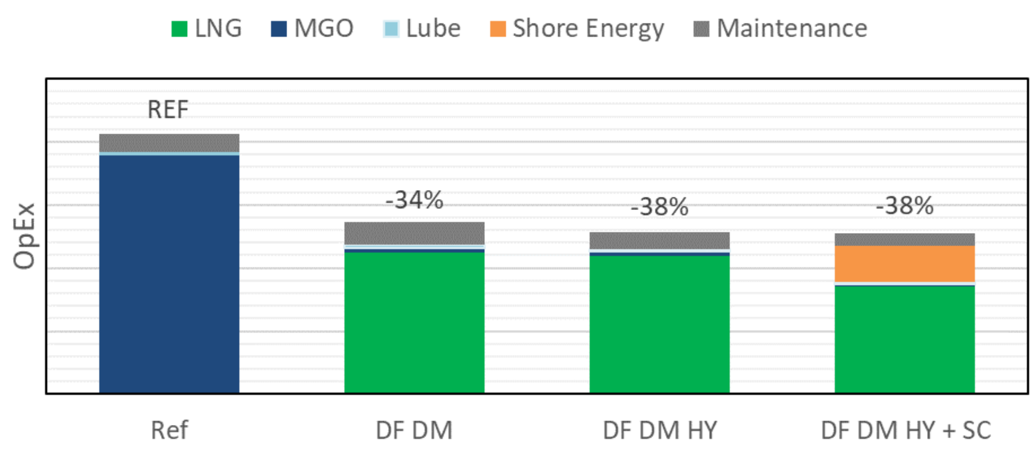
6.1.1 RO-PAX vessel

The longer route selected operate connects Croatia and Italy crossing the Adriatic Sea, between Ancona (Italy) and Split (Croatia), with a distance of approximately 100 NM.

6-1 Consumables' price assumptions for RO-PAX vessel

Consumable	Price
LNG	*400 €/mt*
MGO	*550 €/mt*
Shore energy	*80 €/MWh*
Lube oil	*2300 €/mt.*

6-1 Operating Expenses for the RoPax

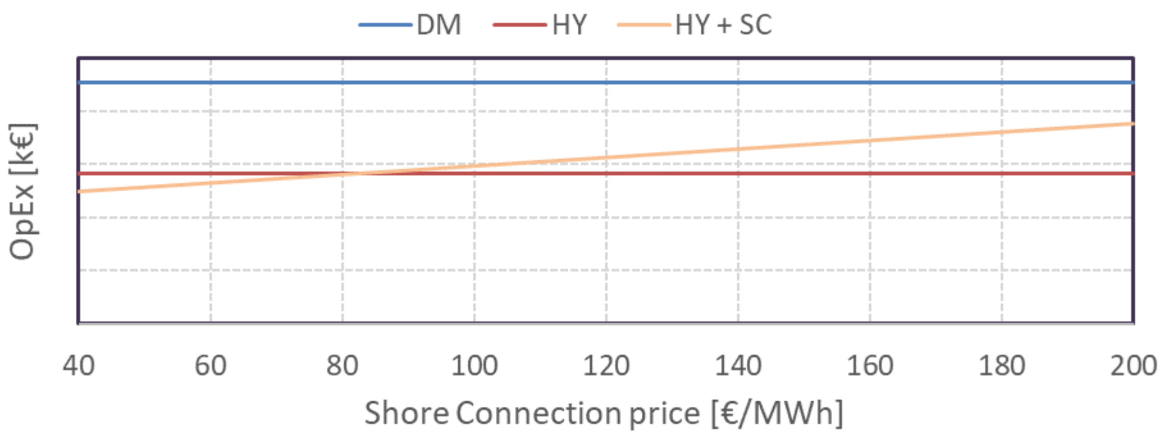


Source: METRO Analysis: 3.1 Hybrid Propulsion Unit, Energy Storage and Controls

Only with LNG we reduce the OPEX as well as with the addition of battery and shore connection, but the last one depends on country where ship works.

In figure 6-1 note that shore connection is favorable only when the cost is under 80 €/MWh compared to the study of the ferry, the configuration with shore connection is economically attractive only with a much lower price for energy, which might be not in line with prices in the region.

6-2 Sensitivity analysis of shore connection price on OpEx for the RoPax



Source: METRO Analysis: 3.1 Hybrid Propulsion Unit, Energy Storage and Controls

6.1.2 Double ended ferry

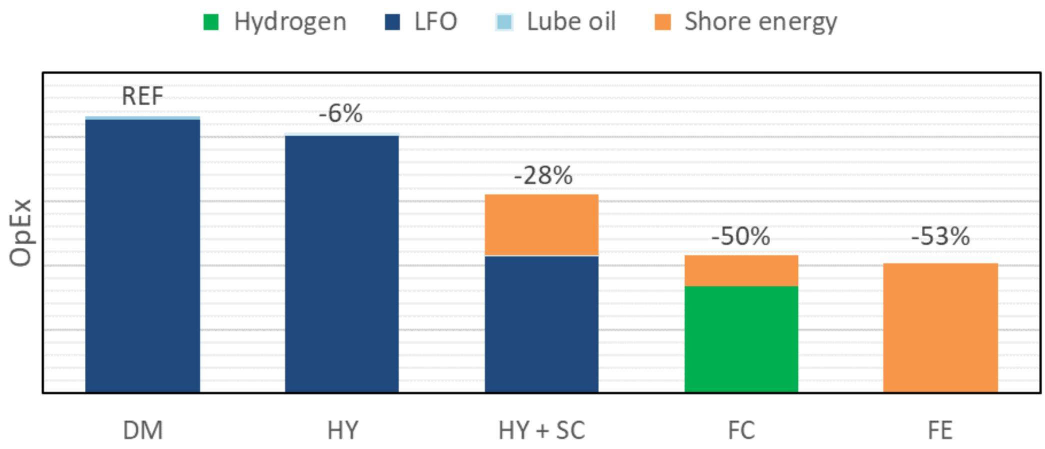
The selected route takes place in Croatia between the berths of Brestova and Porozina, with a nautical distance of about 2.7 NM and a crossing time of approximately 10 minutes.

6-2 Consumables' price assumptions for double ended ferry

Consumable	Price
Hydrogen	*1000 €/mt*
LFO	*450 €/mt*
Shore energy	*80 €/MWh*
Lube oil	*2300 €/mt.*

Although the importance of shore connection price, HY+SC is cheaper than the concept DM.

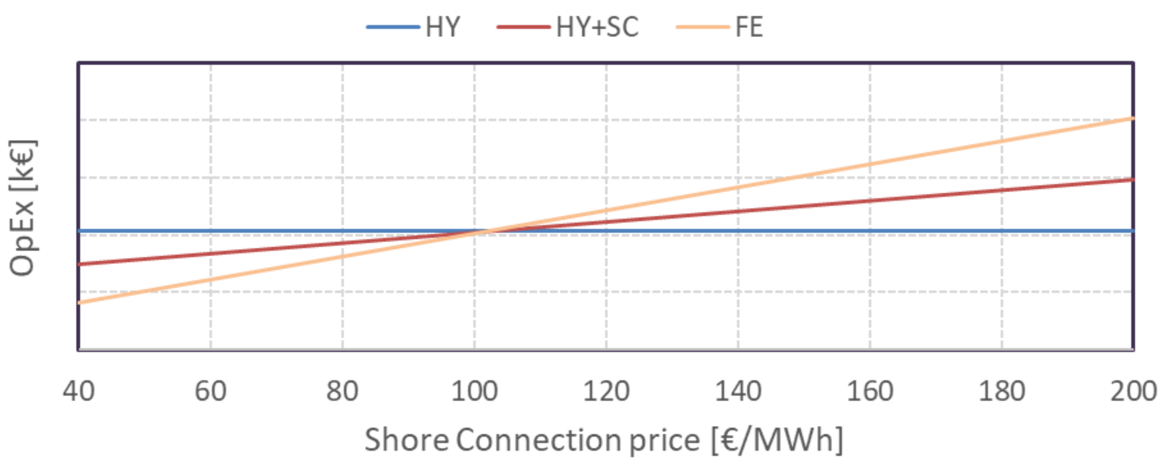
6-3 Operating Expenses of the double ended ferry



Source: METRO Analysis: 3.1 Hybrid Propulsion Unit, Energy Storage and Controls

Since the shore connection plays a relevant role in the simulated configurations a sensitivity analysis has been performed to assess in which scenarios our solutions are interesting. The figure 6-3 highlights that under *100 €/kWh* solutions became competitive, especially the full electric concept. As expected for a short route the full hybrid is the best solution from both economic and environmental point of view.

6-4 Sensitivity analysis of shore connection price on OpEx for the double ended ferry



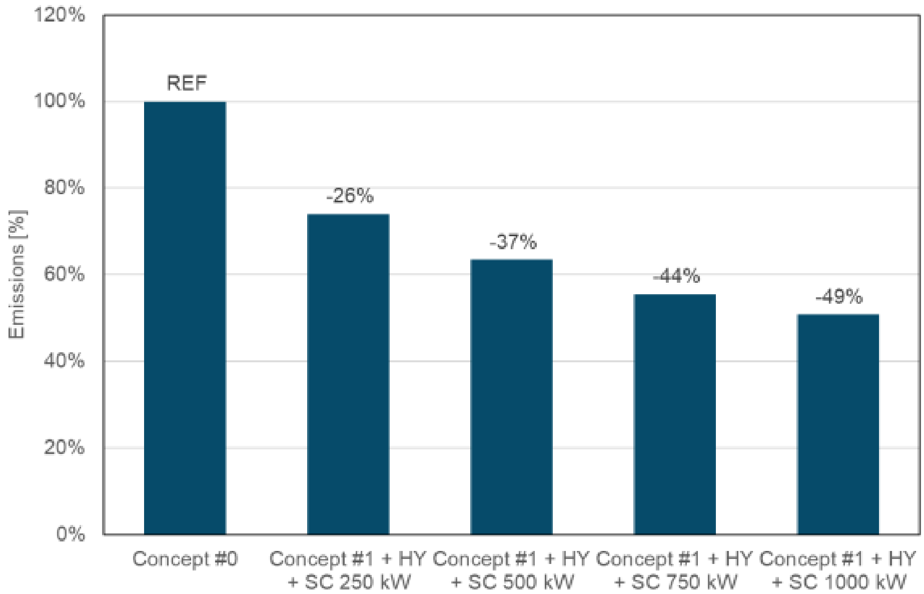
Source: METRO Analysis: 3.1 Hybrid Propulsion Unit, Energy Storage and Controls

6.1.3 Effect of the shore connection power on the results

The effect of the shore connection on the HY+SC, FC, and FE solutions is appreciable. Indeed, the reductions in emissions and OpEx in respect to the conventional propelled solution (DM) are significant. However, to achieve such results it is required to install in the port a suitably sized charging station, capable of delivering more than 1.5 MW to the ship. This may not be possible, depending on the existing shore and land power infrastructure, as well as the future modification opportunities. Therefore, it is useful to evaluate how the emissions and the OpEx changes following a variation in the available shore connection power. The selected configuration is the HY+SC one, which is tested with four different SC powers (250 kW, 500 kW, 750 kW, and 1 MW) and compared with the DM solution.

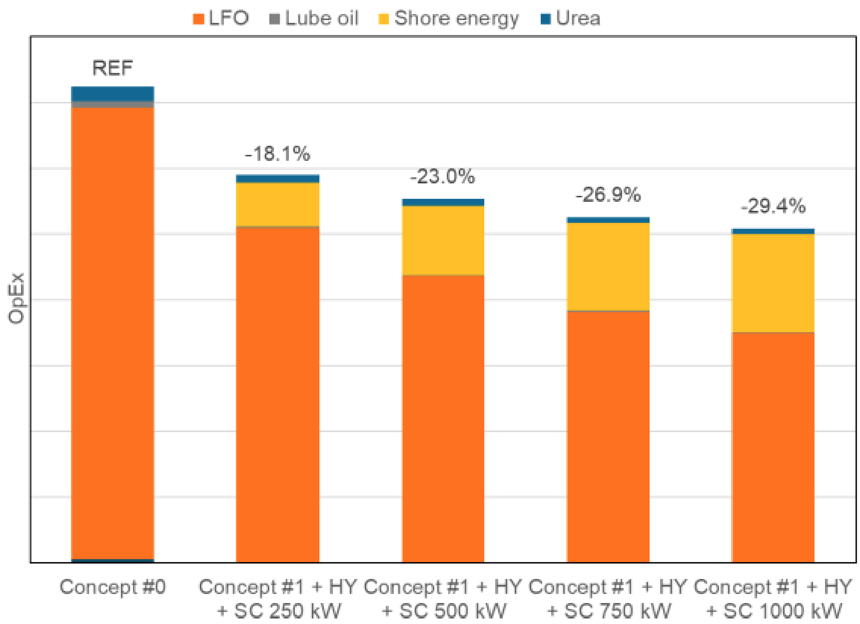
The results regarding overall emissions are depicted in Figure 6-5, where the DM solution (Concept #0) is compared with the HY+SC solution with variable SC power. It is evident how increasing the power of the shore connection reduces emissions, being an increasing quota of energy used by the ship delivered by the land power system. However, using a low power shore connection is still better than running a conventional Diesel-powered vessel, and the achievable emission reduction is still sensible.

6-5 Carbon dioxide emission for the double ended ferry, effect of using different sized shore connection apparatuses



Source: METRO Analysis: 3.1 Hybrid Propulsion Unit, Energy Storage and Controls

6-6 Operating Expenses for the double ended ferry, effect of using different sized shore connection apparatuses



Source: METRO Analysis: 3.1 Hybrid Propulsion Unit, Energy Storage and Controls

6.2 Benefits

After the comparison of different concepts from economical, technical and environmental point of view one configuration for each vessel have been selected for the complete design.

6.2.1 Double ended ferry

The hybrid solution with W16V14 and shore connection concept showed good economical (-30% OpEx) and environmental performance (-35% CO_2), with low footprint and weight. A future solution for this typology of vessel seems to be the expansion of battery capacity towards full electric solution (-75% CO_2 and -55% OpEx).

- *Running hours*: all studied configurations are able to reduce running hours by 80%, reaching 90% through shore connection.
- *Emissions*: the studied solutions enable to reduce CO_2 emissions by 5% up to 40%. Actual reduction is strongly influenced by local carbon intensity of electricity generation.
- *OpEx*: the proposed solutions enable to reduce OpEx by 6% up to 30%. The actual results are quite influenced by shore energy price: to get an actual reduction of OpEx also for solution with SC price should be lower 100€/MWh.

It is important to mention the comparison of emissions on the two routes analyzed through metro project analysis.

6-3 Benefits of Double ended ferry

Emissions	Ferry today	Double ended ferry
Annual fuel consumption for ferries on Brestova-Porozina route	360 tons of fuel oil	210 tons of fuel oil per year
Direct CO^2e emissions for each run	327,88 kg → Annual: 1.158.064 kg CO^2e	193,87 kg → Annual: 684.737 kg CO^2e
Indirect (well-to-tank) CO^2e emissions for each run	66,49 kg → Annual: 234.842 kg CO^2e	37,72 kg → Annual: 136.776 kg CO^2e

Use of new hybrid ferry will reduce annual CO2e emissions:

Directly → 473.300 kg
Indirectly → 98.060 kg

6.2.2 RoPax

The hybrid solution with W8L34DF and shaft generators showed good economical (-37% OpEx) and environmental performance (-30% CO_2). Solutions with also the shore connection is quite challenged by the price of shore connection (to promote more environmentally friendly solution government incentives might be needed).

- *Running hours*: hybrid configurations are capable to cut running hours from 25% to 50%.
- *Emissions*: the studied solutions enable to reduce CO_2 emissions by 25% up to 40%. Actual reduction is strongly influenced by local carbon intensity of electricity generation only for the Shore Connection solution.

OpEx: proposed solutions enable to reduce OpEx by 33% up to 38%. The actual results are again very influenced by shore energy price: to get an actual reduction of OpEx also for solution with SC price should be lower than 80€/MWh.

More details about the comparison can be found within the METRO Analysis 3.1 “Hybrid Propulsion Unit, Energy Storage and Controls”.

It is also important to emphasize the benefits of integration with the green land mobility described in Section 4. Most of the Istrian ports recognized importance of connecting different types of transport by entering in numerous EU projects that for the aim have develop of multimodal transport, mostly in partnership with Italy. Furthermore, cites also recognized importance of sustainable and ecological transport by introducing e-bikes and e-charging stations (for bikes and cars). However, these types of transport do not exist at ports and here lays opportunity for further development of multimodal and sustainable transport. In addition, none of the ports have e-charging station for boats that could help in developing of elite tourism. When speaking about public transport it is not well developed in most of the cites and here also lays another opportunity to develop sustainable and ecological transport with low (or zero) CO2 emission. Improvement in availability and accessibility of the ports by connecting them with the intermodal land infrastructure is needed.

6-4 Benefits of Ro-Pay ferry

Emmissions	Ferry today	Ro-Pax ferry
Annual fuel consumption for Ro-Pax on Ancona-Split route	6750 tons of fuel oil	3930 tons of fuel oil per year
Direct CO^2e emissions for each run	299.972,85 kg → Annual: 20.998.029 kg CO2e	174.978,75 kg → Annual: 12.248.512 kg CO^2e
Indirect (well-to-tank) CO^2e emissions for each run	62.120,65 kg → Annual: 4.348.445 kg CO^2e	36.221,69 kg → Annual: 2.535.518 kg CO2e

Use of new hybrid ferry reduces annual CO^2e emissions:

Directly → 8.749.516 kg
Indirectly → 1.812.928 kg

7 Conclusions

The concept of "Green Port" requires an efficient organization and leadership, coherent policies and regulations, innovations and a management system of environmental protection, energy efficiency and sustainable development. Each seaport can adopt a new, "greener" strategy and upgrade the existing system in order to define steps of the implementation of the model in order to minimize and eliminate the potential consequences of operational and illegal discharges of waste material. Therefore, most ports develop waste management plans in order to protect the port area of waste from ships and daily port operations. The proposed model for the implementation of the concept of "Green Port" development aims at achieving a low consumption of resources and the design of green logistics seaport systems as a prerequisite for achieving environmental protection, energy efficiency and sustainable development. Moreover, green ports are an enabler for correctly supporting the new green ships, which require dedicated shore-side infrastructure to provide their expected environmental advantages. However, the implementation is not possible without an efficient cooperation between public bodies and private companies who are the key to the successful treatment of waste in seaports and its surrounding areas. Finally, the introduction of the concept of "Green Port" development is not only the protection of the environment but also the adoption of the concept of achieving better working conditions in the complexity of seaport operations. It provides a clear definition of responsibilities and training of internal staff, who will work in more environmentally friendly area and with more environmentally friendly equipment. Whatever is mentioned so far, leads to a permanent performance improvement (improving the quality of seaport services) thus positioning seaports as more competitive on the market.

The port systems have been identified as major energy consumers, and they will increase further their consumption in the future, when they will be required to supply green energy to the berthed ships. They represent the systems that have difficulty in the adaption of innovative solutions with regard to energy savings and energy efficiency. The most of port systems are using the outdated technology for the measurement of energy consumption and because of the mentioned facts they do not contribute to energy efficiency, environmental protection and sustainable development. On the contrary, seaports are one of the main drivers of the pressure on the environment, especially because of the fact that most of the seaports and terminals are located close to the urban areas (city areas).

Nowadays, seaports provide numerous services which are mostly related to passenger and cargo transport. Shipping is responsible for approximately 20% of global discharges of wastes and residues into the sea. The busiest the port is, the higher are the risks for suffering from pollution in those ports. On the other hand, port is a conventional word which includes conflict between human act and environment, so they represent a danger to environmental protection. However, the experience has shown that even in the best kept ports and terminals they do occur. For that purpose, oil separators of different kinds, oil booms and skimmers are used to salvage the damage.

Seaports are connecting world through the maritime transport network. They promote international trade and support the global economic growth. However, seaports are the most common point of entry of anthropogenic environmental pollution through the activities of maritime transport. That is a critical challenge for port managers who strive towards providing efficient port protection services related to the environmental protection. The environmental concerns regarding the port systems are very diverse. They can arise from maritime activities, internal port operations, warehousing and transshipment of transport activities within the port area, etc. The increase in transport activities increases also the CO2 emissions and represents potential threats to serious environmental pollution. In recent years, a major priority is to minimize the harmful impact of port operations to the environment. Seaports are trying to achieve a "green" status by introducing new technologies and renewal systems for energy production in the port infrastructure. Therefore, the model of "Green Port" development is an important concept for the development and operation of the port companies to prevent environmental degradation, loss of biodiversity and achieve a sustainable use of natural resources.

The action plan shows the way in which the ecological sustainability in the field of maritime transport can be improved, with special emphasis on tourist connections in the northern Adriatic. They also improve the quality, safety and environmental sustainability of maritime and coastal transport services and hubs by promoting multimodality in the program area. From a technological point of view (development of hybrid solutions to be used on vessels to be used for passenger transport - two-way and RO -PAX trajectory) and logistical (study on adaptation of infrastructure for electricity supply in small ports, defining new routes to be establish among ports in the northern Adriatic).

From the current state in ports (Pula, Trieste, Ancona, Split, Brestova, and Porozina), and future urban development plans, required steps for the development of new touristic routes based on green technology vessels are: