Preliminary study for developing the RENEWPORT RES toolkit for Med ports

Deliverable D.1.1.1

Document control sheet

Programme	Interreg Euro-MED
Project number	Euro-MED0200116
Project acronym	RENEWPORT
Project Title	Harnessing RENEWable energy potential for clean energy transition of MED PORTs
Start /end of the project	01/01/2024 – 30/09/2026
Programme priority	Greener MED
Specific objective	RSO2.4: Promoting climate change adaptation and disaster risk prevention, resilience, taking into account eco-system-based approaches
Project mission	Promoting green living areas
Lead Partner	Port Network Authority of the Eastern Adriatic Sea

Work package	WP1 Developing a toolkit for renewable energy uptake in MED ports
Activity	Activity 1.1 Preparing the RENEWPORT RES toolkit for MED ports
Deliverable name	D.1.1.1 Preliminary study for developing the RENEWPORT RES toolkit for Med ports
Type of deliverable	Study/Methodology
Language	English
Work Package Leader	Valenciaport Foundation for research, promotion and commercial studies of the Valencian Region
Project partners involved	Port Network Authority of the Eastern Adriatic Sea (LP); Port Network Authority of the Northern Tyrrhenian Sea; Var Chamber of commerce and industry; Valenciaport Foundation for research, promotion and commercial studies of the Valencian Region; Valencia Port Authority; Luka Koper, port and logistic system, public limited company; Port of Rijeka Authority; Port of Bar JSC; Durres Port Authority; Piraeus Port Authority SA.
Year of deliverable production	2024

Content

Glossary

ADEME: Agence de l’Environnement et de la Maîtrise de l’Énergie (French Agency for Ecological Transition)

ADRIREC: ADRIatic ports for Renewable Energy Communities project

AdSP MTS: Autorità di Sistema Portuale del Mar Tirreno Settentrionale (Port Network Authority of the Northern Tyrrhenian Sea)

AEO: Authorised Economic Operator

API: Application Programming Interface

APV: Autoridad Portuaria de Valencia (Port Authority of Valencia)

CAPEX: Capital Expenditure

CdTe: Cadmium Telluride

CIS: CuInSe2 – Cadmium Indium Selenide

CSV: Comma-Separated Values

DEASP: Energy and environmental planning document of the Italian port system

DPA: Durres Port Authority

EC: European Commission

EMAS: Eco-Management and Audit Scheme

ERDF: European Regional Development Fund

ESPO: European Sea Ports Organisation

ETU: Ecosystemic Transition Unit

EU: European Union

GDP: Gross Domestic Product

GUI: Graphical User Interface

IPA: Instrument for Pre-accession Assistance

ISO: International Standard Organisation

JSON: JavaScript Object Notation

kWh: kilowatt hour

LCOE: Levelized Cost of Energy

LED: Light-Emitting Diode

LNG: Liquified Natural Gas

MED: Mediterranean

MWh: Megawatt hour

OPEX: Operational Expenditure

PDF: Portable Document Format

PERS: Port Environmental Review System

PNAEAS: Port Network Authority of the Eastern Adriatic Sea

PPA: Piraeus Port Authority

PV: Photovoltaic

PVGIS : Photovoltaic Geographical Information System

RENEWPORT: Harnessing RENEWable energy potential for clean energy transition of MED PORTs project

RES: Renewable Energy Sources

TCA: Toulon Côte d’Azur

TEN-T: Trans-European Transport Network

TEU: Twenty Equivalent Unit

TON: Tonnes

1. Introduction

1.1. Presentation of the Interreg Euro-Med programme

Interreg is a European Union (EU) instrument to improve cooperation between regions within the EU. It promotes regional development, cohesion, and reducing economic disparities. It takes part of the EU's Cohesion Policy and participate of the European Regional Development Fund (ERDF).

For the period 2021-2027, the fund will enable investments to make Europe and its regions:

- More competitive and smarter
- Greener, low-carbon and resilient
- More connected by enhancing mobility
- More social, supporting effective and inclusive employment, education, skills, social inclusion and equal access to healthcare
- Closer to citizens.

Interreg includes 86 programmes divided in three types:

- Cross border programmes (64 programmes)
- Transnational (13 programmes)
- Interregional (4 programmes)
- Outermost Regions (5 regions)

The transnational programmes, grouped as Interreg B, make reference to big areas of Europe. They support a wide range of project investment related to innovation, environment, accessibility, telecommunications, urban development and governance. Interreg Euro-Med makes part of this kind of programmes. It aims to make the Mediterranean region smarter and greener and improve the governance between its stakeholders. The programme includes 69 regions of 14 countries from Northern shore of the Mediterranean, from Lisbon to Cyprus. It includes 10 EU Member States and 4 countries from the Instrument for Pre-accession Assistance (IPA). Around 140 million people live in this area.

The programme has embedded the objectives into missions for a more comprehensive approach. The four missions are:

1.- Innovative sustainable economy Mission, to strength an innovative sustainable economy, to boost a fair transition to a circular economy

2.- Natural heritage Mission focused on protecting, restoring and valorising the natural environment and heritage

3.- Green living areas Mission, to improve the lives of Mediterranean citizens by promoting the development of green living areas

4.- Sustainable tourism Mission focused on fostering a circular tourism considering the sustainability of ecosystem services.

The programme provides funds for projects developed and managed by public administrations, universities, private and civil society organisations. The total programme budget amounts to almost € 300 millions for the 2021-2027 period. Six kinds of projects are foreseen in the programme:

- Thematic Community projects that aim at establishing conditions for the reuse of results, the development of synergies and the increase of coordination between thematic projects working towards the same mission by articulating a community of Interreg Euro-MED projects partners and implementing transfer and mainstreaming strategies of Euro-MED thematic projects results.
- Institutional Dialogue projects contributing to the implementation of transfer and mainstreaming strategies by engaging with local, regional and national authorities and to the implementation of transfer and mainstreaming strategies and setting up long-lasting conditions for a permanent institutional and social dialogue to bridge the transnational dimension with the local solutions.
- Study projects that perform analyses to better address a thematic issue and open the door to the development of new instruments, policies, strategies, and action plans.
- Test projects that experiment common instruments, policies, strategies and action plans already developed to validate concrete solutions to be transferred.
- Transfer projects that optimise and share validated common instruments, policies, strategies and actions plans to have the stakeholders adopt them.
- Strategic territorial projects that conduct studies, test solutions and transfer results addressing the strategic topics of a specific type of territory.

1.2. Presentation of the project

The project "Harnessing RENEWable energy potential for clean energy transition of MED PORTs – RENEWPORT" is a Test project approved under the second all of the Interreg Euro-Med programme. The main objective is to tackle the negative contribution to climate change of ports by supporting the clean energy transition of MED ports, turning them from emitters of pollutants and greenhouse gases to clean energy hubs by exploiting the untapped potential of renewable energy sources (RES). Through RENEWPORT, policy makers will be endowed with new solutions supporting them to fight climate change reaching energy goals and carbon neutrality and citizens will benefit from cleaner air, MED territories becoming greener living areas.

The project is divided in three main activities:

- The first one is the development of a toolkit that will guide MED ports in the adoption of the most suitable renewable energy source in each location, based on their own current and future energy needs. The toolkit will be freely available on the project's website and will be replicable in other geographical contexts, even beyond the MED Area.
- The second one will consist of the testing of renewable energy options in MED ports. Each port participating in the project will implement concrete pilot activities and investments testing the use of RES in different scenarios and contexts. For the evaluation of these pilot actions, the partners jointly elaborate a set of processes, techniques models, tools, methods and services, deriving a solution answering the need of transforming ports in renewable energy hubs to be replicated in the MED area and beyond.

- At the end, the partners will upscale and transfer the project's solutions. By one side, an e-learning platform will be created containing the technical knowledge gathered in the development of the RENEWPORT RES toolkit and pilot activities and investments. By other hand, some networking activities will be organised with target groups at local, transnational and macro-regional level to inform them about the overall project's results.

The project is led by the Port Network Authority of the Eastern Adriatic Sea (Italy) and the partnership is composed of:

- Port Network Authority of the Northern Tyrrhenian Sea (Italy)
- Var Chamber of commerce and industry (France)
- Valenciaport Foundation (Spain)
- Valencia Port Authority (Spain)
- Luka Koper, port and logistic system, public limited company (Slovenia)
- Port of Rijeka Authority (Croatia)
- Port of Bar (Montenegro)
- Durres Port Authority (Albania)
- Piraeus Port Authority (Greece)

1.3. Presentation of the WP1

The first Work Package of the project is divided into 4 activities:

- Activity 1.1: Preparing the RENEWPORT RES toolkit for MED ports
- Activity 1.2: Co-developing the RENEWPORT RES toolkit for MED ports
- Activity 1.3: Evaluating the RENEWPORT RES toolkit for MED ports
- Activity 1.4: Delivering information on the RENEWPORT RES toolkit for MED ports

This deliverable is included in the Activity 1.1 of the Work Package 1 of the project and is the only deliverable of this activity. The aim of this activity is to jointly assess the current situation on RES adoption in MED ports and lay the basis for the development of the toolkit. The partners have to analyse the status quo in this domain, assessing the existing share and source of renewable energy in participating ports, investigating good practices in the European and international context and setting a common methodology for the development of the toolkit.

The second activity of this Work Package is focused on the development of the RENEWPORT RES toolkit defined in this document. This toolkit will have the form of a web tool to be uploaded on the project's website, that will provide practical advice, guidance, information and calculation of the potential of RES us for MED ports, based on their energy needs and the geographical location. This toolkit will be a powerful solution for planning the clean energy transition of MED ports that will be tested by the partners during this activity.

The third activity will consist of a jointly peer review of the results achieved during the test, comparing data and results, learning from each other's experiences and leading the adjustments of the toolkit. The partners will assess the replicability potential of the toolkit in the MED area and beyond.

The last activity of this Work Package refers to the transfer of the know how developed to other ports that are not participating in the project. Some communication materials will be edited such as a dedicated infographic, a digital brochure and a short video. The partners will participate in some workshops and conferences to disseminate the work done among some target groups.

2. Current situation on RES adoption in ports

Maritime transport is an environmentally friendly way of transporting large quantities of goods. Nevertheless, like any other human activity, it contributes to climate change and air pollution. This is even more true in MED ports, located in the proximity of populated areas, degrading local air quality on top of the emitting CO2.

Ports are quite aware about this problem and they are already working on implementing some solutions. One of these solutions is to exploit the untapped potential of renewable energy sources (RES). The most important ports of the world have already installed in their areas some RES, essentially photovoltaic and wind energy. They are already producing renewable energy, to be used by the Port Authority, by the companies installed in the port area and even by the ships calling at the port.

Here we have some examples of these investments in RES, first by the ports participating in the project and then by other ports that present best practices.

2.1. Existing share and source of renewable energy in participating ports

As it has already explained, some ports from the MED area participate in this project. In fact, we have nine Port Authorities from eight countries, six of them from the EU and two more that are IPA countries. They present here their current situation on RES following six questions:

- Description of the port
- What is the total electricity consumption of your port for 2022 (in MWh), including the land side (terminals, offices, cranes, etc.) and maritime side (ships at berth)?
- What was the amount of renewable energy produced in 2022 (in MWh) and the total power installed (MW)?
- What was the origin of such renewable energy?
- Each existing renewable energy investment.
- What are the planned investments (horizon: 2030) in terms of renewable energy production in the port?

2.1.1. Port Network Authority of the Eastern Adriatic Sea

1) Description of the port

The **Port Network Authority of the Eastern Adriatic Sea** is the public body in charge of the management of the ports of Trieste and Monfalcone, whose primary task is to direct, plan, coordinate, promote and control port operations and commercial and industrial activities in the ports (according to the Law no. 84/1994 as amended by the Legislative Decree no. 169/2016).

The ports of Trieste and Monfalcone are located in the north-eastern part of Italy, Friuli Venezia Region, in the most northern part of the Adriatic Sea, at the intersection between shipping routes and the Baltic-Adriatic and Mediterranean TEN-T core network corridors.

The **Port of Trieste** is an international hub for overland and sea trade with the dynamic market of Central and Eastern Europe. The Port of Trieste is also terminal of regular and direct oceanic connections with the Far East, with calls in several ports in the Mediterranean basin, carried out by the main world shipping companies.

With regard to the technical specifications, the Port of Trieste has an internal rail network (70 km of tracks) that connects with the national and international network and allows all the docks to be served by rail with the possibility of shunting and/or assembling freight trains directly in the various terminals. A direct junction and an elevated road (within the Port) connect to the outside road system, which leads directly to the motorway network, ensuring ease of access to the national road network.

The Port of Trieste has a total surface of 2.3 million square meters of which about 1.8 million square meters are free zones. The storage areas are about 925,000 square meters of which covered about 500,000 square meters.

The total length of docks is 12 km, with 58 operational berths (for conventional ships, multi-purpose, container ships, Ro-Ro/ferry, oil tankers, chemical tankers, passenger ships, etc.).

The maximum depths is 18 m.

The Port of Trieste operates in several areas:

- Old Free Zone: this is the “historical” port of Trieste. This area has been assigned to the ownership of the Trieste Municipality.
- New Free Zone: this is the heart of the “new port” with two Ro-Ro terminals (Pier V and Pier VI) and one container terminal (Pier VII).
- Timber Terminal: it is currently dealing with various goods in packages. After completing the construction of the so called “Logistics Platform” this terminal will be converted into a mixed container & Ro-Ro terminal and will act as basement of the future Pier VIII.
- Oil Free Zone: dealing with the arrival of mineral oils that, routed through pipelines, reach several destinations in Central Europe.
- Industrial Free Zone: dedicated to the industrial zone of Trieste, managed by the Trieste Economic Development Agency; the Port of Trieste is its majority shareholder (52%).

The main feature of the Port of Trieste is represented by its legal regime of Free Port, kept in application of the rules of the Paris Peace Treaty (Annex VIII). According to it, the Free Zones of the Port of Trieste enjoy the legal status of customs clearance exception and do not belong to the customs territory of the European Union.

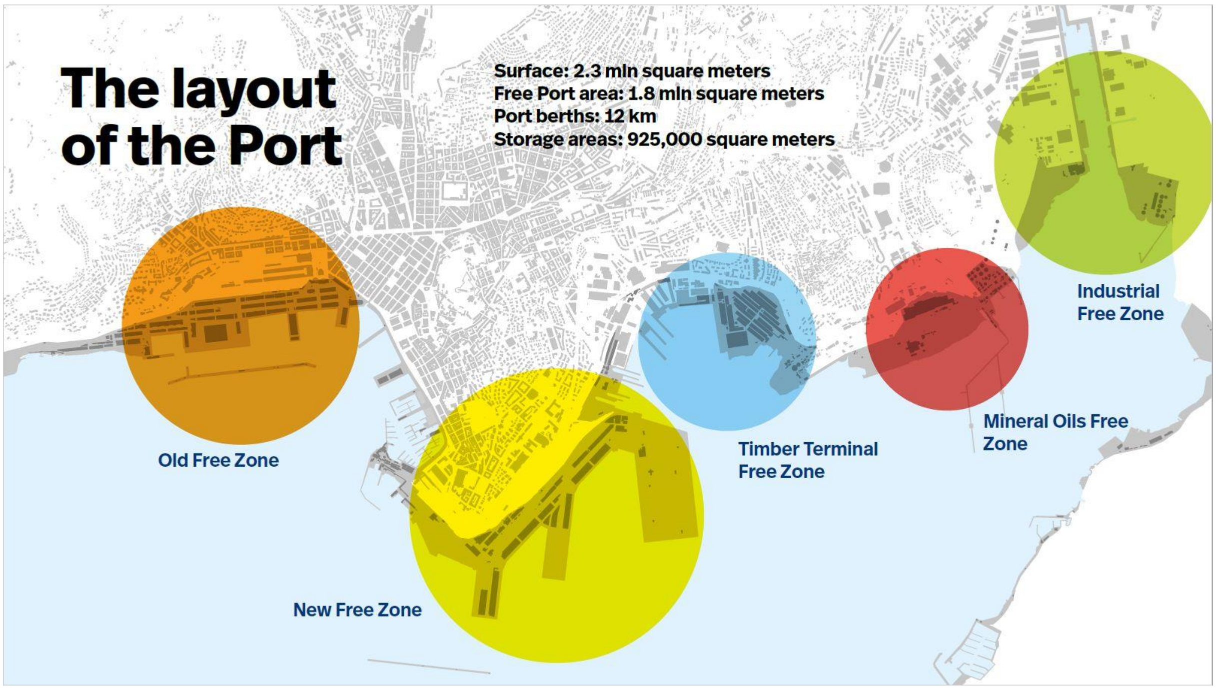


Figure 1: Layout Port of Trieste

The **Port of Monfalcone** is located in the most northern part of the Mediterranean Sea and overlooks the inner part of the Gulf of Trieste.

With the Decree of the President of the Republic dated March 29, 2018, No. 57, entered into force on June 14th 2018, the port of Monfalcone became part of the Port Network Authority of the Eastern Adriatic Sea.

The Port of Monfalcone has a total surface of about 1,550,000 square meters of which about 750,000 square meters still to be infrastructure. The storage areas are about 800,000 square meters of which about 80,000 square meters are covered (warehouses and quay canopies for sheltering goods in transit).

The commercial quay is 1,460 meters long with a variable depth from 6.5 meters of the old part to 11.70 of the new one.

The main goods treated are cellulose, paper, timber, forest products, steel products, kaolin, marble, cereals and cars.

Figure 2: Port of Monfalcone

The Port of Trieste is currently the first Italian port for volume of goods in transit and concentrates the 92% of regional maritime traffic:

Port	2023 throughput (tons)
Trieste	55,624,925
Monfalcone	3,829,721

Table 1: Ports statistics 2023

Statistics show an overall slight increase of traffic over the last three years, mostly due to the port of Monfalcone, with a double-digit growth, while the Port of Trieste is experiencing a loss of traffic amid the general framework of crisis, from the Russian-Ukrainian war to the conflict in the Middle East.

Port	2021	2022	2023	Δ% 21-23	Δ% 22-23
Trieste	55,361,694	57,591,733	55,624,925	0%	-3%
Monfalcone	3,279,833	3,844,489	3,829,721	17%	0%
Total	58,641,527	61,436,222	59,454,646	1%	-3%

Table 2: Statistics of the Ports of Trieste and Monfalcone 2021-2023

Unlike other Italian ports, the Port of Trieste serves only in minimal part the regional and national territory focusing rather on markets in Central and Eastern Europe. The port of Monfalcone, on the other hand, is the import/export hub of a large region with high industrial specialization, with a minimal share of international traffic.

Autorità di Sistema Portuale del Mare Adriatico Orientale Porti di Trieste e Monfalcone

PORT OF TRIESTE
THROUGHPUT STATISTICS - ESPO

TIME PERIOD GOING FROM	01/01/2021 to 31/12/2021			01/01/2022 to 31/12/2022			Difference	
	IN	OUT	TOTAL	IN	OUT	TOTAL	TOTAL	%
TOTAL THROUGHPUT (Ton.)	**47.293.370**	**8.067.887**	**55.361.257**	**48.861.746**	**8.731.067**	**57.592.813**	**+2.231.556**	**+4,03%**
LIQUID BULK	**37.426.452**	**0**	**37.426.452**	**37.882.282**	**0**	**37.882.282**	**+455.830**	**+1,22%**
Crude oil	36.599.282	0	36.599.282	36.917.006	0	36.917.006	**+317.724**	**+0,87%**
Refined (petroleum) products	758.200	0	758.200	901.033	0	901.033	**+142.833**	**+18,84%**
Gaseus, liqufied or compressed petroleum products and natural gas	0	0	0	0	0	0	**0**	
Chemical products	68.970	0	68.970	64.243	0	64.243	**-4.727**	**-6,85%**
Other liquid bulk	0	0	0	0	0	0	**0**	
DRY BULK	**543.642**	**28.149**	**571.791**	**624.307**	**25.411**	**649.718**	**+77.927**	**+13,63%**
Cereals	125.752	0	125.752	125.464	0	125.464	**-288**	**-0,23%**
Foodstuff/Fodder/Oil seeds	0	0	0	0	0	0	**0**	
Coal and lignite	0	0	0	0	0	0	**0**	
Ores/cement/lime/plasters	83.500	0	83.500	57.800	0	57.800	**-25.700**	**-30,78%**
Metallurgical products	334.390	0	334.390	435.986	0	435.986	**+101.596**	**+30,38%**
Chemical products	0	0	0	0	0	0	**0**	
Other dry bulk	0	28.149	28.149	5.057	25.411	30.468	**+2.319**	**+8,24%**
GENERAL CARGO	**9.323.276**	**8.039.738**	**17.363.014**	**10.355.157**	**8.705.656**	**19.060.813**	**+1.697.799**	**+9,78%**
Containerized (including Ro-Ro containers)	4.128.200	3.964.617	8.092.817	4.792.472	3.962.336	8.754.808	**+661.991**	**+8,18%**
Ro-Ro (excluding Ro-Ro containers)	4.327.333	3.848.592	8.175.925	4.559.772	4.244.380	8.804.152	**+628.227**	**+7,68%**
Other general cargo	867.743	226.529	1.094.272	1.002.913	498.940	1.501.853	**+407.581**	**+37,25%**
ADDITIONAL INFORMATION								
NUMBER OF CALLS			**2.125**			**2.290**	**+165**	**+7,76%**
GROSS TONNAGE			**84.071.284**			**86.916.570**	**+2.845.286**	**+3,38%**
NUMBER OF LOCAL AND FERRY PASSENGERS	**2.539**	**5.087**	**7.626**	**5.034**	**6.393**	**11.427**	**+3.801**	**+49,84%**
Local (< 20 miles journey)	0	0	0	0	0	0	**0**	
Ferry passengers	2.539	5.087	7.626	5.034	6.393	11.427	**+3.801**	**+49,84%**
CRUISE PASSENGERS			**127.197**			**437.336**	**+310.139**	**+243,83%**
Home Port	47.443	46.177	93.620	162.788	167.571	330.359	**+236.739**	**+252,87%**
Transits			33.577			106.977	**+73.400**	**+218,60%**
NUMBER OF CONTAINERS (in TEUs)	**399.185**	**358.070**	**757.255**	**470.642**	**407.163**	**877.805**	**+120.550**	**+15,92%**
Hinterland	263.349	266.404	529.753	279.459	316.731	596.190	**+66.437**	**+12,54%**
Empty	62.264	81.813	144.077	58.722	114.744	173.466	**+29.389**	**+20,40%**
Full	201.085	184.591	385.676	220.737	201.987	422.724	**+37.048**	**+9,61%**
Transshipped	135.836	91.666	227.502	191.183	90.432	281.615	**+54.113**	**+23,79%**
Empty	12.255	0	12.255	53.324	4.500	57.824	**+45.569**	**+371,84%**
Full	123.581	91.666	215.247	137.859	85.932	223.791	**+8.544**	**+3,97%**
NUMBER OF VEHICLES	**166.785**	**142.341**	**309.126**	**175.839**	**161.308**	**337.147**	**+28.021**	**+9,06%**
Number of Ro-Ro units	165.035	140.769	305.804	161.264	159.063	320.327	**+14.523**	**+4,75%**
Number of private vehicles	7	55	62	44	177	221	**+159**	**+256,45%**
Number of commercial vehicles	1.743	1.517	3.260	14.531	2.068	16.599	**+13.339**	**+409,17%**

Autorità di Sistema Portuale
del Mare Adriatico Orientale
Porti di Trieste e Monfalcone

PORT OF MONFALCONE
THROUGHPUT STATISTICS - ESPO

TIME PERIOD GOING FROM	01/01/2021 to 31/12/2021			01/01/2022 to 31/12/2022			Difference	
	IN	OUT	TOTAL	IN	OUT	TOTAL	TOTAL	%
TOTAL THROUGHPUT (Ton.)	**2.694.499**	**585.334**	**3.279.833**	**3.318.775**	**525.714**	**3.844.489**	**564.656**	**+17,22%**
LIQUID BULK	**0**	**0**	**0**	**0**	**0**	**0**	**0**	
Crude oil	0	0	0	0	0	0	**0**	
Refined (petroleum) products	0	0	0	0	0	0	**0**	
Gaseus, liqufied or compressed petroleum products and natural gas	0	0	0	0	0	0	**0**	
Chemical products	0	0	0	0	0	0	**0**	
Other liquid bulk	0	0	0	0	0	0	**0**	
DRY BULK	**2.109.632**	**342.850**	**2.452.482**	**2.716.147**	**380.975**	**3.097.122**	**644.640**	**+26,29%**
Cereals	55.756	0	55.756	52.014	0	52.014	**-3.742**	**-6,71%**
Foodstuff/Fodder/Oil seeds	0	0	0	0	0	0	**0**	
Coal and lignite	0	0	0	314.918	0	314.918	**314.918**	**+100,00%**
Ores/cement/lime/plasters	88.496	3.060	91.556	255.685	0	255.685	**164.129**	**+179,27%**
Metallurgical products	1.954.380	339.790	2.294.170	2.078.234	380.975	2.459.209	**165.039**	**+7,19%**
Chemical products	11.000	0	11.000	15.296	0	15.296	**4.296**	**+39,05%**
Other dry bulk	0	0	0	0	0	0	**0**	
GENERAL CARGO	**584.867**	**242.484**	**827.351**	**602.628**	**144.739**	**747.367**	**-79.984**	**-9,67%**
Containerized (including Ro-Ro containers)								
Ro-Ro (excluding Ro-Ro containers)	41.049	102.562	143.611	48.622	113.993	162.615	**19.004**	**+13,23%**
Other general cargo	543.818	139.922	683.740	554.006	30.746	584.752	**-98.988**	**-14,48%**
ADDITIONAL INFORMATION								
NUMBER OF CALLS		**433**			**330**		**-103**	**-23,79%**
GROSS TONNAGE		**9.337.852**			**9.268.601**		**-69.251**	**-0,74%**
NUMBER OF LOCAL AND FERRY PASSENGERS	**17**	**30**	**47**	**19**	**10**	**29**	**-18**	**-38,30%**
Local (< 20 miles journey)	0	0	0	0	0	0	**0**	
Ferry passengers	17	30	47	19	10	29	**-18**	**-38,30%**
CRUISE PASSENGERS		**104.127**			**95.599**		**-8.528**	**-8,19%**
Home Port	40.853	38.243	79.096	35.019	36.907	71.926	**-7.170**	**-9,06%**
Transits			25.031			23.673	**-1.358**	**-5,43%**
NUMBER OF CONTAINERS (in TEUs)	**683**	**810**	**1.493**	**873**	**1.088**	**1.961**	**468**	**+31,35%**
Hinterland	683	810	1.493	873	1.088	1.961	**468**	**+31,35%**
Empty	284	0	284	872	6	878	**594**	**+209,15%**
Full	399	810	1.209	1	1.082	1.083	**-126**	**-10,42%**
Transshipped	0	0	0	0	0	0	**0**	
Empty	0	0	0	0	0	0	**0**	
Full	0	0	0	0	0	0	**0**	
NUMBER OF VEHICLES	**25.988**	**44.776**	**70.764**	**32.556**	**51.110**	**83.666**	**12.902**	**+18,23%**
Number of Ro-Ro units	0	0	0	0	0	0	**0**	
Number of private vehicles	0	0	0	0	0	0	**0**	
Number of commercial vehicles	25.988	44.776	70.764	32.556	51.110	83.666	**12.902**	**+18,23%**

Table 3: ESPO tables of the Ports of Trieste and Monfalcone 2022

2) What is the total electricity consumption of your port for 2022 (in MWh), including the land side (terminals, offices, cranes, etc.) and maritime side (ships at berth)?

The total electricity consumption of the ports of Trieste and Monfalcone in 2021 was 132,145.80 MWh:

- 16,925.80 MWh are related to the land side (terminals, offices, cranes, etc.);
- 115,219.95 MWh are related to the maritime side (ships at berth – electricity produced by on-board generator).

3) What was the amount of renewable energy produced in 2022 (in MWh) and the total power installed (MW)?

Unfortunately, consumption data for the year 2022 are not available, so we report below the data for 2021, which should be in line with those for 2022. The total power installed is the same in both years.

- Renewable energy produced in 2021: 8,274.78 MWh
- Total power installed: 8.05 MW

4) What was the origin of such renewable energy?

100% of the energy produced was solar power.

5) Each existing renewable energy investment

<table>
<tr><td colspan="2"><u>Title</u>
"MERIDIAN" photovoltaic system</td></tr>
<tr><td rowspan="2"><u>Summary</u>
The "MERIDIAN" photovoltaic system is intended to operate in parallel with the electricity distribution grid and connected to the user grid, downstream of the general device, according to the criteria of DM 19/02/07, to incentivize the production of electricity through photovoltaic conversion of solar source.
The photovoltaic system, promoted and realised by a private company, is installed, in concession, on the roofs of the following buildings owned by the Port Network Authority of the Eastern Adriatic Sea, located in the New Free Port area:
- 49
- 50
- 51-53</td><td><u>Results</u>
Annual production: 8,266 MWh
Levelized Cost of Energy (LCOE) = (3 M€ + OPEX in 20 years)/(8,266 MWh x 20 years)</td></tr>
<tr><td><u>Lessons learnt</u>
Specific national incentive tariffs to ensure a fair remuneration of investment and operating costs promote</td></tr>
</table>

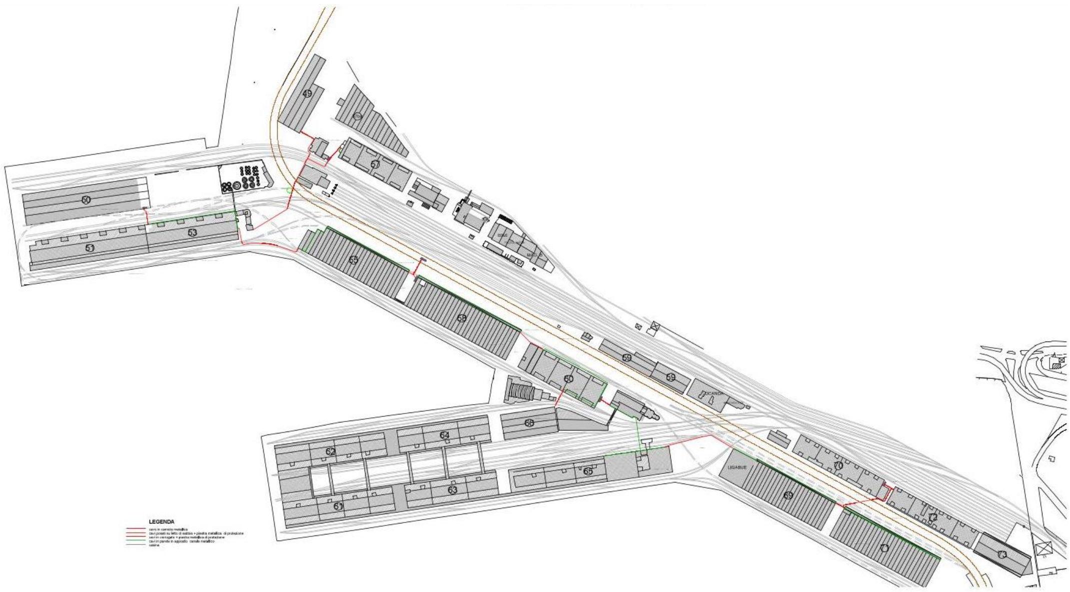
- 57 - 55-58 - 60 - 65 - 66 - 69-71 - 70 - 72 with a total area of 89,212 square meters. The system consists of 40,204 monocrystalline photovoltaic panels of 200W peak, with a total capacity of 8.04 MW (8,040.80 KW). It was built in 2011 at a cost of nearly 3,000,000 Euros. The photovoltaic system guarantees the possibility of taking advantage of electricity produced by photovoltaic conversion of the solar source. The produced energy fed into the grid benefits from the disbursement of a specific incentive tariff, with a duration of 20 years, to ensure a fair remuneration of investment and operating costs as specified in the [Fourth Energy Account of Ministerial Decree 05/05/11].	the installation of renewable energy production systems. Ports or industrial areas marked by the presence of buildings with vast roofs are particularly suitable for the installation of photovoltaic systems, without negative environmental impacts or land consumption.
	

Figure 3: The "MERIDIAN" photovoltaic system in the Port of Trieste

Title **"UPS" photovoltaic system**	
Summary The system, realised by the Port Network Authority of the Eastern Adriatic Sea, consists of 40 monocrystalline photovoltaic panels of 300W peak, with a total capacity	Results Annual production: 8.78 MWh LCOE = (15,000 € + OPEX in 20 years)/(8,780 kWh x 20 years)

of 0.012 MW (12 KW). It was built in 2018 at a cost of nearly 15,000 Euros. The photovoltaic system is installed on the roofs of the Port Network Authority of the Eastern Adriatic Sea headquarters, located in Trieste. The production is dedicated to the self-consumption of the building. The energy consumption of the building in 2021 was 8.83 MWh, while the energy produced by the photovoltaic system was 8.78 MWh.	Lessons learnt The photovoltaic system was installed during the renovation and recovery of an old building of the port. The electricity produced allowed almost complete coverage of the building's consumption. This evidence teaches that installing renewable energy production systems on the roof of new office buildings or when rehabilitating disused ones can help us achieve almost zero emission buildings.

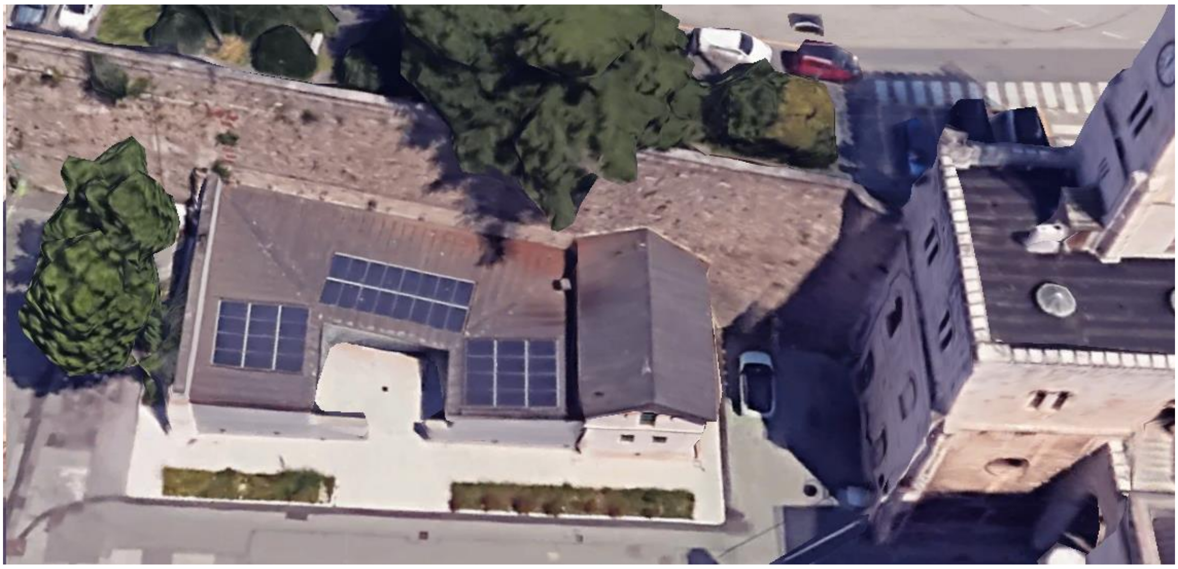


Figure 4: The photovoltaic system on the roofs of the PNAEAS headquarters

6) What are the planned investments (horizon: 2030) in terms of renewable energy production in the port?

Investment	Power (MW)	Cost in euros	Year of conclusion
Solar power production system in	0.045 MW	135,000	2026

the Port of Monfalcone headquarters (Renewport pilot)			
Solar power production system in the Port of Trieste “Punto Franco Nuovo” (New Free Zone in Figure 1: Layout Port of Trieste)	1.1 MW	2,120,000	2026
Solar power production system in the Port of Monfalcone	0.15 MW	927,590	2026

2.1.2. Port Network Authority of the Northern Tyrrhenian Sea

1) Description of the port

The North Tyrrhenian ports of call - Livorno, Piombino, Portoferraio, Rio Marina, Cavo and the island of Capraia -, located in theTyrrhenian-Ligurian (or North Tyrrhennian) port range, are one of the largest Italian port networks in terms of total traffic turnover and Tuscany’s natural logistics platform. The six ports under the jurisdiction of the North Tyrrhenian Port Network Authority, which was set up after Legislative Decree No. 169 of August 4th, 201, contribute 13% of Italian general cargo traffic (Ro-Ro, Containers and breakbulk) and play a major role in the ro-ro traffic segment in terms of tonnes handled and the number of commercial vehicles. The port of Livorno is also a national leader in the forest product and new car traffic sectors.

The position of the North Tyrrhenian Port Network near the rich markets of central and northern Italy is its greatest strength, while the opportunities provided by the TEN-T networks’ transeuropean links put the North Tyrrhenian node in an international dimension. The primary nodes of the network (such as the Port of Livorno and the Tuscan “A. Vespucci” freight village) are in fact located near the road and rail interconnections of the TEN-T Scandinavian-Mediterranean Corridor, along the Pisa-Florence axis, and are well integrated with the secondary nodes of the comprehensive network, such as the port of Piombino, Pisa’s G. Galilei airport and the Interporto della Toscana Centrale freight village in Prato.

The port of Livorno covers an area of over 2.5 million square meters, with about 90 berths, 21 km of docks, a depth of up to -13 m and boasting high-tech facilities and vehicles. The maximum high tide is 0.46 m and the minimum is -0.34m. As part of the Core Network of the TEN-T European infrastructure network (Scandinavian-Mediterranean Corridor), Livorno is among the top national ports in terms of the quantity of goods handled and is renowned worldwide as a multipurpose port.

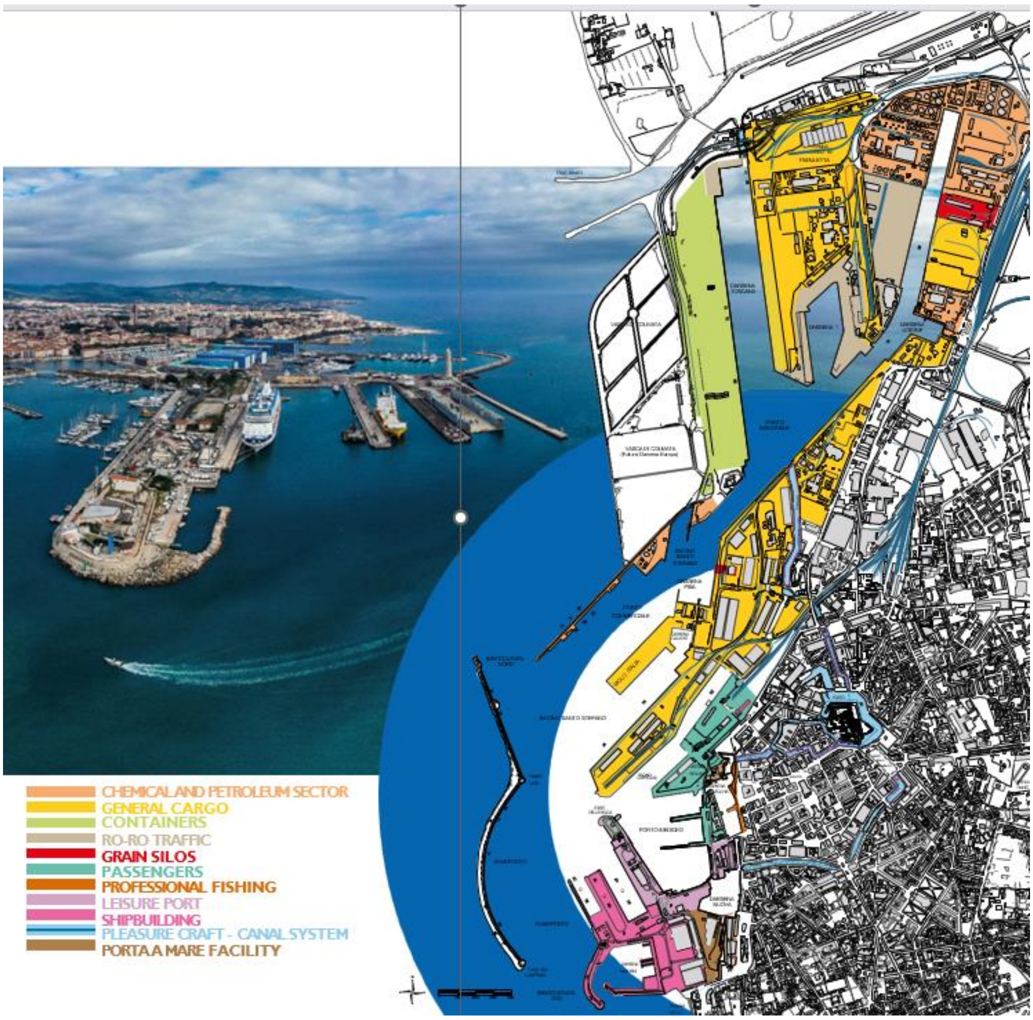


Figure 5: Area Specialization in Livorno Port

YEAR	2022			Difference '21-'22	
	IN	OUT	TOTAL	TOTAL	%
TOTAL THROUGHPUT	**18.575.707**	**13.333.782**	**31.909.489**	**2.436.583**	**-7,10%**
Indicate units used: tonnes					
Tonnes or thousand of tonnes					
LIQUID BULK	**5.009.536**	**1.334.865**	**6.344.401**	**1.024.212**	**-13,90%**
Crude oil	2.106.138	33.454	2.139.592	1.030.984	-32,50%
Refined (petroleum) products	1.517.785	1.117.435	2.635.220	85.679	-3,10%
Gaseus, liqufied or compressed petroleum products and natural gas	446.031	0	446.031	24.576	5,80%
Chemical products	746.286	21.136	767.422	64.149	9,10%
Other liquid bulk	193.296	162.840	356.136	3.726	1,10%
DRY BULK	**594.236**	**99.645**	**693.881**	**55.468**	**-7,40%**
Cereals	50.817	0	50.817	48.108	-48,60%
Foodstuff/Fodder/Oil seeds	0	0	0	0	0,00%
Coal and lignite	24.796	0	24.796	3.645	17,20%
Ores/cement/lime/plasters	376.611	0	376.611	29.408	8,50%

Metallurgical Products	51.049	0	51.049	13.390	35,60%
Chemical products	81.358	0	81.358	34.540	-29,80%
Other dry bulk	9.605	99.645	109.250	19.263	-15,00%
GENERAL CARGO	**12.971.935**	**11.899.272**	**24.871.207**	**1.356.903**	**-5,20%**
Containerized (including Ro-Ro containers)	3.671.874	4.117.177	7.789.051	961.441	-11,00%
Ro-Ro (excluding Ro-Ro containers)	7.267.523	7.553.340	14.820.863	769.923	-4,90%
Other general cargo	2.032.538	228.755	2.261.293	374.461	19,80%
ADDITIONAL INFORMATION					
NUMBER OF CALLS			**5.948**	**14**	**-0,20%**
GROSS TONNAGE			**202.132.456**	**13.275.241**	**7,00%**
NUMBER OF LOCAL AND FERRY PASSENGERS	**1.411.432**	**1.399.890**	**2.811.322**	**584.557**	**26,30%**
Local (< 20 miles journey)	0	0	0	0	0,00%
Ferry passengers	1.411.432	1.399.890	2.811.322	584.557	26,30%
CRUISE PASSENGERS			437.670	381.332	676,90%
"Home Port"	**5.484**	**5.200**	**10.684**	**10.656**	**38057,10%**
"Transits" (to be counted once)			426.986	370.676	658,30%
NUMBER OF CONTAINERS (in TEU) (B41 + B42)	**373.514**	**378.297**	**751.811**	**39.545**	**-5,00%**
"Hinterland"	**318.847**	**323.883**	**642.730**	**55.691**	**9,50%**
Empty	146.203	27.239	173.442	20.162	13,20%
Full	172.644	296.644	469.288	35.529	8,20%
"Transshipped"	**54.667**	**54.414**	**109.081**	**95.236**	**-46,60%**
Empty					
Full					
Number of Ro-Ro units	**235.649**	**245.224**	**480.873**	**29.116**	**-5,70%**
Number of private vehicles	538.991	532.793	1.071.784	204.580	23,60%
Number of commercial vehicles	401.036	90.123	491.159	23.821	5,10%
Number of commercial vehicles	51.018	17.158	68.162	-	-

Table 3 – Statistics about the specific goods and passengers

2) What is the total electricity consumption of your port for 2022 (in MWh), including the land side (terminals, offices, cranes, etc.) and maritime side (ships at berth)?

<u>Livorno</u>

Electricity consumption for 2018 in land side: 39.700,223 MWh

Electricity consumption for 2018 in sea side: unknown

<u>Piombino</u>

Electricity consumption for 2018in land side: 2.676,939 MWh

Electricity consumption for 2018 in sea side: unknown

<u>Portoferraio</u>

Electricity consumption for 2018 in land side: 436,19 MWh

Electricity consumption for 2018 in sea side: unknown

3) What was the amount of renewable energy produced in 2022 (in MWh) and the total power installed?

Livorno renewable energy production related to 2018: 677 MWh

The information about renewable energy will be updated during next months, because the AdSP MTS will realize the new version of the DEASP, as required by Italian legislation.

4) What was the origin of such renewable energy (e.g. solar, wind, wave...)?

The energy produced was obtained through the installation of solar panels on some shed roofs in the Port. The AdSP MTS does not produce energy from renewable sources, but all investments are made by private entities operating in the port. In the coming months the DEASP will be updated, as required by Italian legislation, and it is expected that the value indicated in the previous paragraph (677 mwh), referring to 2018, will be lower than the current plants.

5) Each existing renewable energy investment

There are no current investments in RES.

6) What are the planned investments (horizon: 2030) in terms of renewable energy production in your port?

Investment	Amount of yearly renewable energy produced (estimation in MWh)	Cost *in euros*	Year of conclusion
Photovoltaic system Port of Piombino	2,658 MWh	5.143.000 €	2025
Photovoltaic system Port of Livorno	2,00 MWh	4.544.000 €	2025
Port of Livorno wind farm	0,200 MWh	594.000 €	2026
Port of Livorno Hydrogen production	10 MWh	4.773.000 €	2026
System for the production and storage of photovoltaic electricity in the Port of Livorno from green energy sources at sea (RENEWPORT Pilot Investment n°2)	0,500 MWh	120.000 €	2026

2.1.3. Toulon Port

1) Description of the port

Var CCIV's ports are split in 3 terminals:

Figure 6 : Toulon Bay and its three commercial terminals

- Toulon Côte d'Azur (TCA), with a surface area of 7.24 hectares, which receives ferries, passengers and occasionally exchanges freight with Corsica ferries, especially vehicles. This terminal consumed 644 MWh during 2022.

Figure 7 : Toulon Côte d'Azur terminal

- Bregaillon, which is the largest terminal, covering an area of 36 to 37 hectares, where goods are received and dispatched. This may involve conventional freight, bulk, vehicle parking and car-carriers. The annual energy consumption of this terminal reached around 493 MWh in 2022.

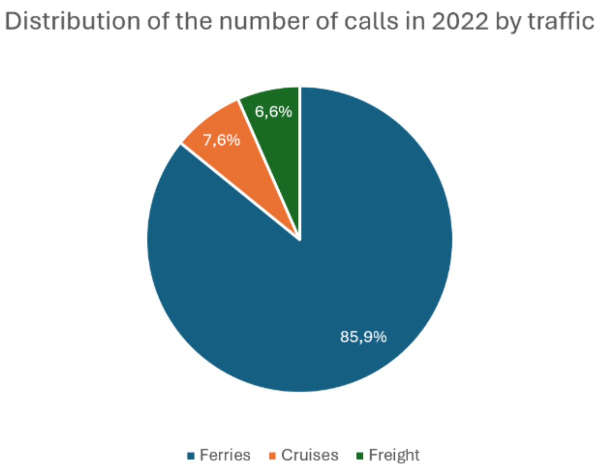
Figure 8 : Bregaillon terminal

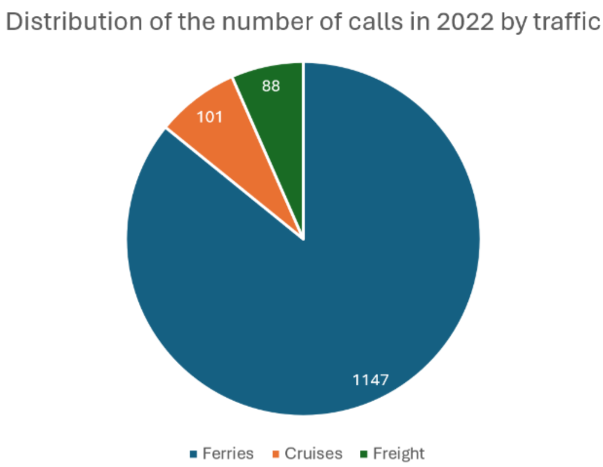
- Môle d'armement, with a surface area of 1.53 hectares, is used exclusively by cruise ships, and thus by passenger flows. The terminal is also used by wintering ferries. It consumed around 143MWh in 2022.

Figure 9 : Môle d'Armement terminal

In total, the port concession covers an area of 45.65 hectares. The distribution of traffic and type of goods for the year 2022 is shown below:

- For ferries, almost 11,467 calls were made, including a total of 689,638 tourist vehicles, 23,432 heavy goods vehicles and 1,771,762 passengers.
- Cruises made 101 calls in 2022, carrying 143,151 passengers.
- A new vehicle traffic activity (reception, on-site parking and transport by car-carriers) began in 2022, with 52 calls for 22,256 new unregistered vehicles and almost 3,920 invoiced parking spaces.
- Conventional and bulk freight was at its lowest level, with 35 calls and 54,017 tonnes of cargo, mainly wood chips, silicate and olives.





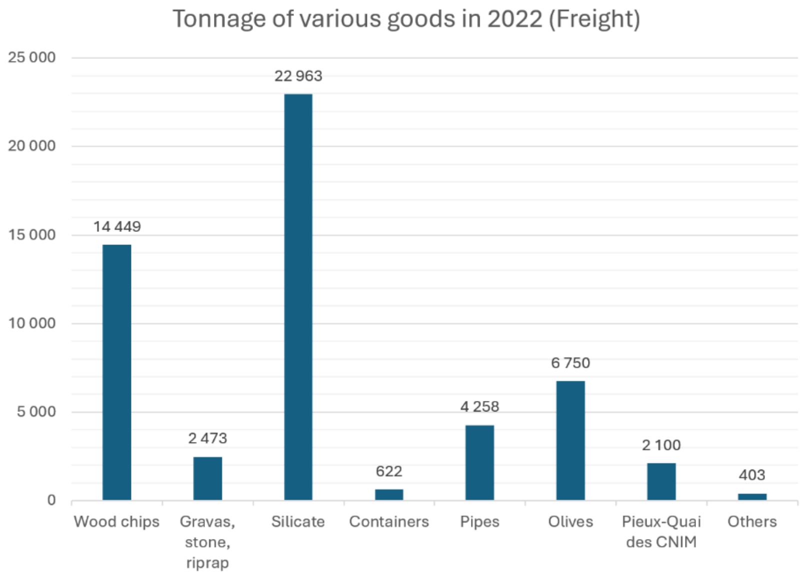


Figure 10 : Traffic in Port of Toulon

2) What is the total electricity consumption of your port for 2022 (in MWh), including the land side (terminals, offices, cranes, etc.) and maritime side (ships at berth)?

The port's total electricity consumption in 2022 amounts to 1280 MWh or land-based facilities alone, given that the Ship Shore Connexion was not yet operational.

3) What was the amount of renewable energy produced in 2022 (in MWh) and the total power installed?

There was no production of renewable energies.

4) What was the origin of such renewable energy (e.g. solar, wind, wave...)?

As there was no renewable energies production, there is no origin.

5) Each existing renewable energy investment.

There weren't any either.

6) What are the planned investments (horizon: 2030) in terms of renewable energy production in your port?

Investment	Amount of yearly renewable energy produced (estimation in MWh)	Cost in euros	Year of conclusion

TCA: Ship Shore Connection at TCA terminal powered by PV panels (5000m²)	6,660 MWh	3,000,000	2nd quarter 2024
TCA: Ship Shore Connection at TCA terminal powered by a hydrogen cell.	825 MWh	4,000,000	2035
TCA: Renewport	6 MWh	130,000	2025
Bregaillon terminal: HYNOMED installation of a hydrogen distribution station for buses and boats.	4,200 MWh	4,000,000	2027
TCA terminal: vehicle control station: shading with PV panels (~100m²)	130 MWh	120,000	2026
TCA terminal: Installation of photovoltaic panels on the roofs of the ferry terminal.	400 MWh	200,000	2026 - 2027
Môle terminal: Installation of photovoltaic panels on the roofs	130 MWh	100,000	2026 - 2027
Môle terminal: solar electric charging stations (*10) for vehicle recharging	0,5 MWh	35,000	2026
Installation of wind turbines	25 MWh	5,000	2026
Wave power turbine at the Bregaillon terminal	under consideration		

2.1.4. Valencia Port Authority

1) Description of the port

The Port Authority of Valencia (APV) is a public entity that manages the three State-owned ports of Valencia, Sagunto and Gandía, in the Valencian Region, Spain. Also known under its commercial brand Valenciaport, the Port Authority of Valencia has developed its own Clean Power Supply Plan and Net-Zero Emissions Plan in Valenciaport to achieve carbon neutrality by 2030, analysing the carbon footprint per port economic sector and defining strategies together with the Valenciaport cluster along with short and mid-term actions. Renewable energy implementation constitutes an opportunity to achieving the Port of Valencia's carbon neutrality goal as it will reduce its carbon footprint, and therefore is an absolute priority for the Port Authority of Valencia together with the electrification of the quays which will be fed with renewable energy.

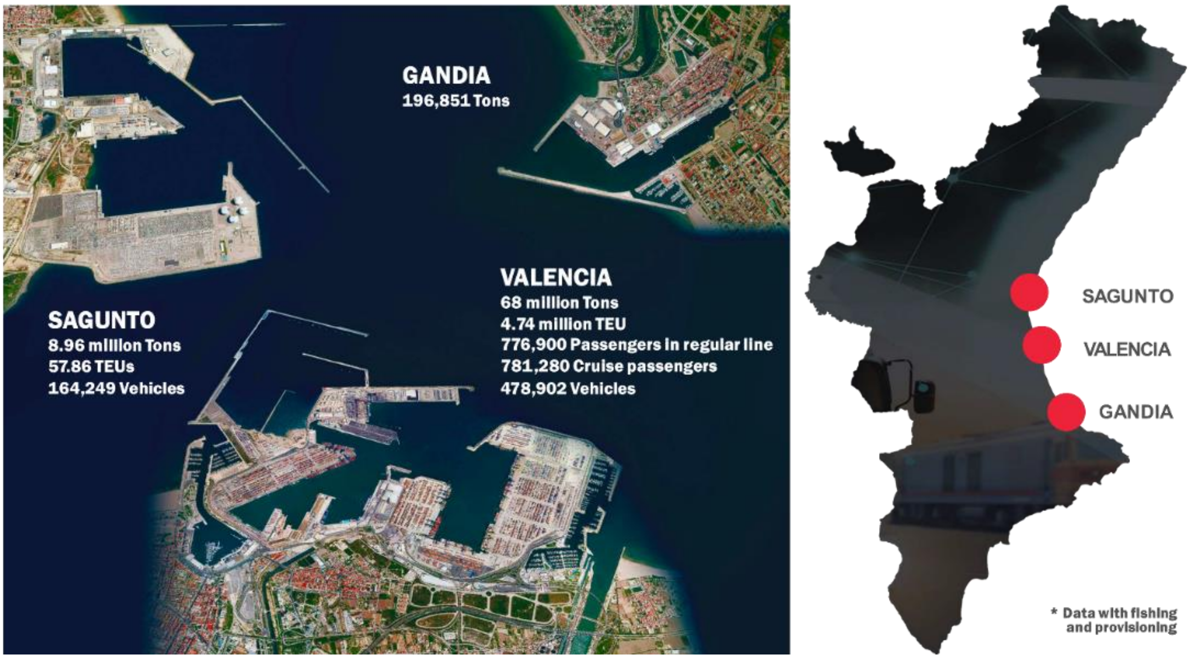


Figure 11: Ports managed by the Port Authority of Valencia

Valenciaport is the first and last port of call for regular shipping lines operating in the Western Mediterranean, providing the following advantages:

- The closest commercial port to the Suez-Gibraltar axis – the main route for interoceanic shipping lines.
- High capacity for concentrating and distributing traffic in the Western Mediterranean.

In addition, our geostrategic position on the Iberian Peninsula makes us a natural port for interoceanic goods traffic by providing:

- Reduced land transport time.
- Well connected to distribute goods to and from all areas of the Iberian Peninsula.

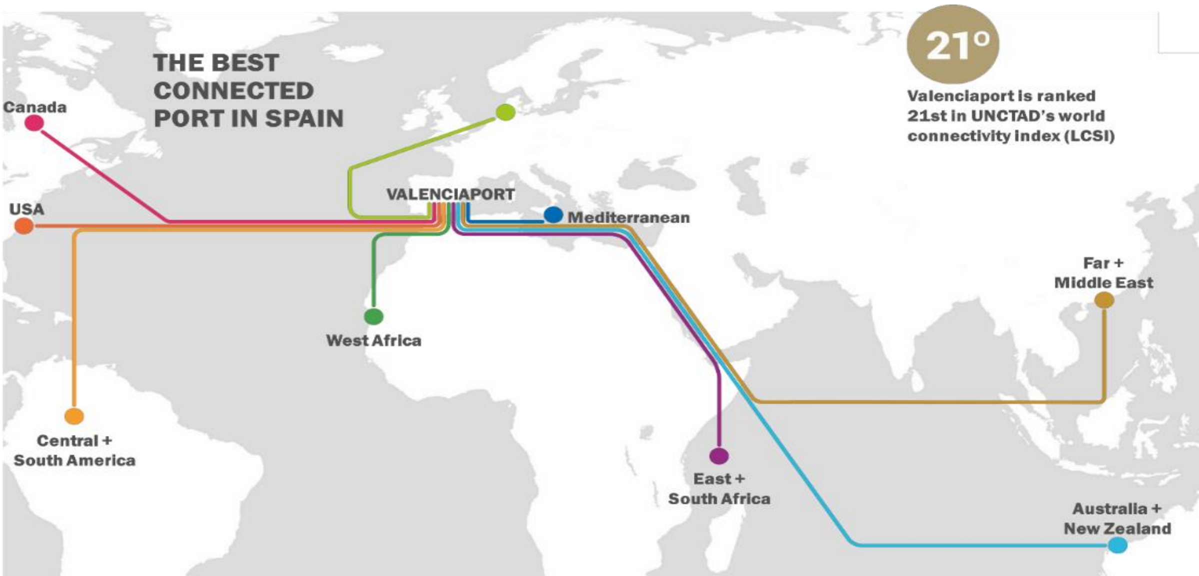


Figure 12: Foreland connections with Valenciaport

Valenciaport is the perfect choice for any shipping lines because of its powerful area of direct influence – among the most dynamic in Europe – and its location close to southern European and north African countries.

Valenciaport's direct area of influence has a radius of 350km – an area that generates 51% of Spain's GDP and includes half of Spain's entire working population.

Valenciaport is located in the heart of the Valencia Region and has excellent road and rail connections to the centre of Spain, making it the ideal natural port for Madrid, and an essential platform for the entire Iberian Peninsula.

Figure 13: Hinterland connections Valenciaport

As a hub for the entire Western Mediterranean, Valenciaport efficiently distributes goods over a radius of 2,000km, both in southern EU countries and in North Africa (Morocco, Algeria, Tunisia and Libya), representing a huge market of 270 million consumers.

Valenciaport offers a complete network of connections with major world ports thanks to:

- Over 100 regular lines, among which are the world's largest shipping companies.
- Multiple regional connections that give Valenciaport an extensive capillary network for goods transport.

	2022	2023	Δ23/22 Dec. accum	Δ23/22 Nov. accum	Annual trend
PORT AUTHORITY OF VALENCIA					
Total traffic (t)	79.365.729	77.163.936	-2,77%	-3,61%	-2,77%
Liquid Bulk	5.819.229	5.296.951	-8,98%	-5,88%	-8,98%
Solid Bulk	2.255.164	2.465.568	9,33%	7,39%	9,33%
Convencional General Cargo	14.763.010	15.310.254	3,71%	3,99%	3,71%
Continerised General Cargo	56.125.555	53.673.651	-4,37%	-5,91%	-4,37%
Fishing	1.053	1.114	5,77%	7,92%	5,77%
Supplies	401.718	416.398	3,65%	7,11%	3,65%
Vessels Number	7.521	7.575	0,72%	0,92%	0,72%
GT	291.259.080	302.474.267	3,85%	4,20%	3,85%
Containers (TEU)	5.052.272	4.796.985	-5,05%	-6,51%	-5,05%
Passengers (units)	1.373.552	1.558.180	13,44%	12,54%	13,44%
Regular Lines	750.499	776.900	3,52%	3,24%	3,52%
Cruise	623.053	781.280	25,40%	23,11%	25,40%
Vehicles (units)	603.566	643.151	6,56%	9,19%	6,56%
RoRo Traffic (t)	12.946.088	13.272.265	2,52%	2,63%	2,52%
UTI	473.973	479.783	1,23%	1,05%	1,23%
Rail Traffic (t)	3.092.702	3.147.133	1,76%	3,65%	1,76%
TEU	233.771	235.504	0,74%	1,05%	0,74%
Vehicles	17.998	55.259	207,03%	241,67%	207,03%

Table 4: Valenciaport traffic statistics for the year 2022 and comparison with the year 2021

2) What is the total electricity consumption of your port for 2022 (in MWh), including the land side (terminals, offices, cranes, etc.) and maritime side (ships at berth)?

The total electricity consumption of Valenciaport, including the activities not performed by the port authority itself accounts around 90 GWh/year.

PORT	ELECTRIC ENERGY CONSUMPTION (MWh)
Valencia	84,122
Sagunto	3,814
Gandía	1,176
TOTAL	89,112

Table 5: Valenciaport electricity consumption 2022

3) What was the amount of renewable energy produced in 2022 (in MWh) and the total power installed?

In 2022 there were no renewable energy production facilities in the ports of Valencia, Sagunto and Gandía apart from some solar thermal installations of a few tens of kW.

4) What was the origin of such renewable energy (e.g. solar, wind, wave...)?

Not applicable.

5) Each existing renewable energy investment.

<table>
<tr><td colspan="2"><u>Title</u>
PV facility of 1,390 kWp at the southern breakwater of the port of Valencia</td></tr>
<tr><td rowspan="2"><u>Summary</u>
It consists of the installation of 2,990 solar panels placed on gantries spaced 5 m apart along 815 m on the crest of the southern dock of the port of Valencia. The unit power of the solar panels is 465 W and the total installed power is 1,390.35 MW. The energy produced will be injected into the port's electricity grid for the port's own consumption.</td><td><u>Results</u>
The estimated annual production is 2,367.81 MWh, however, there are no production records yet, as the plant has been operational since the end of 2023. The CAPEX is 2,576,382€. The OPEX is 37,500€/year. Considering a lifecycle of 20 years.
LCOE = 0.07 €/kWh
The plant has been financed through the EU Resilience and Recovery Fund programme.</td></tr>
<tr><td><u>Lessons learnt</u>
Still not analysed</td></tr>
</table>

Figure 14: PV facility at the southern breakwater of the Port of Valencia

<table>
<tr><td colspan="2"><u>Title</u>
PV facility of 745 kW with storage at the port of Gandía</td></tr>
<tr><td rowspan="2"><u>Summary</u>
It consists of an installation of solar panels on a warehouse located in the port of Gandía. The installation is made up of 1,620 solar panels of 460 W unitary power, with a total installed power of 745.20 kW. The energy produced will be injected into the port's electricity grid for the port's own consumption. In addition, it includes a storage battery of 1 MW, which allows the energy production to be adjusted to the needs of the port.</td><td><u>Results</u>
The estimated annual production is 995.75 MWh, however, there are no production records yet, as the plant has been operational since the end of 2023. The CAPEX is 1,349,895.43€. The OPEX is 24,000€/year. Considering a lifecycle of 20 years.
LCOE = 0.092 €/kWh
The plant has been financed through the EU Resilience and Recovery Fund programme.</td></tr>
<tr><td><u>Lessons learnt</u>
Still not analysed</td></tr>
</table>

Figure 15: PV facility on the shed of the Port of Gandia

6) What are the planned investments (horizon: 2030) in terms of renewable energy production in the port?

Investment	Amount of yearly renewable energy produced (estimation in MWh)	Cost *in euros (excl. VAT)*	Year of conclusion
PV facility of 745 kW with storage at the port of Gandía	995.75 MWh	1,349,895.43	2023
PV facility of 1,390 kWp at the southern breakwater of the port of Valencia	2,367.81 MWh	2,576,382.41	2023
PV facility of 5.76 MWp on the roof of the vehicles silo of the port of Valencia	9,586.28 MWh	12,990,539.79	2024
Wind plant of 18 MW at the new container terminal of the port of Valencia	34,760,000 MWh	19,600,000.00	2028
Floating PV of 1MW outside the port of Valencia	1,507,000 MWh	3,000,000.00	2025

Wave energy converter of 270 kW attached to the breakwater of the port of Valencia	500 MWh	1,800,000.00	2025
Vertical PV of 60 kW attached to the walls of the breakwater of the port of Valencia – RENEWPORT Pilot	105 MWh	120,000.00	2025

2.1.5. Luka Koper, port and logistic system

1) Description of the port

Luka Koper is a public limited company, whose activity leaves an impact on the development of the Obalno-Kraška region, giving it a positive and dynamic economic pulse. The Obalno-Kraška (Coastal-Karst) region is one of the smallest regions in Slovenia in terms of size and among the most developed in terms of economic conditions.

The company Luka Koper provides port and logistics services in the port of Koper. The core business of the port comprises the handling and warehousing of a variety of goods, supplemented by a range of services on goods and other services, providing customers with comprehensive logistic support.

Luka Koper has set itself an ambitious objective to meet the needs of its customers, owners and employees, all at the same time. By achieving the development goals of the port, Luka Koper is reinforcing its competitive advantage.

The port is regulated with future generations in mind, who will live, create and grow up on the Coast. The commitment of Luka Koper to sustainable development has ensured that future development will be friendly to the surrounding residents, the natural environment, and employees.

Luka Koper is fully aware of its significance in relation to the natural and social environment in which it operates; consequently, it maintains a responsible approach towards such issues in its business and development.

In 2000, Luka Koper was one of the first European and the only Mediterranean port to establish an environment management system according to the ISO 14001 standard applying to all port activities, and the company is constantly building upon it. In May 2006 the standard was upgraded to ISO 14001:2004. In 2010 Luka Koper gained the EMAS certificate and became compliant with the very highest environment protection criteria. The company regularly monitors and supervises the environmental impacts of port activities in co-operation with the presiding expert institutions.

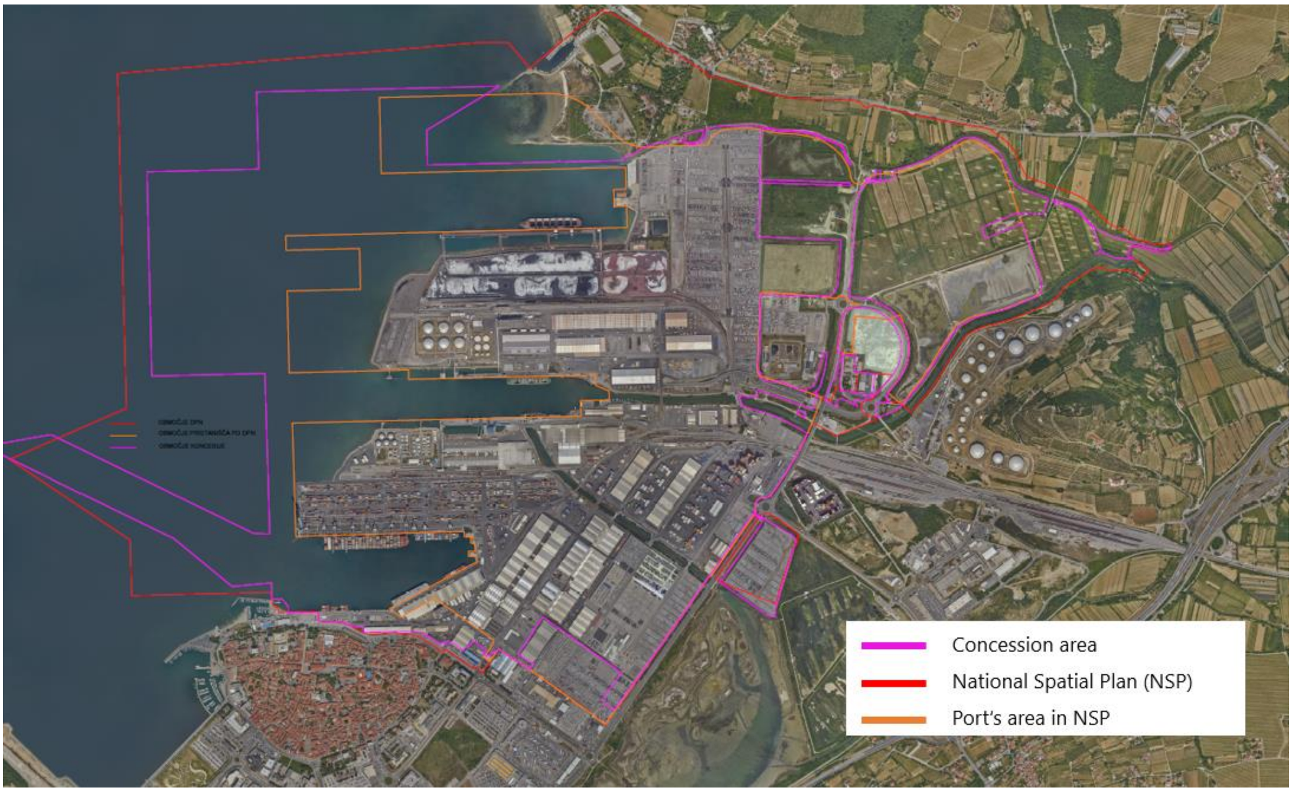


Figure 16: Extension of port's area

Luka Koper treats the area of environment management as a whole. The fact that company Luka Koper, d.d. itself manages the entire area of the port, makes it possible to implement the protection system at all terminals and in all its activities. With the help and inspection of presiding expert institutions, the company regularly monitors substance and noise emissions. At this regard, the company provides for plant-scaping of the port area and in this way improves its appearance. The company also monitors the use of technological sources and sustainable opportunities, those being water and electricity. That's why the RENEWPORT is fully supported in its initiatives and pilot activities will be implemented and promoted as well.

Here below are proposed some basic port's statistics.

Port Area:**288 ha**, Total throughput: **23.248.469** TON
Traffic data 2022:

GENERAL CARGO	1.311.122 ton
CONTAINERS:	9.659.121 ton
CARS:	1.394.106 ton
DRY BULK:	6.239.783 ton
LIQUID BULK:	4.644.337 ton

Table 6: Main traffic data Luka Koper (2022)

2) What is the total electricity consumption of your port for 2022 (in MWh), including the land side (terminals, offices, cranes, etc.) and maritime side (ships at berth)?

Total electricity consumption:

- land side: **31,725 MWh**
- maritime side: **0 MWh**

An aerial view of the total solar energy power installed in the port is provided here below:

Figure 17: Total solar power installed in the Port of Koper (source: Luka Koper's own elaboration)

3) What was the amount of renewable energy produced in 2022 (in MWh) and the total power installed?

271 MWh, 340.5 kWp-z SE Makoter

4) What was the origin of such renewable energy (e.g. solar, wind, wave...)?

The port has only solar renewable energy sources installed in the port area.

5) Each existing renewable energy investment

<table>
<tr><td colspan="2"><u>Photovoltaic system mounted on Warehouses 50 and 51</u></td></tr>
<tr><td rowspan="2"><u>Summary</u>

Location: roof of the warehouses 50 and 51
Technology: Solar panel, the activity was co-financed by the EU project SOPOREM - SOlar POwer for Reducing Emissions.
Installed power: 3,3 MWp, in April 2024
Use of production: Self consumption

Calculated reduction of emissions CO_2 for 1.326 t to 1.522 t CO_2</td><td><u>Results</u>

Annual increased production in the port:
3,630 MWh</td></tr>
<tr><td><u>Lessons learnt:</u>

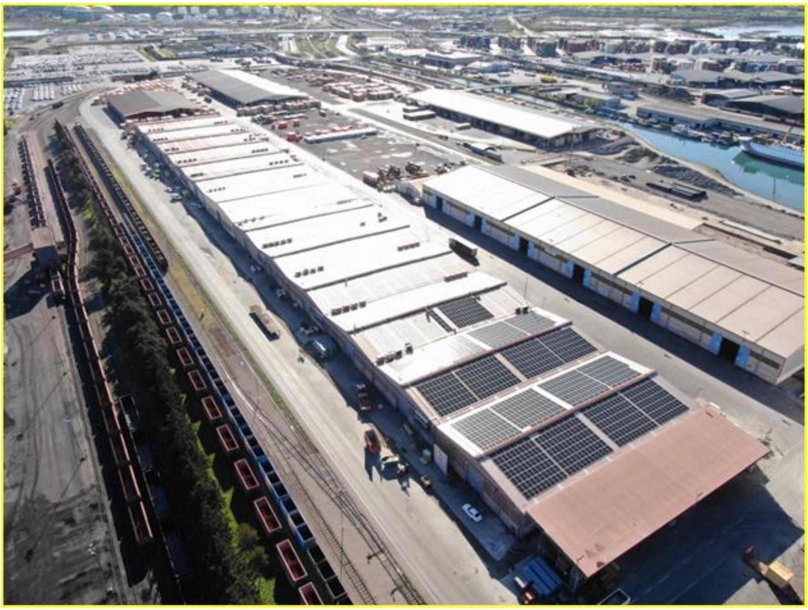
still being analysed</td></tr>
<tr><td colspan="2"></td></tr>
</table>

Figure 18: Solar system co-financed through SOPOREM (source: Luka Koper's own elaboration)

Transformation station n.1 - Silos seaside petrol berth	
Summary Location: roof Transformer station TP1 Silos Obala, (45.55975,13.73707) Technology: Solar panel, Installed power: 4,48kWp, Use of production: Self consumption	Results Annual production: 4,7 MWh Lessons learnt Still being analysed

Figure 19: Transformation Station (Source: Luka Koper's own elaboration)

<table>
<tr><td colspan="2">Photovoltaic system on Transformation station at Terminal for General Cargo</td></tr>
<tr><td rowspan="2"><u>Summary</u>
Location: roof Transformer station TP1 TZŽ, (45.5598, 13.734293),
Technology: Solar panel,
Installed power: 4,48kWp,
Use of production: Self consumption.</td><td><u>Results</u>
Annual production: 4,6 MWh</td></tr>
<tr><td><u>Lessons learnt</u>
still being analysed</td></tr>
</table>

Figure 20: Transformation Station (Source: Luka Koper's own elaboration)

<table>
<tr><td colspan="2">Photovoltaic system at the Transformation station n.1 of the Container Terminal</td></tr>
<tr><td rowspan="2"><u>Summary</u>
Location: roof Transformer station TP1 KT1, (45.55410,13.73235),
Technology: Solar panel,
Installed power: 8,4 kWp,
Use of production: Self consumption.</td><td><u>Results</u>
Annual production: 7,8 MWh</td></tr>
<tr><td><u>Lessons learnt</u>
still being analysed</td></tr>
<tr><td colspan="2">
Figure 21: Transformation Station (Source: Luka Koper's own elaboration)</td></tr>
</table>

<table>
<tr><td colspan="2">Transformation station at the location named TROPLES</td></tr>
<tr><td rowspan="2"><u>Summary</u>
Location: roof Transformer station TP1 TROPLES, (45.55761, 13.75360),
Technology: Solar panel,
Installed power: 7,92 kWp,
Use of production: Self consumption</td><td><u>Results</u>
Annual production: 9,8 MWh</td></tr>
<tr><td><u>Lessons learnt</u>
still being analysed</td></tr>
<tr><td colspan="2">
Figure 22: Transformation Station (Source: Luka Koper's own elaboration)</td></tr>
</table>

<table>
<tr><td colspan="2">Photovoltaic system at the Container Terminal's garderobes</td></tr>
<tr><td rowspan="2"><u>Summary</u>

Location: roof Container terminal changing room (45.55346, 13.74049)
Technology: Solar panel,
Installed power: 42,24 kWp
Use of production: Self consumption</td><td><u>Results</u>

Annual production: 47,3 MWh</td></tr>
<tr><td><u>Lessons learnt</u>

still being analysed</td></tr>
</table>

Figure 23: Container Terminal (Source: Luka Koper's own elaboration)

Photovoltaic system at the Car Terminal's transformation station n.2	
<u>Summary</u> Location: roof Transformer station TP AT1(45.56446, 13.75345) Technology: Solar panel, Installed power: 6,75 kWp, Use of production: Self consumption	<u>Results</u> Annual production: 6,8 MWh <u>Lessons learnt</u> still being analysed

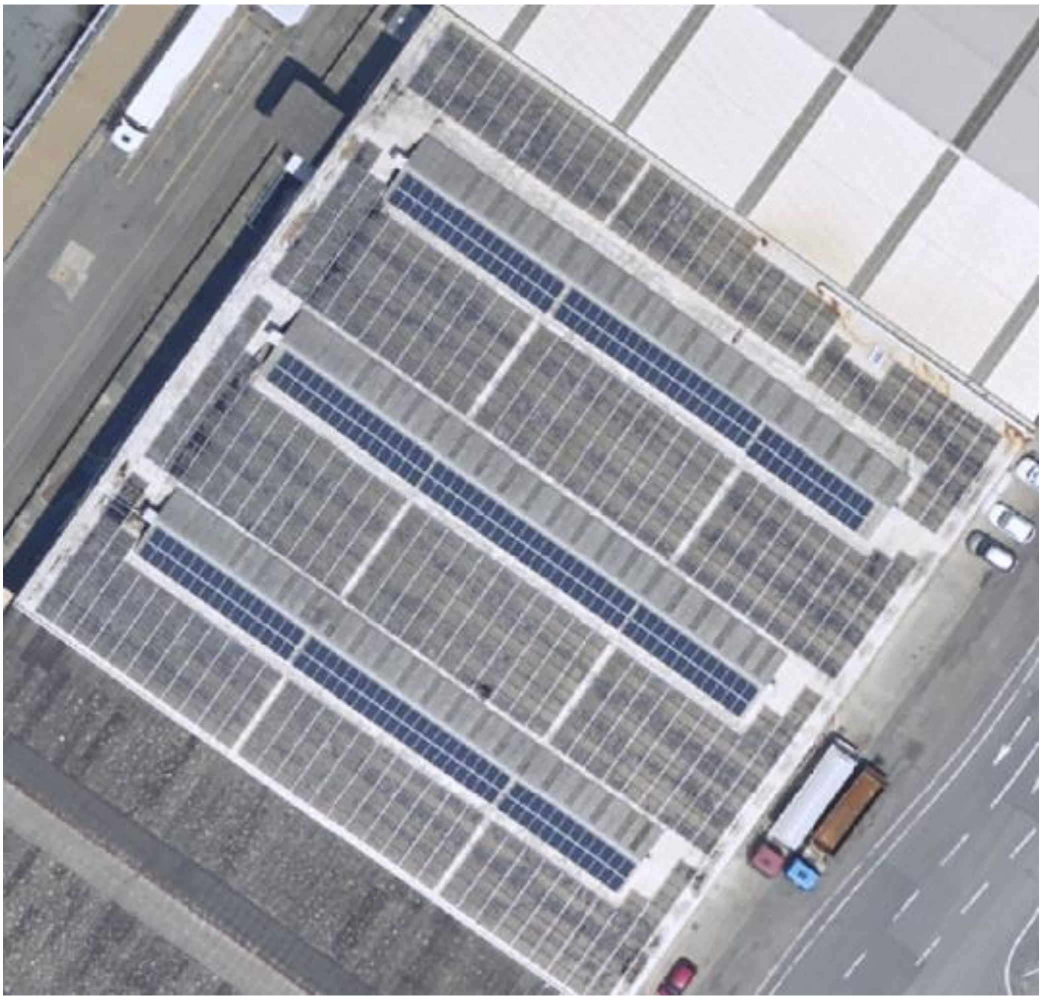
Figure 24: Car Terminal (Source: Luka Koper's own elaboration)

<table>
<tr><td colspan="2">Photovoltaic system at the fuel station in the port</td></tr>
<tr><td rowspan="2"><u>Summary</u>

Location: roof Gas station, (45.55762, 13.75361),
Technology: Solar panel,
Installed power: 20,25 kWp,
Use of production: Self consumption.</td><td><u>Results</u>

Annual production: 0,73 MWh</td></tr>
<tr><td><u>Lessons learnt</u>

still being analysed</td></tr>
<tr><td colspan="2">
Figure 25: Fuel station (Source: Luka Koper's own elaboration)</td></tr>
</table>

<table>
<tr><td colspan="2">Photovoltaic system at the location named MAKOTER</td></tr>
<tr><td rowspan="2"><u>Summary</u>
Location: roof warehouse 18, (45.55026/13.74000),
Technology: Solar panel,
Installed power: 246 kWp,
Use of production: Self consumption</td><td><u>Results</u>
Annual production: 189,6 MWh</td></tr>
<tr><td><u>Lessons learnt</u>
still being analysed</td></tr>
<tr><td colspan="2">
Figure 26: Makoter (Source: Luka Koper's own elaboration)</td></tr>
</table>

6) What are the planned investments (horizon: 2030) in terms of renewable energy production in the port?

Investment	Amount of yearly renewable energy produced (estimation in MWh)	Cost *in euros*	Year of conclusion
PV panels on the rooftops Dispečerski center TA	40.3 MWh	62,000	2023
PV panels on the rooftops TP-KT3	8.2 MWh	13,000	2023
PV panels on the rooftops warehouse 50,51	3,421.0 MWh	4,550,000	2024
PV panels on the rooftops warehouse 16,19	983.2 MWh	1,200,000	2024
Main building Container Terminal	171.6 MWh	220,000	2025
PV panels on the rooftops warehouse 13	491.7 MWh	600,000	2025
PV panels on the rooftops warehouse 54	2,794.0 MWh	3,060,000	2026
Building Fire station	73.7 MWh	80,000	2026
Main building Luka Koper d.d.	171.6 MWh	190,000	2027
PV panels on the rooftops warehouse 33	1,008.7 MWh	1,384,400	2029
PV panels on the rooftops warehouse 27	1,441.0 MWh	1,600,000	2030
PV panels on the rooftops warehouse 34	55.0 MWh	67,000	2030

2.1.6. Port of Rijeka Authority

1) Description of the port

The Port of Rijeka Authority is a non-profit institution for the governance, development and use of the Port of Rijeka. The Port of Rijeka Authority manages the development of port capacitates and is competent for granting concessions to private concession companies for economic activities in the area of the Port of Rijeka, i.e. port basins Rijeka and Sušak, basin Bay of Bakar, basin Omišalj Bay on the island of Krk and basin Raša in Istria.

Figure 27: Port of Rijeka Authority - Administration building

This large port area, operated by the Port of Rijeka Authority, was declared a port of special (international) economic interest to the Republic of Croatia in 1996 and became the most important national port for international transport. Within its area of competence for the whole area, the Port of Rijeka Authority operates in all aspects of management, strategic planning and development of the construction and use of the Port of Rijeka.

Total area covered is approximately 1,481,886 m2. The area under management of PRA consists of various basins where specific cargo is handled, the Rijeka, Raša, Omišalj and Bakar basin.

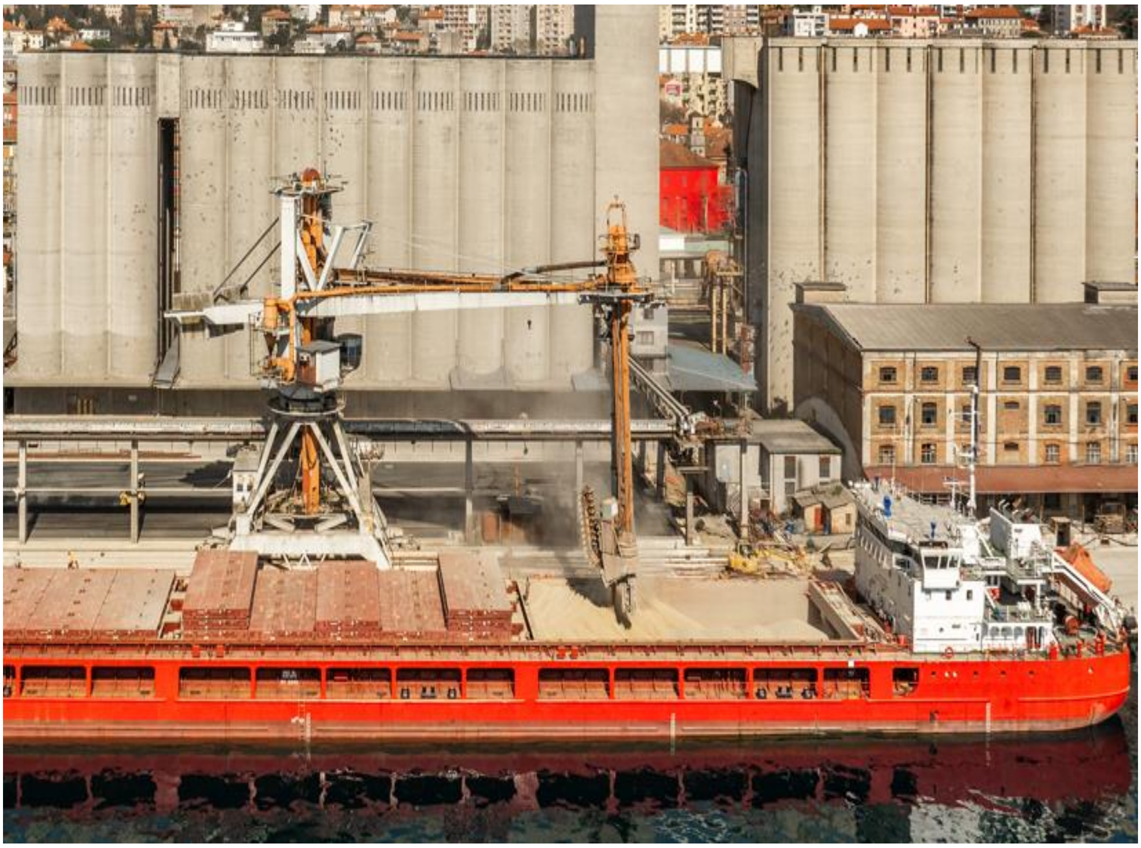


Figure 28: Rijeka basin serves as the general cargo terminal

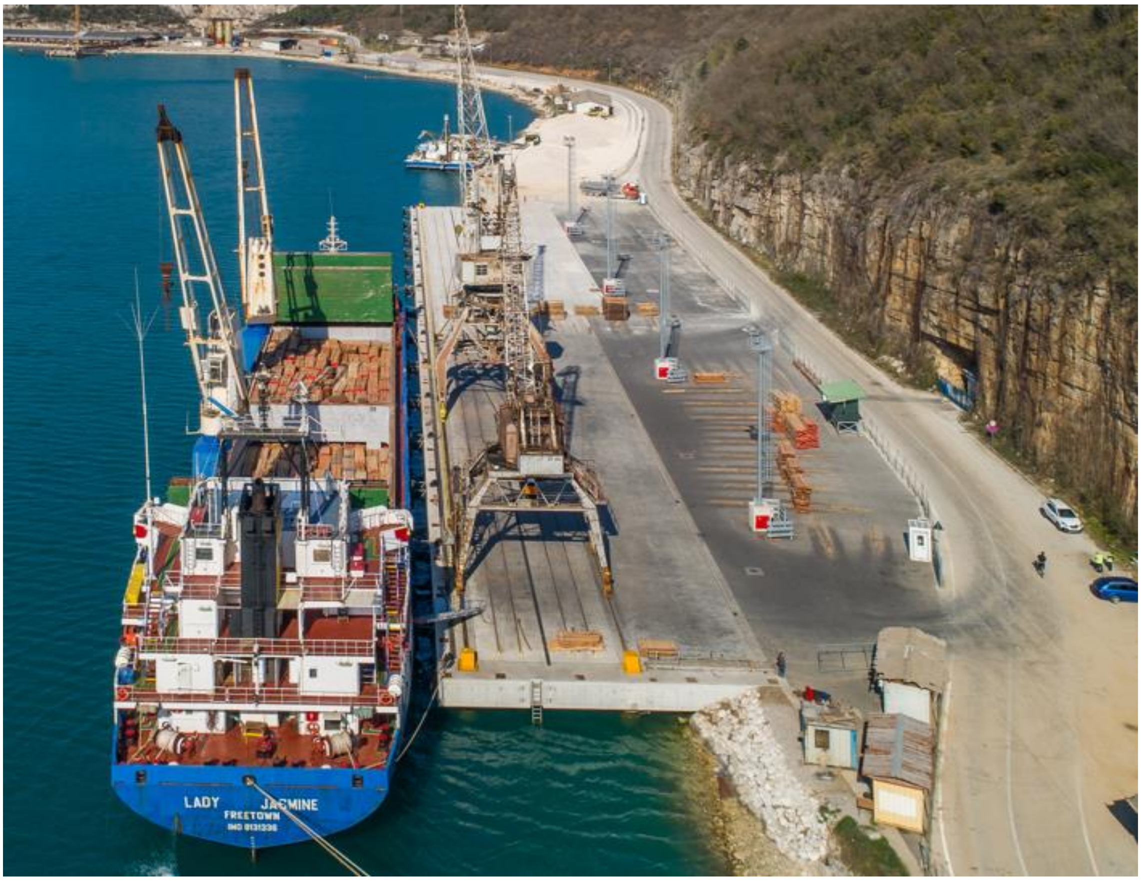


Figure 29: Live stock terminal in the Raša basin

Figure 30: The terminal for liquid cargo in Omišalj

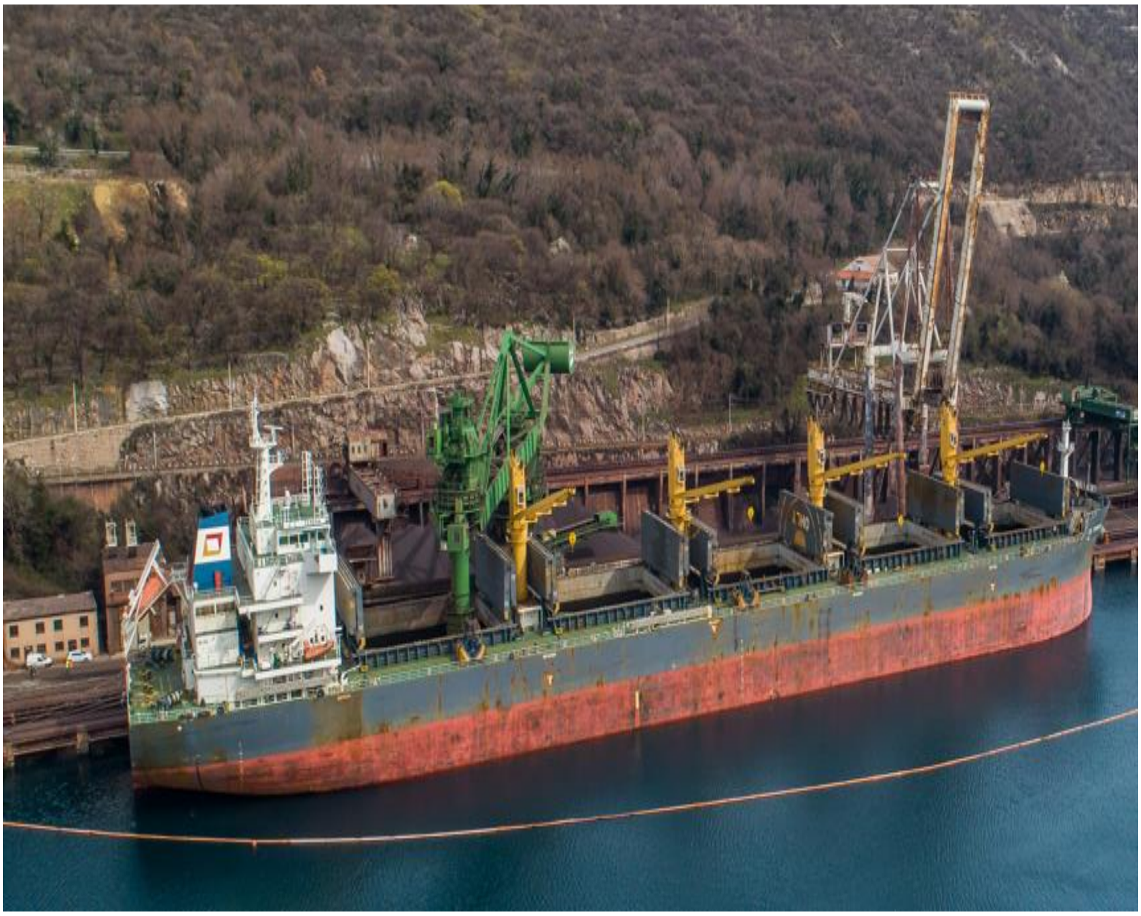


Figure 31: The terminal for bulk cargo in the Bay of Bakar

Figure 32: Zagreb deep sea container terminal

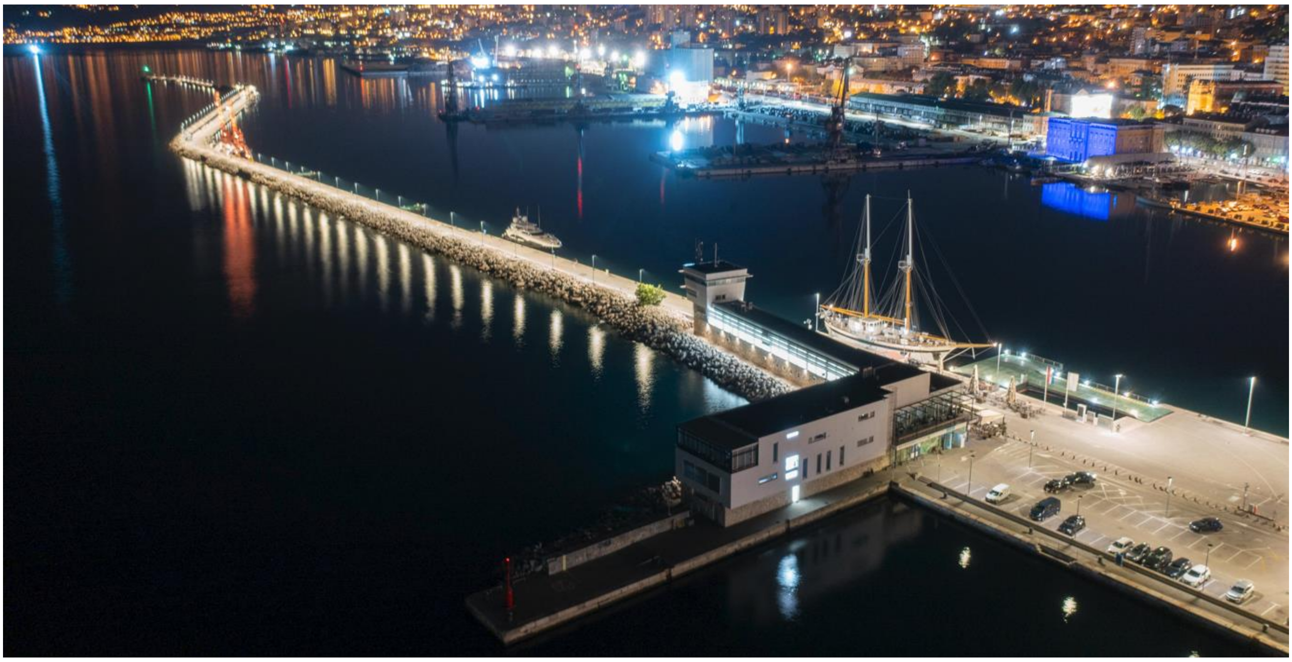


Figure 33: Rijeka breakwater

2) What is the total electricity consumption of your port for 2022 (in MWh), including the land side (terminals, offices, cranes, etc.) and maritime side (ships at berth)?

Total electricity consumption in the year 2022 including both land and the maritime side of the port was approximately 17,28 MWh.

3) What was the amount of renewable energy produced in 2022 (in MWh) and the total power installed?

N/A

4) What was the origin of such renewable energy (e.g. solar, wind, wave...)? Please break down the sources, in energy and power.

N/A

5) For each existing renewable energy investment, please fill in the table at the end of this document, with a picture

N/A

6) What are the planned investments (horizon: 2030) in terms of renewable energy production in the port?

Investment	Amount of yearly renewable energy produced (estimation in MWh)	Cost in euros	Year of conclusion

Within Interreg MED – RENEWPORT-Pilot project Port of Rijeka Authority intend to prepare detail design and construction of a photovoltaic power plant on the roof of the administrative building. The photovoltaic power plant will be 50 to 60 kw and will covered around 50 % of energy cost from green sources. The cost estimate for instalation of photovoltaic power plant is 100,000 EUR	0.06 MWh	100,000.00	2024

2.1.7. Port of Bar

1) Description of the port

The Port of Bar, the main cargo port in Montenegro, was established in 1906. Total area of the port is approx. 130 ha. Capacity of the port is ~5 million tons of different types of cargo, per year. The exact location of the port is at the entrance to the Adriatic Sea, more precisely at 42˚05' of the North latitude and 19˚05' of the East longitude, at a distance of 976 nautical miles (nm) to Suez Canal and 1190 nm to Gibraltar.

The Port (core port in the new TEN-T network) represents a very important link in the chain of intermodal transport. The following contributes to the fact: it is integrated with the Belgrade (Serbia) - Bar railway and road traffic network. There are 2 main operators in the port - Port of Bar JSC (77% shares are owned by the state of Montenegro) and Port of Adria JSC (62% shares are owned by Global Ports Holding - Turkey).

Figure 34: Port of Bar and Port of Adria (source: Port of Bar)

Port of Bar JSC can use a space with a total area of 841,079.5 m2, which includes the following facilities of the port infrastructure:

- the main and the secondary breakwaters,
- Stara obala - berths 04, 05, 06, total length 280m with a depth from 3.0m to 7.2m,
- petroleum berth - berth 07 (with a depth of 13.5m and 66m of distance between two piers),
- Volujica quay (berths 01, 02, 03, total length of 554m and depth from 10.7m to 14.0m),
- bay which connects Volujica quay with pier I,
- bay which connects pier II with pier III, i.e. berth 26, 239m long and 8.1m deep,
- pier III - berth 31, 135m long and 7.4m deep,
- pier V - berths 51, 52, 53, 54 (total length of 245m and depth from 3.0 to 6.5m)
- the bay along the secondary breakwater in the continuation of pier V,
- facilities for security and safety of navigation;
- as well as electric power, water supply, sewerage and telecommunication infrastructure and port road and railway roads (which are located in the area to be used by the „Port of Bar“ JSC).

Facilities of the port superstructure, which are owned by the „Port of Bar“ JSC and have the direct function of performing basic port activities:

- port closed warehouses no. 10 (area 6,300 m^2) and no. 13 (area 5,982 m^2),
- grain silo, with a capacity of 30,000 t,
- cold storage, area 7,749 m^2,
- fabricated warehouse on Volujica quay, area 1,200 m^2,
- fabricated warehouse, area 600 m^2,

- warehouses of "B" materials;
- 4 truck scales 60t;
- 3 gantry cranes 12t, mobile harbour cranes 144t and 120t, forklifts, wheeel loaders, etc.

Free Zone Port of Bar

Except for the Passenger Terminal (Pier V) as well as the part of the space at Pier III, the entire area and capacities of „Port of Bar“ JSC and „Port of Adria“ JSC are in the free zone regime, which is regulated by the Law on Free Zones.

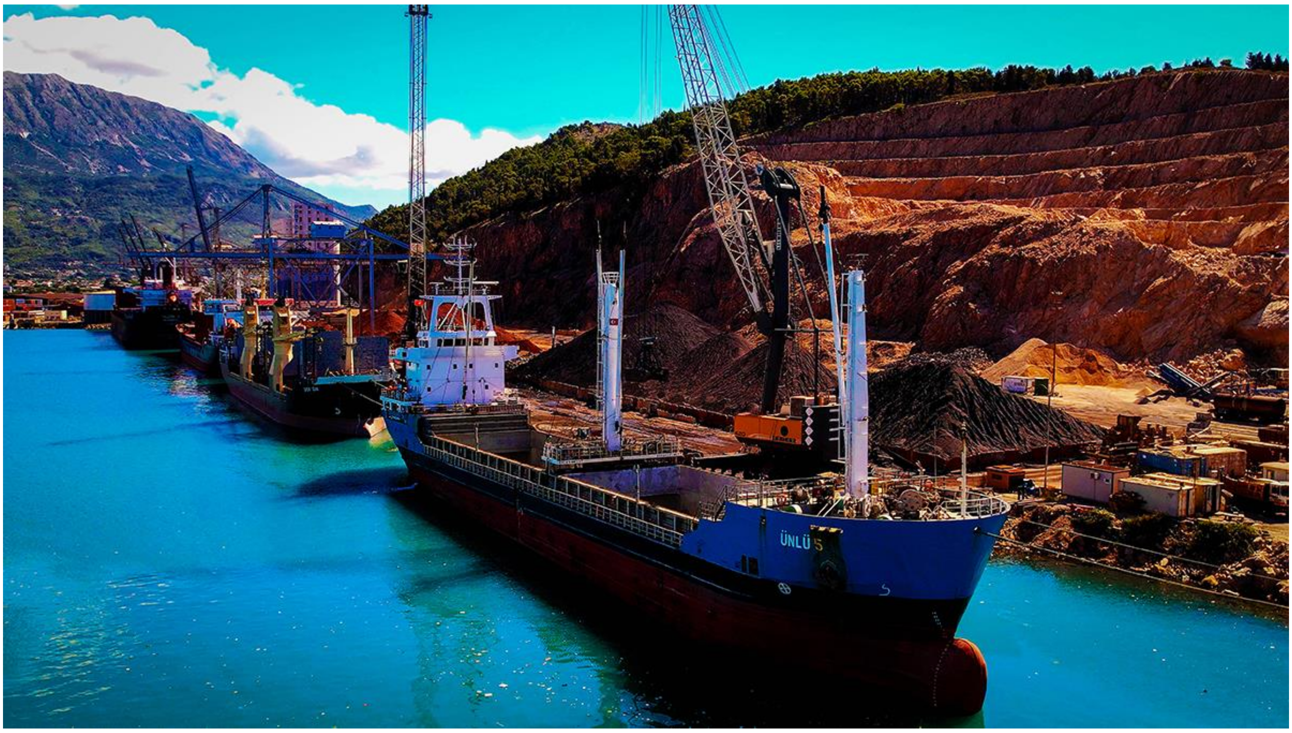


Figure 35: Volujica quay – Dry bulk terminal in Port of Bar (source: Port of Bar)

“Port of Adria”

Port of Adria is a multipurpose port featuring quay length of 1,440 m with dedicated terminals for container ships, general cargo ships, Ro-Ro and cruise ships. It covers the total area of 518.790 m2 with nine berths. Whole area of Port of Adria is within the Free zone regime.

As for the Port of Adria, there are three following specialized terminals:

- General cargo terminal
- Container terminal
- Timber terminal.

General cargo terminal

General cargo terminal with surface of 12,300 m2 is located on Piers 1 and 2 that are, in terms of space and technically, qualified and equipped for acceptance and dispatch of all types of general cargo. General cargo terminal includes closed and open storage systems, handling-operational and traffic surfaces. On the terminal there are complete horizontal and vertical mechanical equipment with 15 portal cranes with carrying capacity ranging between 3-20 t and quay, that is 1,370 m long with average depth of sea up to 10 m. It is specialized for acceptance and dispatch many final or semi-final products.

Container terminal

The length of the operational quay is 330 m (with two berths for container vessels), the depth of the aquatorium is 12 m. The soil below the level – 12 m consists of sandy material with layers of clay. The terminal occupies the area of 45 900 m2.

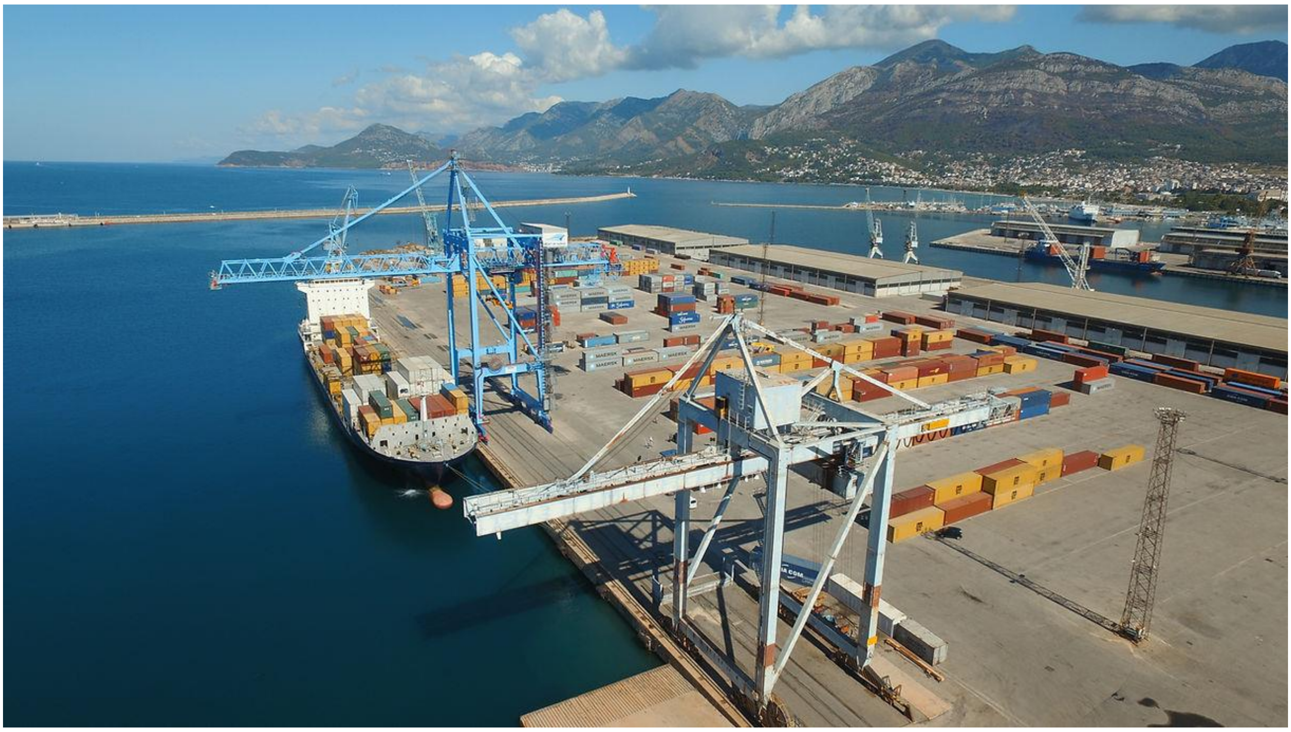


Figure 36: Container terminal in Port of Adria (source: www.portofadria.me)

Timber terminal

Timber terminal covers the area of 5.86 ha and encompasses several subsystems for: acceptance and despatch of transportation vehicles, loading, unloading and transhipment, storing sawn wood, wood products, sorting and forming units for despatch, drying of woods and others. Capacity of the terminal ranges from 40,000 to 60,000 m3/year, depending on type and shape of wood products. The terminal includes 23 400 m2 of covered space.

The quality of the port infrastructural links with Its hinterland has a strong influence on the current port capacity utilization rate. Main markets of the port (Serbia, Bosnia and Herzegovina, Kosovo, etc.) are given in the following image.

Figure 37: Main markets of the port

Statistics for the Port of Bar and Port of Adria are given in the following tables.

Port of Bar				
Year	Dry bulk	Ro-Ro and general cargo	Liquid	TOTAL
2022	2.021.330,37	95.970,34	273.796,46	**2.391.097,17**
2023	1.598.033,33	63.945,34	244.660,45	**1.906.639,12**

Table 7: Main figures of traffic of the Port of Bar

Port of Adria		
Year	TEU	Ro-Ro and general cargo
2022	41.917	185.428,00
2023	48.203	80.016,00

Table 8: Container traffic of the Port of Adria

Total throughput in Bar in 2022 was 2.576.525t.

2) What is the total electricity consumption of your port for 2022 (in MWh), including the land side (terminals, offices, cranes, etc.) and maritime side (ships at berth)?

Total consumption of the port (Port of Bar and Port of Adria) is 5,476.22 MWh (landside consumption). There are no OPS in the port at the moment.

In following table is electricity consumption in 2022.

Month 2022	MWh
January	466.96
February	404.30
March	508.13
April	466.69
May	334.82
Jun	468.27
July	469.12
August	459.25
September	424.90
October	467.54
November	437.70
December	568.54
Total	5,476.22

Table 9: Electricity consumption

3) What was the amount of renewable energy produced in 2022 (in MWh) and the total power installed?

There are no renewable energy installations within the port area.

4) What was the origin of such renewable energy (e.g. solar, wind, wave...)?

Not applicable.

5) Each existing renewable energy investment

Not applicable.

6) What are the planned investments (horizon: 2030) in terms of renewable energy production in the port?

Investment	Amount of yearly renewable energy produced (estimation in MWh)	Cost in euros	Year of conclusion
RENEWPORT pilot project investment (purchase and installation up to 50kW solar panel system and the canopies for parking lots).	66 MWh	100,000	2025
ADRIREC pilot project investment (purchase and installation up to 50kW solar panel system and the canopies for parking lots).	66 MWh	80,000	2025

2.1.8. Durres Port Authority

1) Description of the port

Port of Durres is the biggest port of Albania and a multipurpose port accounting for 90% of Albanian Maritime Trade. DPA handles all types of cargo including dry bulk, break bulk, general cargo, chemicals, dangerous cargo, containers, cement, minerals construction material, foodstuff, and steel, and operates 24 hours/ day- 365 days/year.

Durres Port is located in South East Europe.
LATITUDE /LONGITUDE
41° 19´ N
19° 26´ E
BURGAS 900 Km
VARNA 950 Km
BAR 205 Km
SKOPJE 320 Km
PRISTINA 281 Km
BEOGRAD 710 Km

Figure 38: Aerial view of the Port of Durres

Information about the traffic of the port.

Year 2023			
	Import	Export	Volume Ton
West Terminal	252,519	-	**252,519.22**
East Terminal	78,944	174,939	**253,882.07**
Ferry Terminal	612,241	385,247	**997,488.00**
Container Terminal	1,336,358	732,206	**2,068,564.00**
***MBM- Porto Romano**	2,771,362	76,290	**2,847,651.79**
TOTAL Durres-Porto Romano Port Complex			**6,420,105.08**
Container (Volume ne TEU)	92,100	91,917	**184,017**
	Arrival	Departures	**Total**
Passanger nr.	409,839	418,013	**827,852**
MJETE LUNDRUESE VITI 2023			
	Dalje	**Hyrje**	**TOT**
Bulk Cargo Ship, East Terminal	32	22	54
General Cargo Ship, West Termin	-	109	109
Container ships	-	155	155
Ferries	-	1,000	1,000
Cruises	-	22	22
Yachts	-	126	126
Porto Romano Ship	11	352	363
TOT	**43**	**1,786**	**1,829**

Durres Port has 4 terminals.

CONTAINER TERMINAL

QUAY LENG	265 ML
QUAY DEPTH	8.6 M – 10.00 M
YARD	60.062 M2
MHC	3 UNITS, 100-150 mT
REEFER PLUGS	200 UNIT
STORAGE CAPACITY	3.000 TEU
HANDLING CAPACITY	180.000 TEU/YEAR

Figure 39: Container Terminal

Figure 40: Container Terminal

FERRY TERMINAL

QUAY LENGTH	580 ML
QUAY DEPTH	8.5 M – 10.00 M

TERMINAL BUILDING	5.400 M2
YARD SURFACE	87.000 M2
HANDLING CAPACITY	10.000 PASSENGERS/DAY

Figure 41: Ferry Terminal operated by AFTO

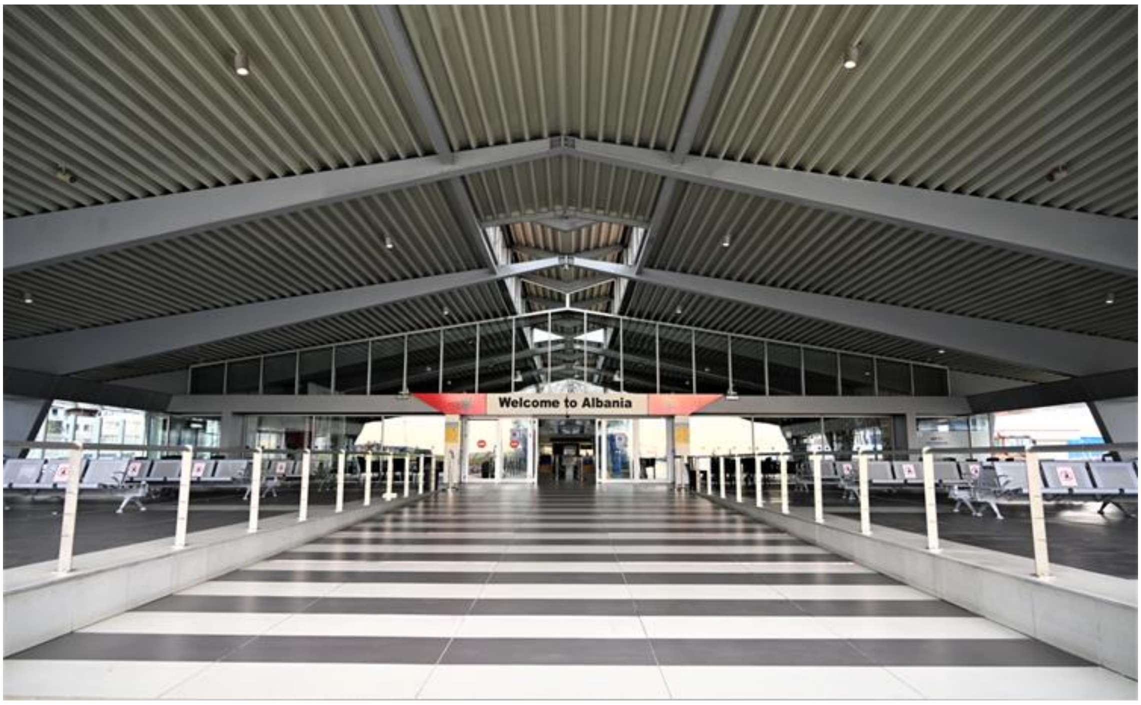


Figure 42: Ferry Terminal operated by AFTO

Figure 43: Ferry Terminal operated by AFTO

GENERAL CARGO TERMINAL

QUAY LENGTH	800 ML
QUAY DEPTH	7.00 M – 8.2 M
WAREHOUSE	5.257 M2
YARD SURFACE	92.680 M2
GANTRY CRANE	12 UNITS 5- 45 TON
MHC	2 UNITS 63 -120 TON
HANDLING CAPACITY	1.500.000 TON/YEAR

Figure 44: General Cargo Terminal

Figure 45: General Cargo Terminal

EAST TERMINAL OPERATED BY EMS-APO

QUAY LENGTH	422 ML
QUAY DEPTH	6.5 M - 11.5 M
YARD SURFACE	135.000 M²
GANTRY CRANES	5 UNITS 15-27 TON

Figure 46: East Terminal

Figure 47: East Terminal

Figure 48: East Terminal

The following photos show the buildings where we want to implement our action plan and where the solar panels will be implemented.

Figure 49: Administrative Buildings of DPA

Figure 50: Administrative Buildings of DPA

Figure 51: Administrative Buildings of DPA

Figure 52: Administrative Buildings of DPA

A. The existing issues are for example:

1. Commercial buildings use, on average, 20% more energy than needed. This translates into a significant amount of money. This is due primarily to the fact that management does not know where the waste is occurring and what to do to eliminate or reduce this loss.

2. High lighting consumption in squares and terminals due to SAP lights.

3. High consumption of port mechanisms with energy and fuel consumption.

B. Projections in the future:

1. We have started and are finishing the replacement of SAP lighting with LED lighting for squares and terminals.

2. We have started investing in electric vehicles for the institution.

3. We design the installation of solar panels on the terraces of the port buildings and then in the car parking facilities. Also, in the New Commercial Port in Porto Romano, we are thinking of building a photovoltaic plant that will have a capacity of over 2 MW.

Figure 53: Buildings and parking areas where the solar panels will be installed

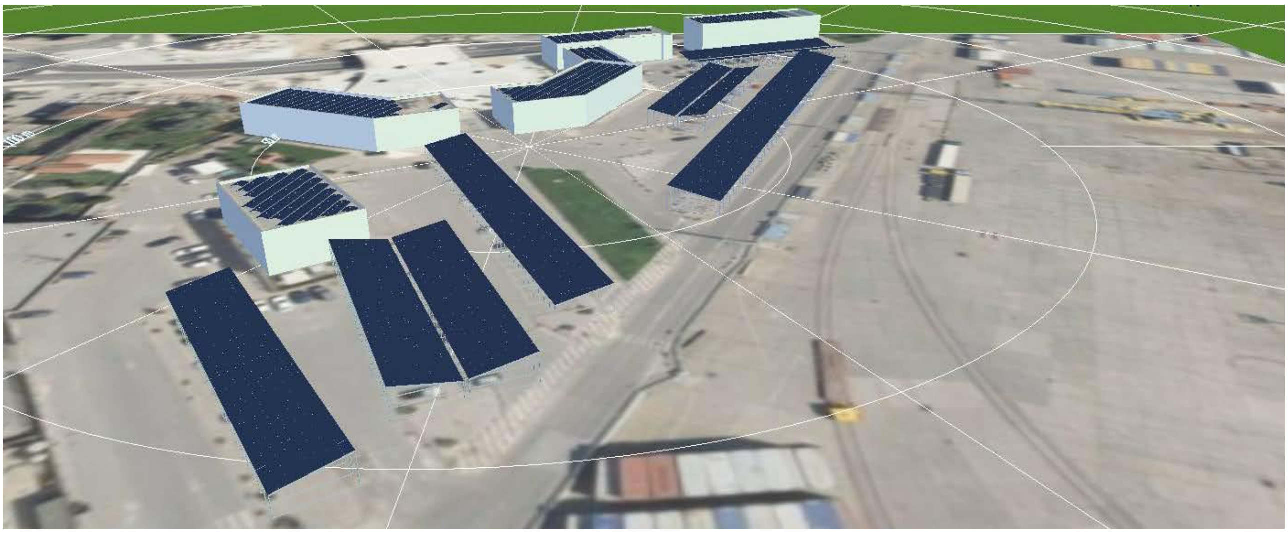


Figure 54: Buildings and parking areas where the solar panels will be installed

2) What is the total electricity consumption of your port for 2022 (in MWh), including the land side (terminals, offices, cranes, etc.) and maritime side (ships at berth)?

Zone	kwh
Container Terminal	162,748
Ferry Terminal	51,705
General Goods Terminal	153,163
East Terminal	79,880
Buildings & others	149,283
Total	596,778

Total Consume of kwh in DPA for the Period February 2022-February 2023

Types of Customers	kwh
Electric Cranes	61,280
Lighting (terminals, roads ect)	30,745
Buildings	66,753
Total	158,778

Table 10: Electricity consumption

7,550,000 kWh is the summary of the total electricity consumption of February 2022- February 2023 of Durres Port Authority

3) What was the amount of renewable energy produced in 2022 (in MWh) and the total power installed?

0 (we have not yet installed renewable energy production plants.)

4) What was the origin of such renewable energy (e.g. solar, wind, wave...)?

We have not yet installed renewable energy production plants.

5) For each existing renewable energy investment, please fill in the table at the end of this document, with a picture

6) What are the planned investments (horizon: 2030) in terms of renewable energy production in the port?

Investment	Amount of yearly renewable energy produced (estimation in MWh)	Cost in euros	Year of conclusion
An important investment during the last 3 years for implementation until 2030 is that of solar panels, first installations on the terraces of the buildings and then tents in the parking lots of the port facilities.	509 MWh	550,000.00	2028

With the construction of the new commercial port in Porto Romano, we think to design solar plants farm for renewable energy as well as plants for the production of energy from marine waves, taking into account that the position of the new port is at the northern end of the city of Durres.	2,896 MWh	n/a	n/a

2.1.9. Piraeus Port Authority

1) Description of the port

Piraeus port is the largest port in Greece, with a covered area of 3,900 hectares (39 km2), and one of the largest ports in the Mediterranean playing a crucial role in the development of international trade and contributing to the local and national economy. The port today has a range of activities concerning the Commercial and Central Ports, ship services and real estate development. It connects continental Greece with the islands and is an international cruise center and a commercial hub for the Mediterranean, providing services to ships of any type and size. Piraeus is considered the natural port of Athens, just 10Km away from the capital, and is the country's main gateway for imports and exports. It is the first European port after the Suez Canal with the necessary infrastructure to serve transit trade and overland transport. Situated near international trade routes, the port is a hub of international trade being the only European port in the East Mediterranean with the necessary infrastructure for the accommodation of transshipment cargo.

Coastal Traffic (no of pax)	Cruise Traffic (no of pax)	Container Traffic (TEU)	Car Terminal (no of vehicles)
14.976.394	880.416	648.889	350.970

Table 11: Traffic statistics for Piraeus Port in 2022

Facilities	Info
Passenger Terminal	4 passenger terminals
Cruise Terminal	3 cruise terminals Total quay length: 2.800m Draft: 11m Capacity: 11 berths

	Facilities and services available
Container Terminal	3 container terminals (Piers I, II, III) Average length: 1150m Max depth: 18m Capacity: 1.100.000 TEU Superstructure and mechanical equipment available Services cover loading-unloading, transshipment and storage facilities of containerized cargo, temporary storage for containerized dangerous goods
Cargo Terminal	1 logistics centre (ODDY) Total quay length: 4.200m Depth: 12m Capacity: 86.402 m2 Warehouses, superstructure and facilities available
Car Terminal	2 car terminals including storage facilities No of berths: 5 Max Draft: 11m Capacity: 6.700 vehicles Superstructure, mechanical equipment and terminal facilities available
Other	- ship repair zone - 4 dry docks (2 floating and 2 stationary)

Table 12: Piraeus Port infrastructure and facilities

PPA SA serves all types of cargo (conventional and unitized) from all origins to all destinations (import-export and transshipment), passenger traffic in relation to both coastal and cruise lines, and also hosts vessel repair activities. In a glance, the port serves nearly 15 million passengers per annum, more than 0.9 million cruise passengers, more than 0.3 million cars with more than 70% destined for other Mediterranean countries, and around 0.6 million containers (TEU) per annum at two terminals. Its main comparative advantages are summarized in the following:

- Strategic geographical position at the crossroads of Asia - Africa - Europe
- Infrastructure and natural depths for the accommodation of even the largest modern container ships
- Operation under a free zone type II status
- 24 hour - 365 day operation of the Container and Car Terminals
- Scale of tariffs based on the volume of transshipment containers and cars
- Competitive storage fees
- Extended feeder services connecting the port with almost all main ports in the Mediterranean
- Integrated information system supporting port operations
- Operational and safety standards according to international regulations
- Operating conditions and safety on the basis of international standards and regulations (ISPS).
- Certification by AEO - Authorized Economic Operator.
- Qualified and experienced staff for all port functions.

- Among the first ports in the Mediterranean to apply an Environmental Management System certified by PERS and ISO 14001.

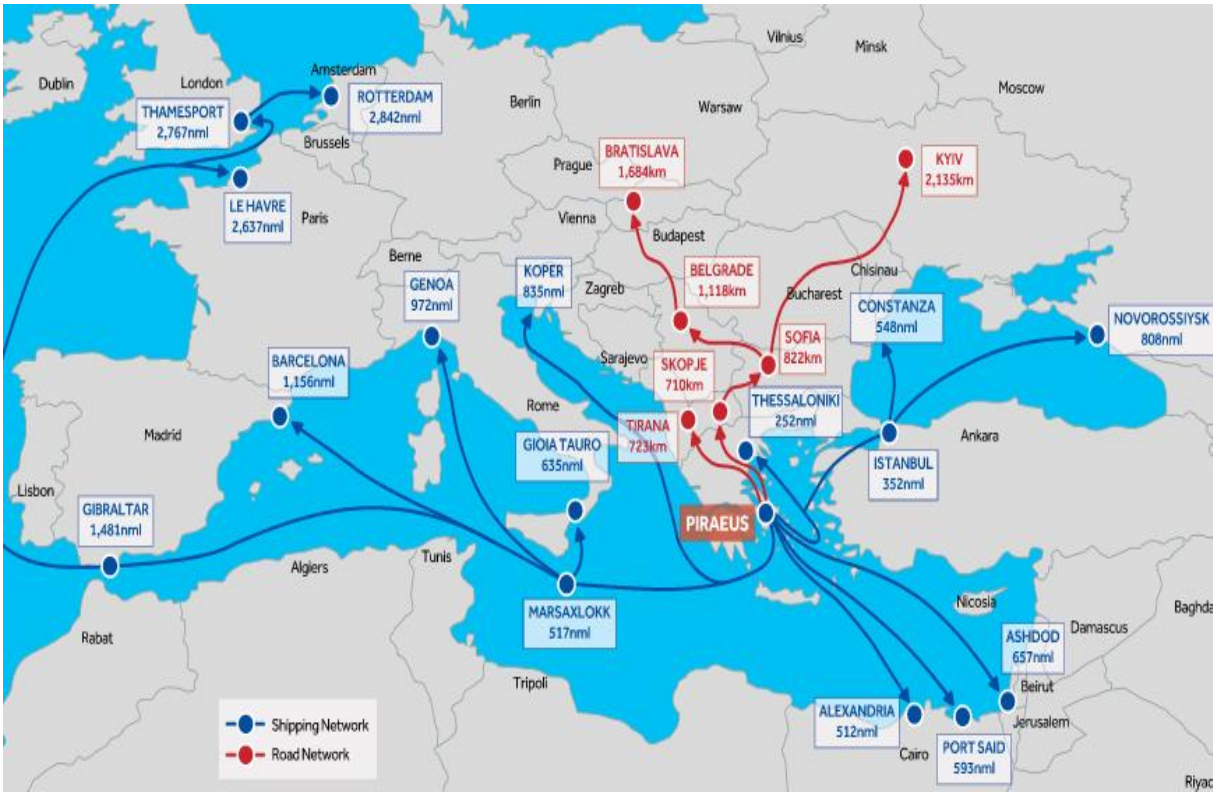


Figure 55: Main connections of Piraeus Port

2) What is the total electricity consumption of your port for 2022 (in MWh), including the land side (terminals, offices, cranes, etc.) and maritime side (ships at berth)?

Total electricity consumption in the year 2022 including both land and the maritime side of the port was approximately 132 MWh.

3) What was the amount of renewable energy produced in 2022 (in MWh) and the total power installed?

PPA's first photovoltaic station generating energy using solar panels has been put into operation in July 2016, generating up to 430 kWp. The photovoltaic Station is linked up to the Public Power Corporation electricity grid. The installation provides 635,000 'green' kWh per year to the electricity grid, corresponding to 635 tonnes of CO2 emissions that are avoided. In 2022 the total amount of energy produced from photovoltaic station was 682 MWh.

4) What was the origin of such renewable energy (e.g. solar, wind, wave...)? Please break down the sources, in energy and power.

Only solar renewable energy sources installed in the port area.

5) Each existing renewable energy investment

Figure 56: Photovoltaic panels on PPA's facilities

6) What are the planned investments (horizon: 2030) in terms of renewable energy production in the port?

Investment	Amount of yearly renewable energy produced (estimation in MWh)	Cost in euros	Year of conclusion
RENEWPORT - PPA will install a solar power production system on canopies located in their parking areas, including photovoltaic modules converting solar energy into electricity (DC voltage and current), EV charging stations to satisfy the needs of the users.	0.05 MWh	€ 63,960.00	2026

ADRIREC - PPA will install a Photovoltaic Solar Parking Structure allowing the optimisation of energy efficiency, limiting and reducing energy consumption by electricity or fossil fuel. Detailed description: - PV modules converting solar energy into electricity (DC voltage and current). The panels are estimated to have an average size of 0,75 sq.m. - Structures from aluminium profiles and stainless-steel fasteners - DC board with lightning protection, overvoltage and overcurrent protection - Solar Inverter AC/DC (230V / 50Hz) compatible with power consumption devices and power grid requirements.	0.05 MWh	€ 31,500.00	2026
TRIERES – A small-scale FC APU (Fuel Cell Auxiliary Power Unit) operating in the premises of PPA to produce clean energy for port applications. The system will have a capacity of 100kWe using PEM fuel cells. Storage system will cylinder storage that can be transferred to the port by truck. The consumption for 5days/12h operations is estimated to be 18tpa. Although, small scale this application could provide useful evidence for its implementation at small ports and non-interconnected islands. Energy users under this task are envisaged to use 1,000 tons of green hydrogen per year after the implementation of the necessary works.	0.1 MWh	€ 450.000,00	04/2027

2.2. Good practices in the European and international context

Other ports in the world are also implementing RES with good results. Here we have some cases that could serve as good examples for the ports that have still huge needs in terms of renewable energy. The first point is about the project COMPOSE, funded by the Interreg Med Programme, that developed a toolkit to help entities to design a sustainable energy plan that could be interesting also for ports.

2.2.1. COMPOSE project

To help Mediterranean regions to increase the use of renewable energy and create local businesses, the Compose project launched fifteen small-scale demonstration projects in eleven countries. These included the installation of energy saving measures in public buildings and the organisation of energy efficiency awareness campaigns aimed at residents. An open access web tool was developed that planners and policy makers can use to launch their own green economy initiatives with community support.

COMPOSE brought together 25 partners from universities, research centres, local and regional authorities, development agencies, business networks, non-governmental organisations and sustainable energy associations.

Thanks to these projects, a total of 558,000 tonnes of CO2 emissions per year will be avoided in the participating countries by 2030. The project was widely disseminated, reaching some 140,000 people. The share of renewable energy use is expected to increase in rural areas in the Mediterranean by 12% and by 19% on islands such as Crete and Cyprus. A total of 250 local and regional policy makers from 11 countries signed the Compose Memorandum of Understanding.

Demonstration projects were launched in Albania, Bosnia and Herzegovina, Croatia, Cyprus, France, Greece, Italy, Montenegro, Portugal, Slovenia, Spain and France. They used solar, wind and geothermal energy, as well as biomass. Energy saving measures adopted included improved insulation and the installation of technology to control energy consumption.

In each location, a problem was identified, a plan was developed with local authorities, partnerships were established, citizens were involved, and training and awareness-raising activities were carried out. This approach and the web tool are intended to ensure that the methodology can be replicated elsewhere.

In the Provence-Alpes-Côte d'Azur region of France, one in six inhabitants lives below the poverty line. Poor households spend a disproportionate share of their income, up to 15 %, on energy bills. Many of these dwellings are not adequately insulated. In the cities of Aix-en-Provence and Marseille, visits were made to forty low-income households to determine which energy-saving measures might be feasible. Those found to be most effective were installed, resulting in energy savings of 40,000 kWh or EUR 4,000. Energy consumption in 20 of these households will continue to be monitored.

In the municipality of Rethymno on the Greek island of Crete, the recycling of cooking oil, which is used to make biodiesel, was increased thanks to an awareness campaign targeting residents (adults and schoolchildren). Smart bins with integrated sensors connected to a web-based tracking platform make it easier to determine when they are full, saving fuel consumption and collection trips. The project increased recycling and safe disposal of used cooking oil and created a biodiesel supply chain. The project aims to save 17 tonnes of CO2 emissions per year and 48.5 tonnes of oil equivalent by 2030.

In the municipalities of Zreče and Slovenska Bistrica (Slovenia), a micro district heating system was installed and a sports hall was renovated to improve its energy efficiency. The aim was to increase air quality and the use of biomass, as well as to improve local energy supply chains. The work started with a feasibility study on the development of a biomass logistics centre and the construction of a cogeneration district heating system. Discussions were held with local authorities, residents, development and energy agencies and representatives of the Natura 2000 network.

COMPOSE has also created the Sustainable Energy Planning Toolbox. This toolbox will help discover COMPOSE's step-by-step approach to creating a low-carbon community through renewable energy and energy efficiency measures that harness local potential. The COMPOSE website (reselplan-toolbox.eu) provides access to tools and resources for implementing local energy plans more effectively, integrating not only technical aspects, but also socio-economic and environmental aspects.

This toolbox supports policy makers and development planners, local authorities' technical staff and other stakeholders involved in the development and implementation of local/regional energy plans.

The step-by-step approach is divided into 6 steps:

1.- Choosing a problem

This step aims to identify the priority RES and EE projects, which will contribute most to the local community's socio-economic and technological development. Two options are possible:

- To identify the local energy needs
- To estimate the local RES or EE potential

2.- Creating local action group

This step provides information on how to identify the local stakeholders who can contribute to the design and implementation of a local RES or EE project. Two actions are necessary:

- To identify potential actors
- To engage local stakeholders

3.- Local action plan

The main challenge of this step is to summarize input from stakeholders' participation and shape it into a local action plan. Depending on this information, three option are defined:

- To plan RES or EE measures
- To plan circular economy projects
- To build an Energy Community

4.- Creating Local Partnerships

The scope of this step is developing a partnership committed to the implementation of the project, with clear obligations and responsibilities. Three actions are encouraged:

- To develop a detailed financial plan
- To look for funding instruments
- To know the European Green Deal and the investment plan it mobilises

5.- Implementation procedures

This is one of the most important steps in the entire process. The challenge of this step is to put the ideas into reality and accomplishing the necessary procedures. This step involves:

- Assigned qualified and skilled management and work team
- Realistic time and resources planning
- Provision of all necessary technical documentation
- Risk mitigation plan and problem solving procedures
- Approved implementation plan, amongst all involved stakeholders.

6.- Monitoring and evaluation

The last step aims to monitor and measure the actual performance and impact of a project. The fundamental point for the impact evaluation is the identification of performance indicators. Four kinds of indicators have to be defined:

- Environment indicators
- Energy indicators
- Economy indicators
- Social capital indicators.

2.2.2. Ecosystemic Transition Unit

The Ecosystemic Transition Unit (ETU) initiative has been developed in the framework of the ETU project, financed by the Interreg Med programme. This project was one of the horizontal projects grouping modular projects by theme, having grouped together the six projects dealing with renewable energies. The ETU model aims to help localities and regions to develop their own energy transition plan.

The project has developed an ETU toolbox to collect tools and technologies that support energy transition initiatives. The tools are organised into four pillars:

1. Energy planning – the territorial pillar
   The pillar addresses to the urban and land use planning parameters that involves the local RES potential and design of a distributed grid and microgrids. The type of tools targeted are:
   - Estimation of RES potential
   - Estimation of energy demand
   - Dimensioning of the energy infrastructure
   - Optimisation of energy demands
   - Indicators estimation (emissions and energy balance)
2. Energy facilities – the technological pillar
   This pillar represents the energy facilities and equipment required for the functioning of the local energy community. The type of tools targeted for this pillar are:

- RES infrastructure
- Microgrids' monitoring tools
- Digital tools for RES community management
- Monitoring tools and devices

3. Energy Communities – the social pillar

   The third pillar responds to the social component and the toolbox gathers the tools that are useful for the management of the community especially the production and sharing of the energy.

   The type of tools targeted are related to the following topics:
   - Awareness campaigns
   - Training tools for community facilitators
   - Guidelines for community management
   - Energy consumption monitoring tools
   - COMPOSE sustainable energy planning tool
   - PEGASUS business model

4. Energy governance – the organisational and legal pillar

   For the last pillar, the toolbox offers a set of policy recommendations at local level that enhance the governance at different levels. The type of tools of this pillar are:
   - Green fiscal policies
   - Tax bonifications
   - RES trade agreements among territories
   - Funding subsidies and grants
   - Financial schemes – crowdfunding
   - Local energy community's legal entity

As a good example of tool for the first pillar we have the PRISMI toolbox. PRISMI is a project funded by Interreg Med programme that has developed a tool tailored to MED islands, able to assess and map RES potential. PRISMI methodology is based on three tools:

1.- EnergyPLAN used for energy scenarios modelling
2.- Wind Power Calculator generating a wind power production series
3.- Load-flow tool analysing the RES impact on the grid

A good example of tool of the second pillar is the COMPOSE tool that has already been explained in this document.

A good example of tool for the third pillar is the LOCAL4GREEN methodology. It helps to design, implement and evaluate the local fiscal policies to promote RES. It is based on 19 steps based on the Deming cycle: Plan, Do, Check and Act, being the most important the following ones:

- Plan
  - Generating the political will to implement local fiscal policies
  - Analysis of the potential of RES in the municipality

    - Analysis of alternatives
    - Establishment of the fiscal measures
- Do
    - Drawing up of the appropriate instrument
    - Drawing up of a resolution of political impact
- Act
    - Drawing up of a series of indicators
    - Evaluating the local fiscal policy
- Check
    - Review of the appropriate instrument

In the fourth pillar, the good example is the tool to design energy storage systems by the StoRES project. The objective of this tool, based on 8 steps, is to optimise residential energy consumption by boosting photovoltaic self-consumption through a storage solution. The 8 steps are:

1.- PV system data
2.- Consumption data
3.- Electric costs
4.- Storage system
5.- Policy
6.- Financial
7.- Inputs validation
8.- Getting the results

2.2.3. Other Italian ports

Port System Authority of the Southern Adriatic Sea

The Port System Authority of the Southern Adriatic Sea, in 2022, successfully tested a wind turbine with a vertical axis generator with a rated power of 30 kilowatts (kw), installed on quay number 18 of the “Molo Foraneo” in the commercial area of the port of Bari. The system has an estimated annual production of about 39 kilowatt hours (kwh) of electricity. The energy is fed into the grid allowing for a reduction of the energy cost. The production of renewable electricity from the wind turbine is estimated to reduce the annual CO_2 emissions into the atmosphere by approximately 18,600 kg.

Figure 57: The wind turbine installed in the port of Bari.

The Port System Authority of the Southern Adriatic Sea has built a photovoltaic plant, located on the flat roof of the Maritime Station, San Vito terminal in Bari. The system consists of 380 monocrystalline silicon panels grouped in 23 strings, each consisting of 16 or 22 panels, supported by four inverters. The production potential is around 170,000 kWh/year.

Figure 58: The photovoltaic plant installed in the Maritime Station of the port of Bari

Port of Ravenna Authority

Thanks to the "SUSPORT" project, the Port of Ravenna Authority in 2023 installed photovoltaic panel shelters in the headquarters' car park, in addition to the already existing photovoltaic panels on the rooftop of the Port Authority headquarters.

The power of the new photovoltaic system is 122,208 kWh per year, which, added to the output of the previous system producing 38,602 kWh, fulfils the energy needs of the headquarters and supplies the electricity needed to power the EV chargers installed in the parking area.

Figure 59: The photovoltaic panels installed in the headquarters' car park of the Port of Ravenna

Central Adriatic Ports Authority

In 2016, a EUR 4.5 million rooftop installation was completed, which was privately built on areas obtained under concession by the Port System Authority of the Central Adriatic Sea in the Port of Ancona.

It is a project that includes over 15 thousand photovoltaic modules, covering an area of 19 thousand square metres. The structure can produce around 3.7 million kWh of clean energy per year and is able to meet the energy needs of 4500 households.

The structure stands in place of the old asbestos roofing of an industrial plant: in addition to the environmental benefit of the solar-powered plant, which saves more than 623 tonnes of CO_2 each year, this construction has ensured the redevelopment and remediation of the area.

Figure 60: The photovoltaic plant installed in the Port of Ancona

Port Network Authority of Northern Tyrrhenian Sea

The aspects of use of renewable energy sources are indicated, for the Italian port authorities, in a document required by law, art. 4-bis of law 84 of 1994 (and subsequent amendments), with the aim of carrying out planning of the port system which must respect the criteria of energy and environmental sustainability, in coherence with the policies promoted by the current European directives on the matter. The DEASP (energy and environmental planning document of the port system) of the port of Livorno indicates the following best practices to be implemented in the coming years:

- Construction of cogeneration systems.
- Production of electricity from renewable sources with small-scale systems, such as: photovoltaic systems, mini wind farms, systems that exploit wave motion
- Production of electricity with waste sources (e.g. Residual heat from industrial processes)
- Creation of systems for the recovery and reuse of refrigerants from cryogenic processes (e.g. LNG)
- Creation of accumulation systems

Which also includes actions to reduce emissions into the environment such as:

- electrification of the docks to allow docked boats to turn off their engines
- creation of incentive measures for shipowners who intend to adapt their ships to shore power supply
- efficiency and sensorisation of the lighting of external areas

Port Network Autorithy of Western Ligurian Sea

The vision and strategic objectives for an efficient energy transition of the port system can be broken down according to the different time phase of implementation, thus distinguishing between short, medium and long term objectives:

- In the short term, attention will be paid to increasing the efficiency of existing structures, to the development of energy infrastructures (including systems from renewable sources, such as solar photovoltaic on the roofs of buildings within state boundaries, but also the production experimental energy from wave motion), to the provision of "green" services connected to the storage and bunkering of technologically mature alternative fuels or to the availability of alternative energy sources (electricity for vehicles and dockside vehicles, cold ironing and LNG), the supply and reuse of excess energy and the improvement of digital and organizational processes.

- In the medium term, the transition towards a new energy system will accelerate, mainly focused on the sustainable use of energy by industrial companies located in port areas. The capacity of the energy infrastructure will be increased for electricity, but also for hydrogen and the creation of the market for the latter energy carrier through a combined strategy of blue hydrogen (at the roll-out stage) and green hydrogen (projects pilot and demonstrators, in this regard, see the FER-4 sheet), together with the exploration of technologies for the sequestration and reuse of CO_2;

- In the long term, the renewal of raw materials and the supply system will progressively materialize, allowing the large-scale supply of green electricity and hydrogen to the port industrial cluster, allowing the possible launch of innovative district heating projects that will help maximize the potential of CO_2 reduction, together with the development of recycling hubs.

Figure 61: Aerial view of the Port of Genoa

P.783 - Cold ironing Cruise terminal Port of Savona

AdSP of Genova, with the aim of improving air quality and reducing noise pollution in port areas and surrounding areas, intends to create the systems necessary for the electrical supply of ships, as envisaged by the program of interventions implementing the plan restoration and protection of air quality and for the reduction of greenhouse gases. In the port of Savona, the cruise terminal is optimal from an energy point of view, as it has no gaseous emissions of its own and integrates a photovoltaic system which reduces the environmental impact and energy of the structures but the two approaches are extremely close to the city center which is why the population is very sensitive towards the issue.

The project incorporates the service needs and defines a plant structure suitable for the present and flexible to adapt to future needs linked to the evolution of the shipping market. Objective of system is to guarantee the full operation of the ship without the use of on-board diesel generators.

The main elements of the project, which briefly describe its functioning, are the following:

- newly built 10 MW electricity supply at the conversion cabin;
- frequency conversion: necessary to convert the frequency of the national electricity grid, 50 Hz, to that used by ships, 60 Hz, using a static converter positioned in the cabin;
- distribution system: power lines that connect the two platforms to the cabin;
- land-ship connection system: consisting of a mobile structure equipped with a crane, to bring the connection sockets closer to the side of the ship.

Figure 62: The two cruise terminal at Port of Savona and its photovoltaic system

P.800 – Installation work of charging systems for mobility

The aim of the project is to define an infrastructure made up of columns equipped with charging sockets for electric vehicles, distributed at the ports of Savona and Vado Ligure, also to serve future cars electricity from AdSP itself.

The installation areas were chosen as they are located in designated areas to parking; in some cases the intervention will allow the actual installation of the column, in others cases, arrangements will be made.

The use of this technology will allow savings in emissions of polluting substances from vehicles of this type traditional and a saving of fossil fuel as the energy used will be that produced by the other Green Ports interventions planned and described below.

Figure 63: Aereal view of the terminal of Port of Vado Ligure

P.801 – Construction works of the Port Grid system

The project pursues the objective of creating an energy district that is sustainable from an environmental point of view in which the use of self-production from renewable sources is maximized and intelligent strategies for managing energy flows. The intervention involves the creation of a smart grid for the port of Savona with the aim of governing the photovoltaic production systems, storage systems, withdrawals, loads and exchanges with the public network.

The project therefore involves the installation of systems for accumulating the energy produced with photovoltaic systems and an energy control and management system to guarantee energy services. Management, as well as the adaptation of existing AdSP systems (lines, cable ducts and medium and low voltage substation components) to allow their automation/remote control.

P.802 – Construction of photovoltaic systems in warehouses in the southern embankment area and P.803 – Construction of photovoltaic systems in warehouses in area 32 of the high seabed

The interventions involve the construction of six photovoltaic systems on the roofs of a similar number of warehouses:

- P.802 – lot 1 - warehouses called T2, T3 and T4;
- P.803 – lot 2 - warehouses called T7, T8 and MLM.

The project also involves the construction of the ancillary works necessary for connection to the port network through the installation of three prefabricated cabins with the relevant components and cable ducts. The photovoltaic modules are available in two different types: latest generation "monocrystalline silicon", which guarantees a high power value and "thin film", with lighter weights than could better adapt to the buildings involved.

Port Network Autorithy of Central Northern Tyrrhenian Sea

The Port of Civitavecchia is currently the largest photovoltaic park in the area, as it contains some systems with a total power of almost 1,900 kWp. Considering an average value of the solar radiation incident on the plants, which is associated with a production of 1,242 kWh/kWp, it appears that at the date of this document, approximately 2,347 MWh/year of electricity is produced annually in the areas managed by the AdSP.

The first photovoltaic system, at Darsena Romana, came into operation in 2010 and was installed on a multifunctional building located in Darsena Romana, in the port of Civitavecchia. The plant covers an area of over 850 m2, for a total installed power of over 115 kWp; it is composed of 576 high-efficiency polycrystalline photovoltaic modules (Suntech STP 200W) with a nominal power of 200 Wp each. The conversion group consists of 2 "Sunway Tg 61 660V" type inverters, located inside the MV/LV transformation cabin serving the structure of the dock itself. The plant is also equipped with a remote control system that allows you to monitor its productivity.

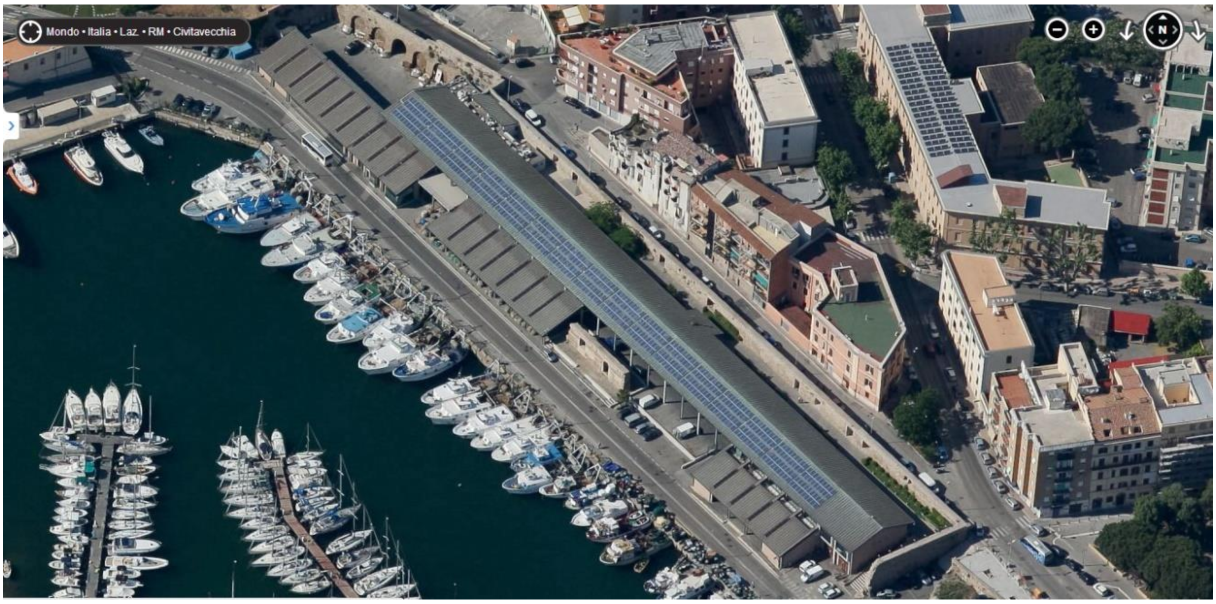


Figure 64: Tbe photovoltaic system at the Darsena Romana in Civitavecchia Port

The second photovoltaic system, at Civitavecchia Forest Fruit Terminal S.p.A. (C.F.F.T.), came into operation in 2012 and was built on the roof of a warehouse of the CFFT concessionaire (Civitavecchia Fruit & Forest Terminal - S.p.a). The plant covers an area of over 4,051 m2, for a total power of over 583 kWp; it is made up of 2,383 photovoltaic modules with a nominal power of 245 Wp each. The inverters were located inside a cabin located near the same building.

Figure 65: Tbe photovoltaic system above the Forest Fruit Terminal in Civitavecchia Port

The third plant, at Konig S.r.l., came into operation in 2012 and was built on the roof of the warehouses of the Konig S.r.l. concessionaire. (formerly Privilege Yard S.p.A.). The plant covers a total surface area of over 35,000 m2 divided into 4 sections, for an installed power of over 1,100 kWp. The system is composed of amorphous silicon modules (Unisolar Ovionic) completely integrated into the roof of the building. The inverters (Power one) were located inside a cabin located near the same building.

Figure 66: Tbe photovoltaic system on the Konig Srl building

The fourth photovoltaic system, at the meeting village, came into operation in 2017, and was built on the roof of the building used as the meeting village's infirmary. The system, made up of 60 photovoltaic modules with a nominal power of 250 Wp each, is spread over an area of over 100 m2, for a total installed power of 15 kWp.

The fifth photovoltaic system, at Roma Cruise Terminal S.r.l. (Amerigo Vespucci), came into operation in 2017, and was built on the roof of the new passenger terminal of the concessionaire RCT (Roma Cruise Terminal Spa) on platform 12 bis North of the Port of Civitavecchia. The plant will develop over an area of approximately 1000 m2, for a total power of over 75 kWp. The system will be composed of 300 photovoltaic modules with a nominal power of 250 Wp each. The inverters will be located inside a cabin located near the same building.

Port Network Autorithy of Central Tyrrhenian Sea

The Port of Naples has carried out various studies and analyzes with the aim of reducing, by using renewable energy sources, the overall weight of the port's energy consumption also to encourage the use of energy electricity at the service of moored ships, thus achieving a notable environmental benefit due to the reduction of exhaust from the combustion engines of the massively used generators, taking into account that the port of Naples is located close to the town center and constitutes an important source of pollution, of an acoustic nature and, above all, deriving from emissions of polluting substances into the atmosphere.

In particular, the objective that was intended to be achieved was the production of approximately 50÷60% of the electricity used at the time by the Port Authority of Naples (for public lighting of port areas and public services), estimated at approximately 3,000 MWh/year.

In this way it would have been possible to allocate the equivalent part of the energy supplied by the network to the future electrification of the docks, in order to allow the ships to be powered from shore during mooring (cold ironing). Significant environmental benefits would thus have been guaranteed for the port area and the urban areas adjacent to them. These environmental benefits would have been both direct, i.e. deriving from the production of electricity from renewable sources (low impact), and indirect, deriving from the future lower pollution induced by the ships' engines during their mooring.

In detail, the project concerned the construction of photovoltaic systems on the roofing surfaces of some state-owned buildings in the port area. The systems should have been built, mainly, through the use of photovoltaic panels, and in minimal part (limited to some curved roofing surfaces) by photovoltaic sheath, and would have occupied a total roofing surface of the state-owned buildings estimated at approximately 21,000 m2. Assuming that the net surface area occupied by the panels and photovoltaic sheaths was equal to 50% of the gross surface area of the roofs and that the average peak specific power between the panel and the photovoltaic sheath was 120 Wp/m2, for the system in question an overall installed power of 1,260 kWp and annual energy production of 1,500 had been estimated MWh. The project also included the construction of the connections of the photovoltaic system to the electricity grid and the necessary maintenance interventions on the roofing surfaces of the buildings to make them suitable for the installation of the same system.

Within the buildings whose roofs are available to the Port Authority of Naples, the surfaces shown in the following plans had been identified, which can potentially accommodate photovoltaic systems and which in total amount to approximately 21,000 gross m2.

Figure 67: Tbe photovoltaic system on buildings near the Port of Naples

Port Network Authority of Sardinia

The ports of Cagliari (Historic Port and Port Canal), Olbia - Isola Bianca, Golfo Aranci, Santa Teresa Gallura, Porto Torres, and Portovesme have long been interested in technologies and policies for energy efficiency and emission reduction. In particular, through PNRR funds, activities for the construction of on-shore power supply (cold-ironing) systems for the electrical supply of ships docked at the aforementioned ports have been financed. The project includes seven plants: 22 megawatts of power for Olbia; 3 megawatts for Golfo Aranci; 0.6 MW for each port at Santa Teresa and Portovesme; 15 MW for Porto Torres; 22 MW for the port of Cagliari (historic and ro-ro terminal) and another 13 megawatts for the Port Canal.

All system ports are currently engaged in a series of energy efficiency interventions based on the following activities:

- Replacement of all port lighting sources (particularly light towers) with LEDs.
- Adoption of unified power systems standardized in a few basic types.
- Definition of a management plan that allows for rationalized interventions, containing costs without compromising the quantitative and qualitative level of service.
- Energy requalification of buildings (Port Authority headquarters).

The energy requalification and optimization interventions designed for the public lighting of port areas will lead to savings of 53%, with a reduction in consumption of 2,781,636 kWh. Meanwhile, the energy requalification and optimization interventions designed for the buildings will lead to savings of 13%, with a reduction in consumption of 42,000 kWh compared to the current situation.

Figure 68: Solar panel localization hypothesis in port of Oristano

Port Network Authority of Eastern Sicily

The ports of Catania and Augusta aim not only to achieve a reduction in energy consumption through the efficiency of the building-plant system but also, and above all, to replace carbon-based energy with renewable energy sources and advanced energy carriers, thus also promoting an advantageous economic saving as well as guaranteed environmental respect. The main strategies to be implemented concern the following three themes:

- Reduction of energy consumption of vessels of all orders and grades (from large ships to small service boats).
- Reduction of energy consumption of buildings and port structures and infrastructures.
- Incentivizing the development and implementation of energy efficiency actions and energy production plants from renewable sources.

The projects currently included in the programming plans are as follows:

- Construction of plants for the production of electricity from renewable sources in the port area.
- Electrification of mooring docks in the port area.
- Development of energy generation systems through sea-engine apparatuses aimed at exploiting the wave motion of the port area.
- Project for the production of electricity from photovoltaic conversion on the available area of the port domain.
- Construction of plug-in columns for the supply of energy from photovoltaic conversion serving the electric mobility of the port area.
- Energy and environmental requalification of buildings and their facilities falling within the port domain.

In particular, the Sicily region, due to its geographical position, enjoys greater solar irradiation compared to other regions, thus it is an opportunity to exploit the solar source at a lower cost but above all with zero emissions. The Authority's program includes the construction of two plants:

a) Construction of photovoltaic systems for the production of electricity from renewable sources in the buildings of the Eastern Sicily Sea Port System Authority located at the Commercial Port of Augusta.

b) Construction of photovoltaic systems on shading canopies for the production of electricity from renewable sources in parking areas at the Ports of Augusta and Catania.

As early as 2016, canopies were installed to serve the parking lot of the AdSP headquarters in Augusta, with a roof made up of photovoltaic panels.

Port Network Authority of Western Sicily

The ports of Palermo, Trapani, and Porto Empedocle are committed to reducing environmental emissions and have planned interventions for energy efficiency. First and foremost, the project for the modernization and requalification of the Low and Medium Voltage Electrical Ring of the port of Palermo and the ports of the System has been updated. A photovoltaic system with a power of 536 MWh and a trigeneration system with a power of 260 kWe will soon be installed at the buildings and parking slots of the port of Palermo on a total surface area of 2,250 square meters. With reference to the ports of Trapani and Porto Empedocle, energy efficiency interventions linked to the Smart Port project and complementary interventions leading to a significant reduction in consumption of 20-25% over the next two years are being accelerated. Among other sector interventions, the project for the reconstruction of the new passenger terminal at Porto Empedocle stands out, which, due to energy measures and the requalification of the adjacent parking area equipped with two photovoltaic systems and charging stations for electric bikes. The AdSP is also engaged in the feasibility study and dialogue with the major players and stakeholders in the Cold

Ironing sector for its application in the Entity's ports. This technology consists of the direct supply of electricity to a ship moored in the port, allowing the onboard engine to be turned off, thus reducing or eliminating the ship's emissions. These interventions as a whole will allow the electrification of multiple berths intended for Ro-Ro ships, the main core business of the Authority. Through PNRR funding, the planned interventions are listed below:

- Palermo: New electrical system and port area lighting, including the electrification of 7 berths for a total of 32 MW.
- Trapani: Green Port intervention, including the electrification of 2 berths for a total of 6 MW.
- Porto Empedocle: New electrical system and port area lighting, including the electrification of 1 berth for a total of 3 MW.
- Termini Imerese: New electrical system and port area lighting, including the electrification of 2 berths for a total of 6 MW.

Figure 69: Solar panels on the rooftop of port of Palermo building

Port Network Authority of "Stretto"

The ports of Messina and Reggio Calabria intend to undertake the following activities to achieve more energy-efficient port management:

- Electrification of port docks - "Cold Ironing"
- Optimization of the public lighting network
- Installation of photovoltaic systems on roofs located within the boundaries
- Experimentation for energy production from marine currents

The above-mentioned interventions are expected to reduce CO2 equivalents by approximately 22,930 tons.

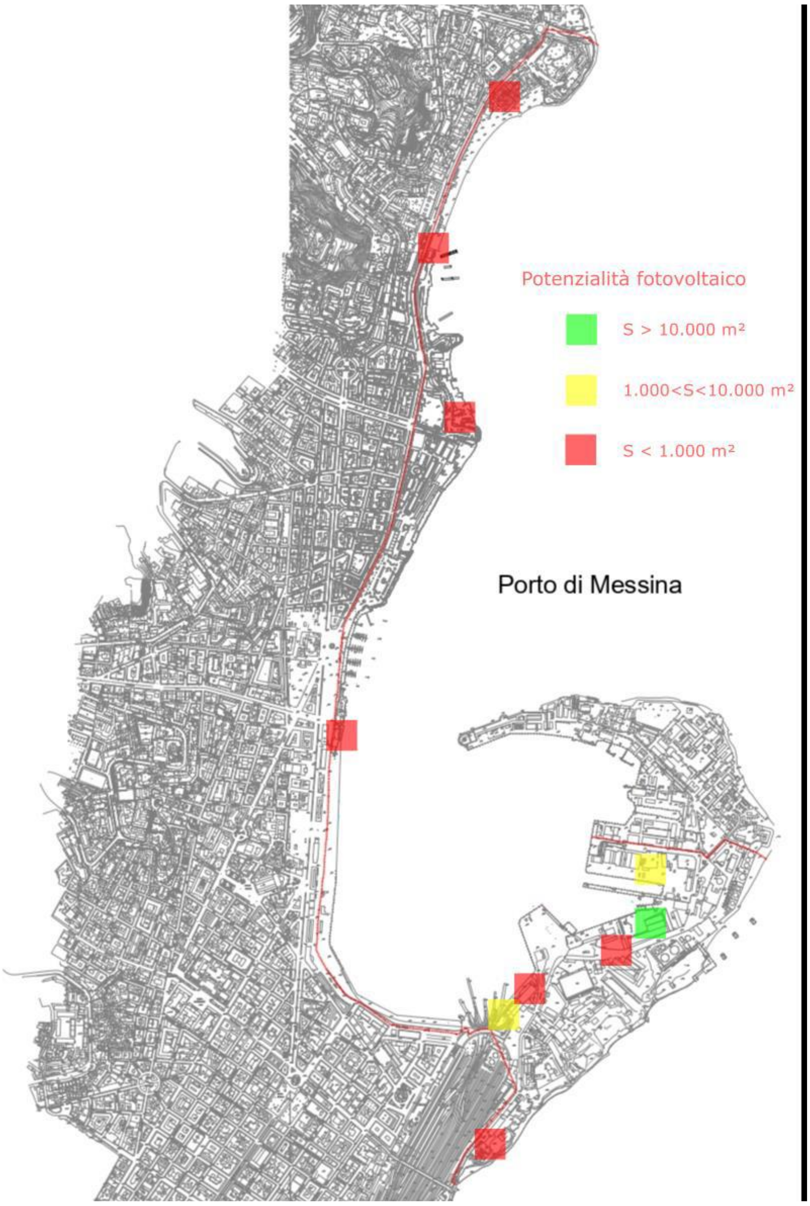


Figure 70: Map of the potential of photovoltaic systems for the port of Messina

2.2.4. Other French ports

Port of Ajaccio

In 2018, la Méridionale experimented with LNG power supply for ships at berth in Ajaccio. However, the development of this project was hampered by regulatory issues concerning LNG. In addition, Corsica's regulations on dangerous goods, which include LNG, limit its use, as its supply poses logistical problems.

2 supply methods have been considered, but are still restrictive:

- Importing LNG by ship every 2 weeks to Ile Rousse, then transporting it to Ajaccio by heavy goods vehicle (causing CO2 emissions).
- Direct transport via La Méridionale ferries, but regulations concerning the number of passengers on board put the brakes on this transit, as the number of passengers must be reduced.

Since 2017, 3 Corsican ships have been supplied with electricity from the high-voltage grid directly from the quayside in Marseille.

In 2017, Corsica was unable to connect to the grid for technical reasons, so the LNG option was considered as an alternative. Currently, Corsica is particularly keen to adapt these ships to ship shore connection for the ports hosting them. For Corsican ports, the ship shore connection project is still at the preliminary study stage.

Corsica's ADEME has launched two calls for projects to enable island ports to propose electrical connection solutions for ships. An initiative focusing on a "hydrogen ecosystem" could also lead to the ports of Bastia and Ajaccio being equipped by 2025.

Port of Bastia

These two projects, led by Corsica Energia, plan to connect ships to the quayside by 2030, thanks to the development of 2 large hydrogen power stations powered by photovoltaic cells coupled to electrolyzers producing green hydrogen. This hydrogen will then be converted into electricity by fuel cells to power ships at berth.

In addition to powering the ships, the heat and cold emitted by the fuel cells will be used to heat and cool the surrounding buildings. Any excess of green electricity will be injected into the EDF grid.

Each site would produce over 150 tons of hydrogen per year, which would be temporarily stored before being transported by truck to the ports. A 2 MW fuel cell would produce electricity, hybridized with batteries to manage power variations, and connected to ships at berth via jib cranes.

RENEWPORT | Interreg Euro-MED | Co-funded by the European Union

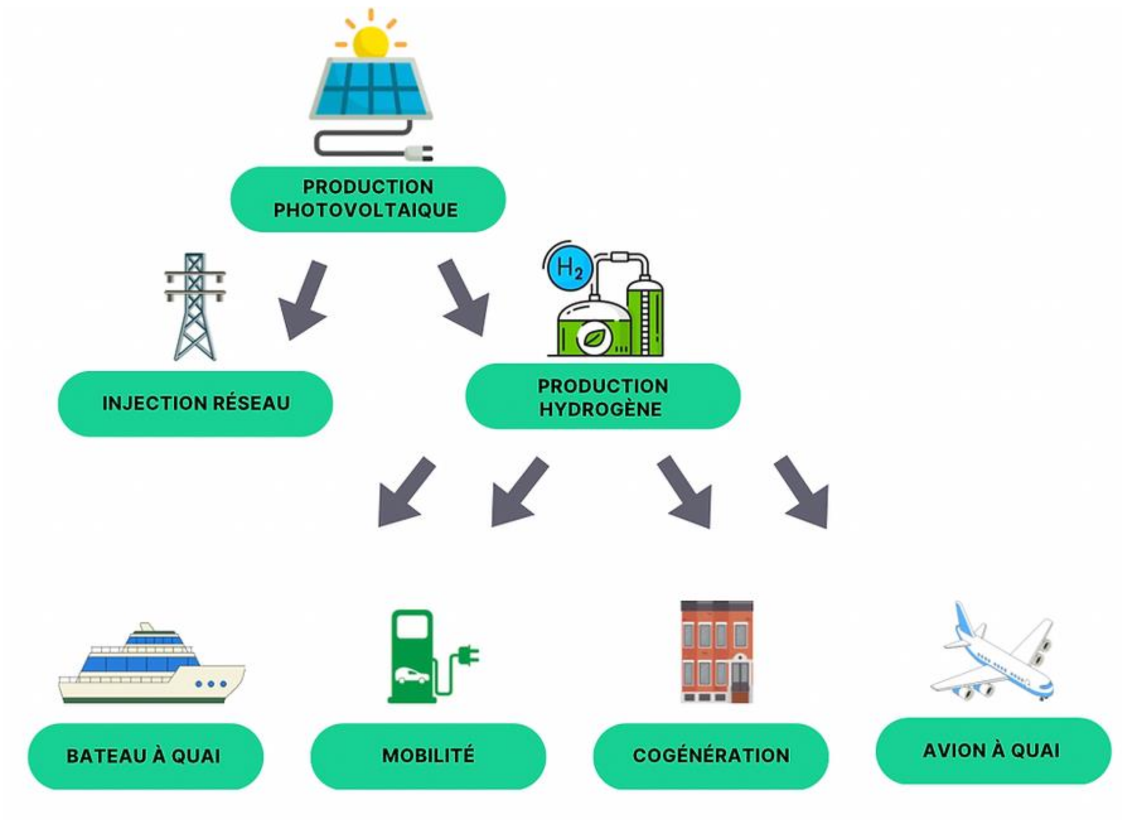


Figure 71: Representation of the distribution of energy produced

Grand Port Maritime de Marseille

The Port of Marseille Fos launched a ship shore connection in 2017. This enables ships to switch off their engines while in port, reducing pollutant emissions and noise. The first phase of development involved improvements to the port's electrical grid, enabling new delivery points to be established and electricity to be supplied to ship repair terminals and container handling equipment.

Figure 72: Shore power connection - Marseille

The Port of Marseille plans to improve this project:

Ship shore connection equipment for cruise ships at Môle Léon Gourret:

- Project to be able to connect 2 cruise ships simultaneously to the same terminal for a maximum power of 32 MW at 60 Hz.
- By 2025, all types of vessels in the port of Fos will be able to be connected (mixed cargo vessels from Corsica, ferries from North Africa, cruise ships, i.e. over 2000 addressable calls per year).

Creation of a photovoltaic power station:

- Aims to supplement the land-based power supply (Enedis) with local, renewable energy production (photovoltaic panels on 6 port building roofs producing a power output of 9MWp). The plant will be controlled by Smartgrid software.


Atelier F10
Forme 10
Poste de garde
Déchetterie
Digue Sud-Ouest

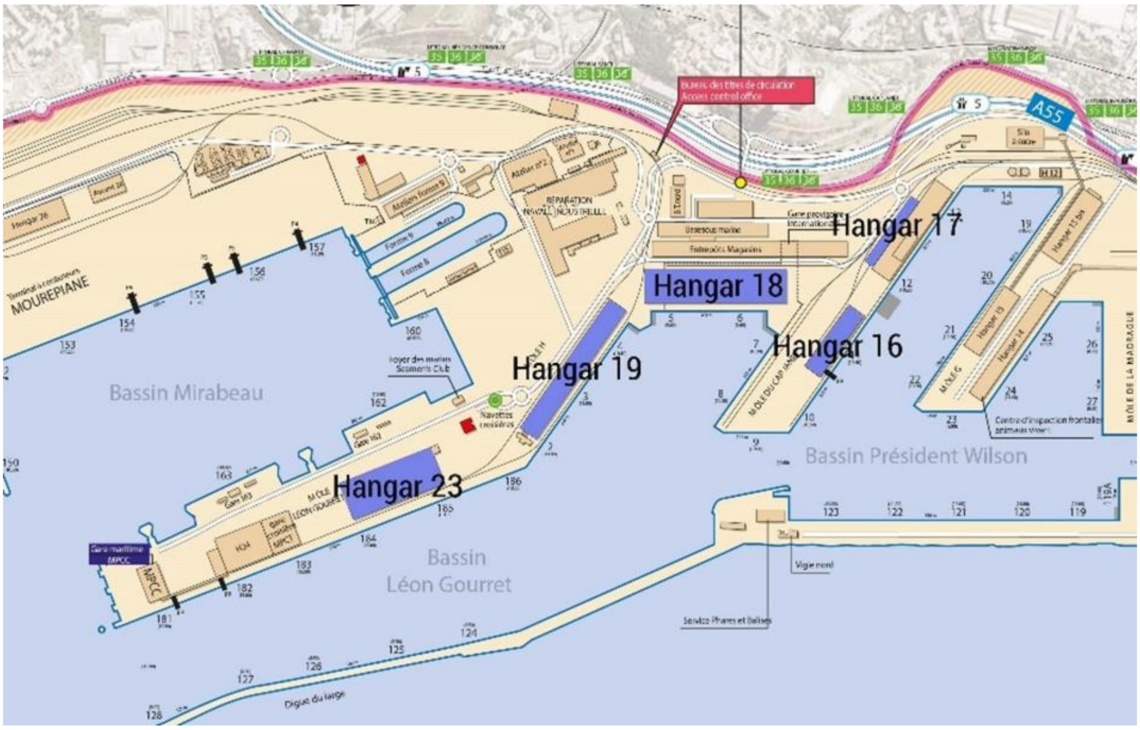

Hangar 17
Hangar 18
Hangar 16
Hangar 19
Hangar 23
Bassin Mirabeau
Bassin Président Wilson
Bassin
Léon Gourret
MOUREPIANE
A55
Digue du large

Figure 73: Areas where photovoltaic panels should be installed

Offshore Wind Development Project:

- By 2028, the Port of Marseille FOS will have developed an 80-hectare platform with a 1000-meter-long quay. It will also be able to offer storage areas afloat.
- It would be possible to install 25 wind turbines per year, requiring an investment budget of €550 million.

Figure 74: Offshore wind turbine in Marseille FOS

2.2.5. Other Spanish ports

Almería Port Authority

Photovoltaic plant of 100 kW on the Passenger Terminal of the port of Almería.

- 180 MWh of generated Energy
- Energy storage with batteries of 1,260 Ah
- Utilisation: Self consumption

Figure 75: PV plant of 100 kW port of Almeria (Source: Port of Almeria)

Málaga Port Authority

Photovoltaic plants of 250 kW on the roof of the car park canopies at he Port Authority premises.

- About 400 MWh of generated Energy

Vigo Port Authority

Photovoltaic plants of 146 kW on the Fish Market building and 40 kW at the Port Authority premises.

- 200 MWh of generated Energy
- Energy storage with batteries
- Utilisation: Self consumption

Figure 76: Photovoltaic plant on the Fish Market building. Port of Vigo. (Source: Industrias Pesqueras)

Tenerife Port Authority (comprises 7 ports in the Canary Islands)

Photovoltaic plants of:

- 210 kW in Puerto de Santa Cruz de Tenerife
- 30 kW in Puerto de los Cristianos
- 52 kW in Puerto de Granadilla
- 42 kW in Puerto Santa Cruz de la Palma

- About 380 MWh of generated Energy
- Utilisation: Self consumption

Figure 77: Photovoltaic installation of Fish Market (source: IAPH_Sustainability_Tenerife Port ZERO)

Port of Tenerife is also working on wave energy. It is managing a R&D project that consists of the development of a wave energy generation system that aims to produce electricity on a large scale and ensure high durability in the marine environment. The implementation of this wave energy production system will provide a research and development platform to verify its technical and commercial feasibility. It will collect valuable data, analyse the feasibility of the system and improve its design and operation.

Figure 78: WEC R&D system installed (source: IAPH_Sustainability_Tenerife Port ZERO)

Las Palmas Port Authority

Photovoltaic plants of:

  - 30 kW in Puerto de Las Palmas
  - 20 kW in Puerto de Las Palmas
- About 80 MWh/year of generated Energy
- Utilisation: Self consumption

Figure 79: Photovoltaic plant Port of Las Palmas – 30 kW (Source: Las Palmas Port Authority)

Figure 80: Photovoltaic plant Port of Las Palmas – 20 kW (Source: Las Palmas Port Authority)

Bilbao Port Authority

Wind plant of 10 MW at Punta Lucero pier of the port of Bilbao

- 5 wind turbines of 2 MW each
- Estimated generation of 17 GWh/year
- Utilisation: For sale inside and outside the port

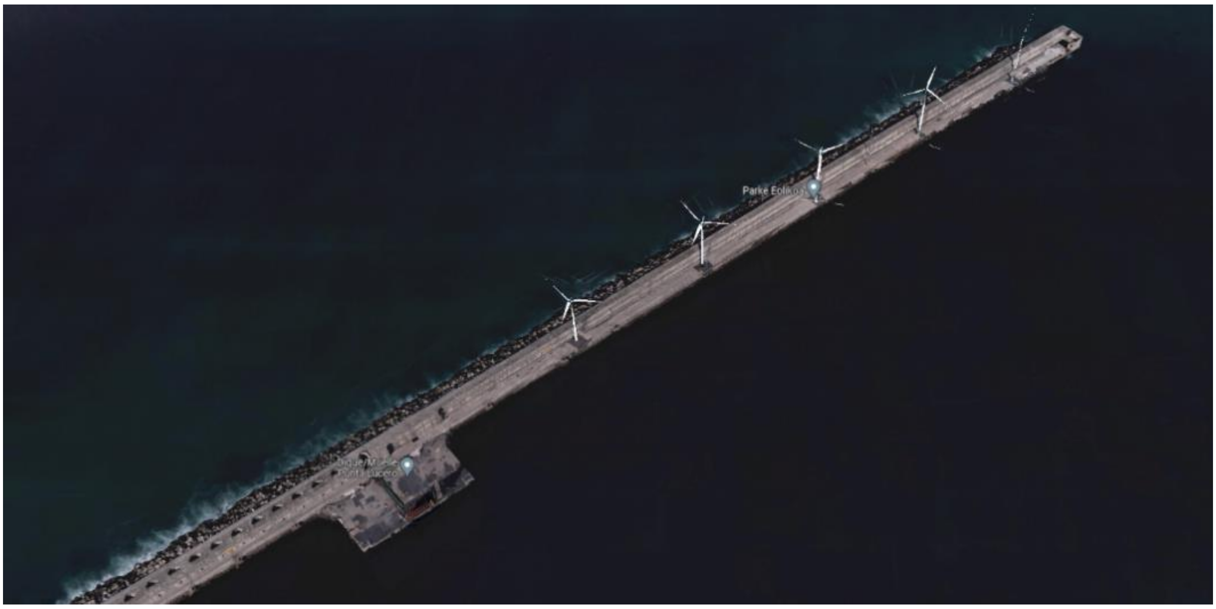


Figure 81: Wind power plant Port of Bilbao (Source: Google Earth)

2.2.6. Other Croatian ports

Port of Ploče

A photovoltaic power plant with an installed power of 190.9 kWp was built on the roof of the administration building of the entrance terminal of the port of Ploče (Croatia), during 2023 and 2024.

Photovoltaic panel with a power of 575 Wp, manufactured by EGING, model EG-580NT72-HLV, dimensions 2278x1134x30 mm, and weighing 27 kg, was used, placed on the flat roof of the building on suitable metal supports so that are inclined at an angle of 10° in relation to the horizontal surface.

A total of 332 photovoltaic panels were installed, the efficiency rate of panel is 22.25%.
The photovoltaic field is connected to two three-phase network inverters with a power of 125kW and 50kW, manufactured by SUNGROW, model **SG125CX-P2 and SG50CX-P2.**

The planned production of electricity is 222 MWh per year, which achieves a reduction of CO2 emissions by 52.1 tons per year.

Figure 82: Port of Ploče Authority headquater-before instalation

Figure 83: Port of Ploče Authority headquater – after instalation

Figure 84: Port of Ploče Authority headquater – after installation

2.2.7. Other international best practices at ports

Port of Antwerp-Bruges

Port of Antwerp-Bruges is aiming for climate neutrality by 2050. That's why the port has long since opted for RES. The port companies produce a great deal of renewable energy locally with solar panels and wind turbines. The wind turbines at the port generate power for terminals, ships and local residents in an environmentally friendly way, without burning fossil fuels.

Today, there are already a number of wind turbines in the port, and they are making a major contribution to green energy. In the port of Zeebrugge there are 50 wind turbines installed with a total capacity of 130 MW. In the port of Antwerp a total a 80 wind turbines are in operation, with a capacity of 200 MW.

Figure 85: Wind Turbines in the port of Antwerp-Bruges (source: [www.portofantwerpbruges.com)](http://www.portofantwerpbruges.com)

In the terminal of ADPO in Kallo there is a solar park with a special solar-powered technology. It is about the first concentrated solar thermal plant in Europe. Two rows of 120 parabolic mirrors convert sunlight into heat. A containerised energy storage system has been also installed and heat can be stored and used at night.

Figure 86: Concentrated Solar Thermal (CST) platform in ADPO (source: www.adpo.com/en/sustainability)

Port of Antwerp-Bruges is also making some tests with tidal energy. In 2017 the construction of a waterturbine was ordered after a public tender procedure. Previously, the port made some studies on waterflow in the existing culverts and about the behaviour on the water household at the harbour. Using 3D design, Virtual Reality, Computerized Fluid Dynamics a prototype was developed, constructed and installed in December 2018. The results of the test were much better than foreseen and the target of 100 MW was exceeded, reaching 150 MW.

Busan Port Authority

Busan Port Authority has completed one innovative project utilizing the features of sea port, called "piezoelectric power generation system". It consists of a system that uses harvesting modules to convert and store electric energy from the pressure and vibrational loads imposed by wheels of trucks passing above the system before the gate of container terminals. During 2022, the prototype of the piezoelectric power generation system has been successfully developed.

According to the result of text, the prototype module installed at one gate of container terminal is expected to generate 45 MWh/a year. If the modules are to be installed at all the 47 terminal gates in the Busan New Port, it is expected to generate 2,115 MW in total.

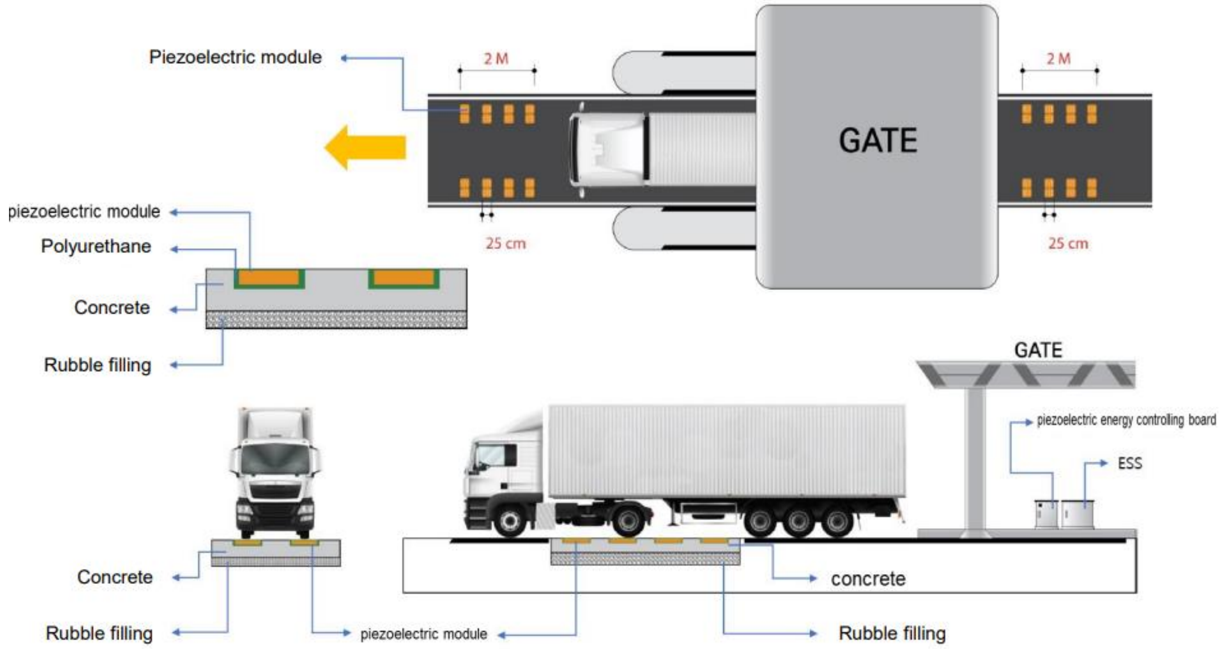


Figure 87: Conceptual overview of piezoelectric system (source: Busan-Port-Authority_Piezoelectric-System.pdf)

North Sea Port (The Netherlands)

North Sea Port and some of the companies installed in the port have already invested in renewable energy sources in the last years. They supply sustainable wind energy to the electricity grid by building wind farms and wind turbines. The port area accommodates about 100 wind turbines, which jointly generate 280 megawatts each year. In parallel, the port includes some facilities to build and maintain some wind farms working on the North Sea.

By other hand, installing solar panels and parks, the companies also generate energy that is supplied to the electricity grid. Together with the terminals located in the port, North Sea Port has embraced sustainability by locally producing green energy using existing infrastructure. They are together working on the forthcoming electrification of port equipment.

North Sea Port reached a new step on its energy transition in 2021. More than 140,000 photovoltaic panels have been installed over 2 terminals (Verbrugge Scaldia Terminals - VST and Verbrugge Zeeland Terminals – VZT). This is not the first time that North Sea Port installs panels on rooftops. The innovative elements of this project are its huge scale, the use of light weight panels to maximize capacity and the connection between the two solar parks by a high voltage cable of 1.5 kilometers. The plant has a total capacity of 50 million watts in 2021. This allows to yield more that 16 million kWh of energy a year.

Figure 88: Warehouses with phovoltaic panels (source: World Port Sustainable Program of IAPH)

Ports of Stockholm

Ports of Stockholm currently has five solar cell system installations that have a total production capacity of 995 MWh/year. These installations are distributed among four different port areas:

- Frihamnen
- Nynashamn
- Vartahamnen
- Stockholm Norvik

More than 3,400 solar panels have been installed since 2013 and cover a surface of more that 8,500 m2. The maximum power output exceeds 1 MW and the Ports of Stokholm produces almost 1 GW/year.

The most important facility is installed in the port of Norvik. This port, with a container and a ro-ro terminals, has 3,600 m2 of solar cells that have a maximum power output of 605 kW and can provide electricity up to 560 MWh annually.

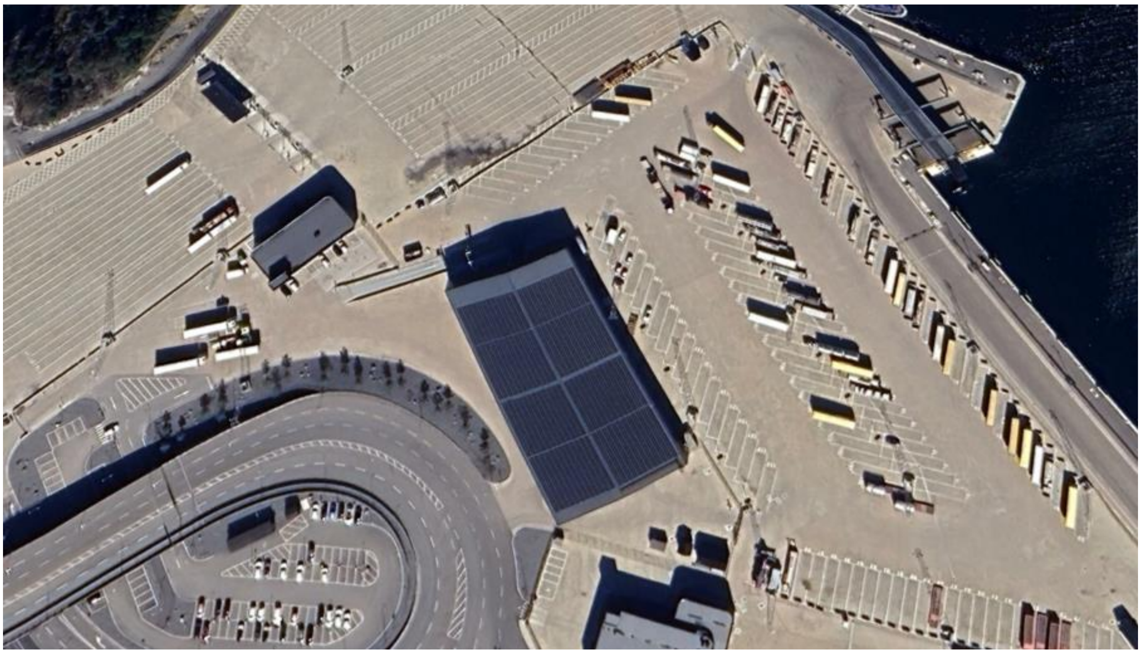


Figure 89: Port of Stockholm Norvik (source Google Earth)

Port of Hamburg

The Hamburg Port Authority (HPA) has just established a joint venture with the municipal company Hamburger Energiewerke (HEnW) to drive forward the decarbonisation of the Port of Hamburg. To this end, renewable energies such as photovoltaics and wind power are to be further expanded in the port area and renewable energy solutions are to be developed.

The Port of Hamburg has already succeeded in installing wind turbines in the particularly difficult harbour environment. This is rare in Europe and unique in Germany. The approval requirements to install wind turbines in ports are much stricter than on greenfield sites. The port has already erected six turbines in the harbour and therefore have the experience to build and operate renewable energies in this urban area.

Figure 90: Wind turbines in the Port of Hamburg (source: Port of Hamburg)

Port of Seattle

The port of Seattle has completed the installation of four solar arrays on port properties: a pilot project on a net shed at Fishermen’s Terminal, the rooftop of Per 69 (the port headquarters), and two arrays at Shilshole Bay Marina. These projects are moving the Port closer to its goal to reduce greenhouse gas emissions 50 percent by 2030, and be carbon neutral or negative by 2050 compared with 2005.

The solar projects utilize monocrystalline PV panels built in Washington state. The Port contracted with local firms to design and install the solar arrays, an investment in the local community and the economy.

The Pier 69 Solar project was completed in April 2019. The solar array was installed on the roof of Port headquarters, a three-story 191,000 square-foot structure that was built in 1931. The main facts of the project are:

- Designed to generate approximately 120,000 kWh annually, which will offset greenhouse gas emissions by about 2.0 to 2.5 metric tons CO2
- Projected to save $10,000 in energy costs per year
- The system includes 390 Washington-sourced Monocrystalline PV panels
- Total cost of $ 484,000

Figure 91: Port headquarters

The Fishermen's Terminal Solar demonstration project was completed in December 2017. Fishermen's Terminal Net Sheds 3, 4, 5, and 6 all needed new roofs, so the Port used solar in the installation of one of the roofs as a smaller-scale pilot project to test solar and gather data to inform future solar panel installations.

The project included 44 Washington-sourced solar panels on Net Shed 5. During the first year of operation, the array produced over 16,580 kWh. The cost of the project was $ 113,000.

At the end, Shilshole Bay Marina solar project was completed in October 2020. Two identical solar arrays were installed at Shilshole Bay Marina's new Central and South Customer Service Facilities. The project supposes approximately 2,000 square feet of solar array area for each building, with an estimated annual solar production capacity of 23,500 kWh.

Figure 92: Shilshole Bay Marina Customer Service facility

Port of Portsmouth

The port of Portsmouth has finalised in July 2023 the project for the installation of 2,660 solar panels. This investment provides 35% of the site's electricity. The project began with installing roof-mounted solar panels across several buildings, large battery storage and the first solar canopies at a UK port.

The solar system has a full potential of 1.2 MWp and it is complimented with an onsite battery with a capacity of 1.3 MWh. Both systems work in conjunction with each other, providing balancing services to the national grid and storing power during periods of lower pricing.

Figure 93: Solar canopies at the Port of Portsmouth

3. Methodology for the development of the RENEWPORT toolkit

3.1. Introduction

In recent years, European ports have embarked on a path of energy transition and sustainability, where the introduction of photovoltaic and wind technologies has been promoted to generate sustainable energy and thus reduce the impact of using electricity from less sustainable sources. This part of the document is reserved to the definition of the RENEWPORT toolkit. It will serve as the main document for the tender to be launched to get a company to develop the toolkit. This will take the form of a web tool to be uploaded on the project's website, that provides practical advice, guidance, information and calculation of the potential of RES use for MED ports, based on their energy needs and the geographical location. The main objective of the RENEWPORT toolkit is to facilitate easy and straightforward planning for calculating the potential use of photovoltaic and wind farms in port areas.

Currently, there are various web applications that enable the calculation of installed capacity for both photovoltaic and wind systems separately. These applications require input data such as installation area, type of technology, installation height, etc., to provide a total installed capacity value. The performance of the RENEWPORT toolkit should facilitate user access to this calculation, allowing them to input specific data for each port and perform a capacity analysis to determine the suitability of these systems for each location. Therefore, a potential user can assess the availability of both photovoltaic and wind technology at their facility by aggregating the capacities of both sources.

3.2. Toolkit's stakeholders

The potential stakeholders of the toolkit will be ports and all entities involved in their logistical activities. Therefore, both shipping companies and logistics centers, port authorities, mooring operators, terminals, tugboat operators, as well as all other companies operating within ports, will be likely to use the application.

The scope of this toolkit is focused on European ports, specifically those in the Mediterranean region initially, with the intention to expand access to ports across Europe in the future.

3.3. Data collection from port stakeholders and communication with APIs

The toolkit will require a series of input data specific to each port to calculate the output power derived from photovoltaic or wind systems.

3.3.1. Photovoltaic generation

In the case of estimation of PV potential, the online PVGIS tool, developed by the EC Joint Research Centre (https://re.jrc.ec.europa.eu/pvg_tools/en/) and, more specifically, its API, will be used.

The description of the API and the input and output data can be found in the following link: https://joint-research-centre.ec.europa.eu/photovoltaic-geographical-information-system-pvgis/getting-started-pvgis/api-non-interactive-service_en#ref-1-basics

As an example, some of the variables needed as an input are the following (for a complete list, the two previous links should be reviewed):

Location:

- Latitude: The angular distance of a location north or south of the equator, measured in degrees.
- Longitude: The angular distance of a location east or west of the Prime Meridian, measured in degrees.
- Elevation: The height above sea level of a particular location, measured in meters.
- Mounting system: The anchoring system of photovoltaic panels can be fixed or tracking.

Photovoltaic module technology:

- There are different types of photovoltaic module technologies such as Crystalline Silicon, CIS, or CdTe.
- Peak power installed (this value depends on the installation surface and the number of photovoltaic panels).
- System loss: a default value is used unless a different value is indicated.

The RENEWPORT toolkit will allow the possibility to estimate the potential PV peak power that can be installed as a function of the surface selected on a map of the port. To do so, the toolkit must allow the selection of this surface by drawing subsequent points on the GIS interface. Once the area has been selected, the estimated peak power will be calculated applying the formula that relates the peak power with the area of modules, i.e.:

$$Ppeak = Area * panel\_efficiency$$

To do so, some parameters will be needed, such as the solar panels' efficiency and the relation between the total area available and the effective area of panels that fit into that area. More information can be found, for instance, in the following link: Using PVGIS - Frequently Asked Questions - European Commission (europa.eu).

3.3.2. Wind energy generation

To calculate the estimated wind energy production at a given site, the API of the Global Wind Atlas will be used (http://windatlas.xyz/docs/api/). This API needs specific input data such as the following:

- lat: Latitude
- lon: Longitude
- date_from Inclusive start date of requested data in YYYY-MM-DD format.
- date_to: Inclusive end date of requested data in YYYY-MM-DD format.
- height: Hub height in meters.

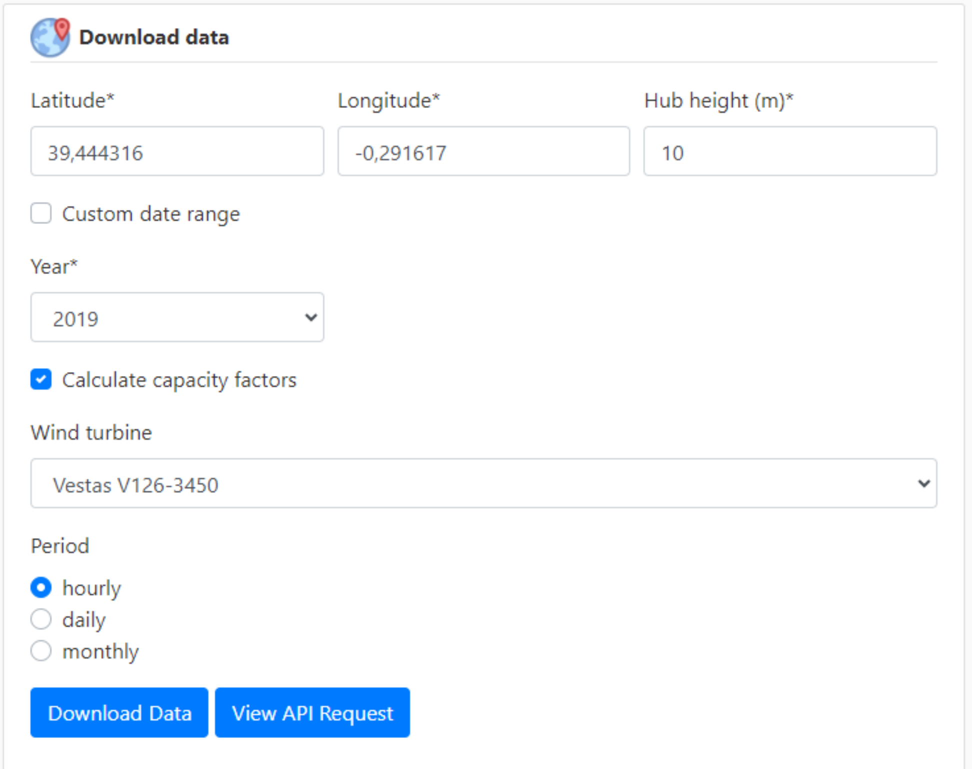


Figure 94: Example of input data to call the API.

In this case, the model of the turbine must also be chosen as an input. Therefore, the RENEWPORT toolkit will have to allow the user a selection of the model from a list, using the same models of turbines and their characteristics provided by the Global Wind Atlas tool, that can be found here: Windatlas - Wind Turbines .

The output of the API is a list of variables by each hour, for a complete year (2019, the last year with records available). The energy in KWh must be calculated as the product of the maximum nominal power of the turbine by the capacity factor (%) for each hour. Then, the energy obtained will be aggregated by month and displayed.

3.4. Toolkit functionality

The functionality of the tool is based on obtaining the necessary data to perform the photovoltaic and wind energy calculations, the calls to the corresponding APIs in order to obtain the installed power measurements, and the representation of this data independently or aggregated, with the idea of being able to have a general idea of the benefits of installing photovoltaic panels and/or wind turbines.

To perform these calculations, it is necessary to integrate a map so that the user can select the location of the port to be studied and extract the latitude, longitude, and elevation data. An example could be Google Maps API, Leaflet, Mapbox OpenLayers or Openstreetmap. This will be useful for both photovoltaic and wind energy cases.

Once the point where the installation would be made is selected, it should be possible to choose whether the calculation will be for photovoltaic or wind energy. Once the type of calculation is selected, the other necessary variables must be entered to perform the calculation. After all the data is entered, the user should press a "Calculate" button to have the application send the request to the corresponding API and obtain the calculated data.

Once the data is obtained, it should be graphically represented, showing a monthly estimate of the energy production for one year, by each installation and also aggregated. Each query, whether for wind or photovoltaic energy, should be saved in the user's session. Additionally, it should be possible to select these queries in the results panel to study how the installed power varies when installing turbines or photovoltaic panels in different locations within the port. Each turbine has a nominal power and the API gives the capacity factor in the desired installation area therefore the toolkit has to calculate energy produced by hour and aggregate it by month.

Datetime	Wind_speed	Capacity_factor
2019-01-31	9.07	0.54
2019-02-28	8.87	0.47
2019-03-31	10.91	0.57
2019-04-30	8.41	0.53
2019-05-31	7.24	0.4
2019-06-30	7.74	0.42
2019-07-31	7.04	0.37
2019-08-31	7.34	0.4
2019-09-30	9.56	0.6
2019-10-31	10.26	0.68
2019-11-30	9.73	0.61
2019-12-31	11.34	0.65

Vestas V110-2000 thewindpower

Power: 2000.0 kW

Diameter: 110.0 m

Power per swept area: 210.5 W/m^2

Figure 95: Vestas V110-2000 specifications

3.5. Information shared by the toolkit

The information that will be shared by the tool will be that related to each case study that the user wishes to enter. Therefore, for both the photovoltaic and the wind part, the results obtained by the user can be displayed or downloaded in CSV or JSON format, or PDF documents with graphics and statistics.

3.6. System Architecture

3.6.1. Architecture overview

The architecture proposed for the tool will be composed of a database which will contain all the information necessary for queries to the APIs of external tools, a backend responsible for performing the necessary functions to obtain, calculate and manage the application's data, and finally a frontend responsible for visualising the data obtained and the different web visualisation modules.

3.6.2. Front-end

The frontend will be in charge of generating the GUI of the tool. The GUI is intended to be friendly and simple, with tips and basic information that can facilitate its use to the end user.

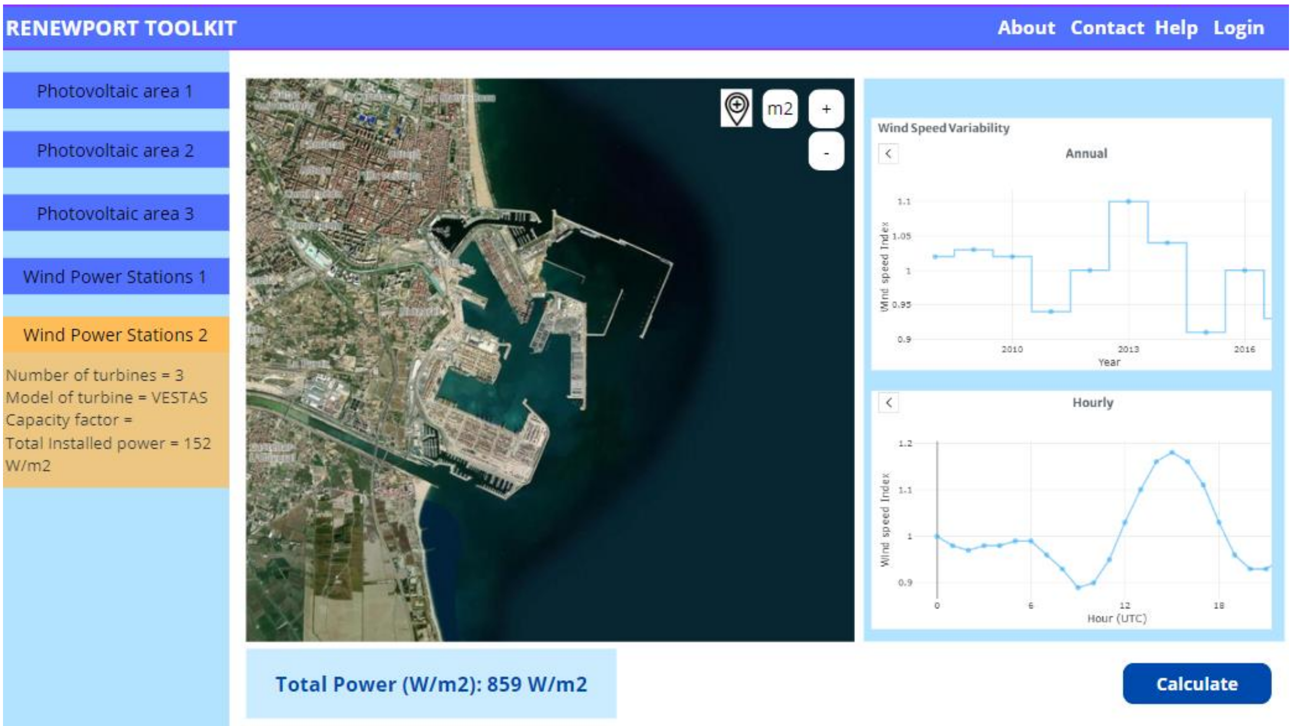


Figure 96: Example of proposed Angular Frontend

The desired framework must be Angular, using NodeJS as runtime environment.

Results will be displayed in the frontend, and also available for download in csv and json formats, and also as pdf reports, very similar to the results obtained when using the PVGIS tool (see an example in the next Figure). The graphs produced should be also available for download in PNG format, similar to the PVGIS tool results' interface.

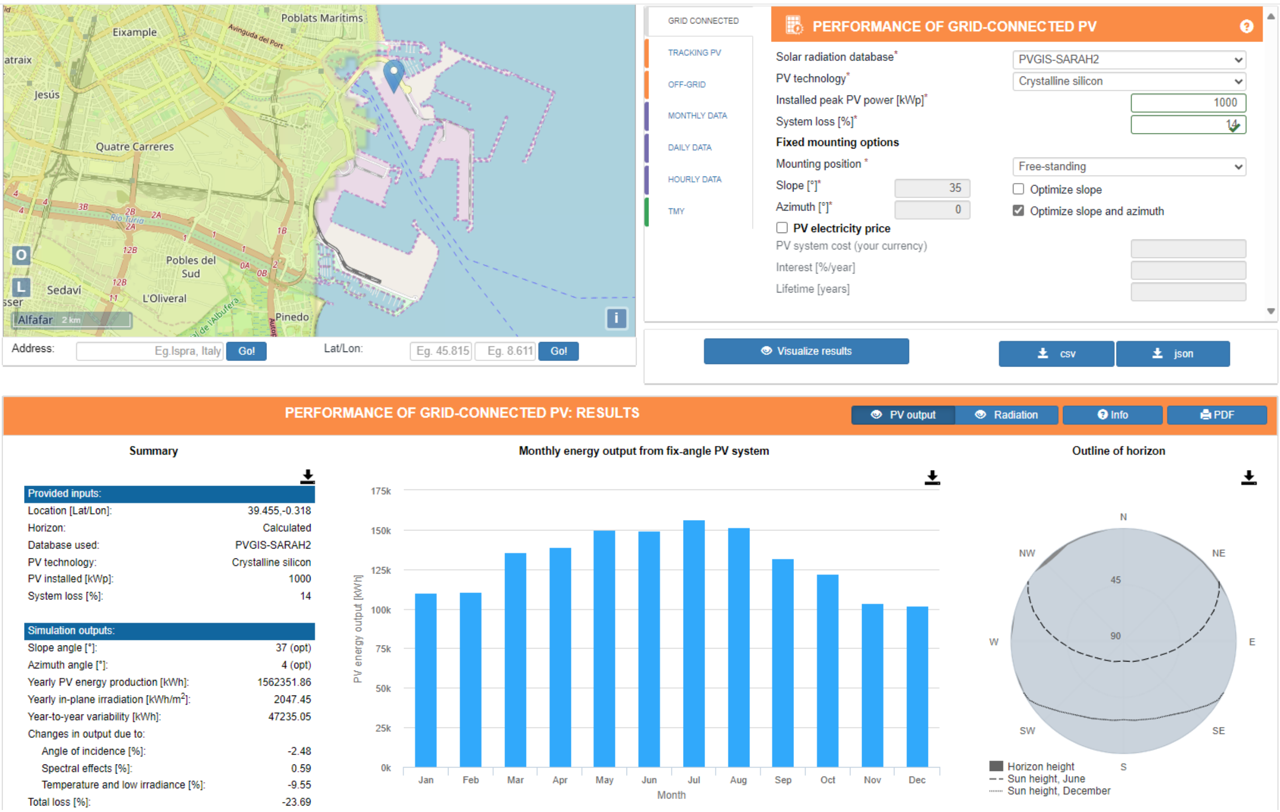


Figure 97: Example of results' interface in PVGIS

The frontend must include mention to all the APIs used in its development, and specifically references to Global Wind Atlas and PVGIS, as indicated in their respective sites, https://globalwindatlas.info/es/about/TermsOfUse and Photovoltaic Geographical Information System (PVGIS) - European Commission (europa.eu).

3.6.3. Backend

The backend will be in charge of receiving the requests and managing them, the programming modules must be able to manage queries for both photovoltaic and wind calculations. Once the input information has been collected, the call to the corresponding API must be made, which will calculate and return the calculated data. Once the data has been obtained, the information must be prepared so that the frontend can retrieve it and carry out the visualisation tasks.

The desired framework must be Django/Flask if Python is preferred or NodeDJ with typescript.

Additional programming will be needed for the special case when the GPS coordinates entered by the user are not recognized by the PVGIS or Global Wind Atlas APIs. This can happen because the selected area might be assigned to a sea, offshore region. In this case, a search algorithm should reallocate the coordinates to the nearest GPS coordinates that can be identified by the API. This can be done by implementing an iterative k-Nearest Neighbor algorithm, such as the one that can be found in the following link: https://kandi.openweaver.com/codesnippet/Find-Distance-to-Nearest-GPS-Coordinates-Nearest-Neighbors-Search--4592868945950067.

3.6.4. Database

Ideally, MongoDB will be used (other NoSQL platforms could be discussed). The models must ensure the correct data management and authentication.

3.7. Security

At the security level, a certificate policy must be established for the interconnection of the different hosts or services, since the tool will be public, all the necessary security measures must be guaranteed in order to face possible cyberattacks.

3.7.1. Roles and Permissions

The toolkit will allow access to all internet users so that they can make use of it, lower level records will not be persisted in memory. On the other hand, the toolkit will allow the creation of identified users, for these users it will be necessary to manage the history of queries and approaches made. In this way, it will be possible to retrieve information over time and also to modify the data of a specific query. In addition to these two levels, an administrator level will be created, which will have access to all the searches and proposals that have been made by each of the users, and will also have access to the elimination, creation and modification of level 2 users.

3.7.2. Infrastructure

The infrastructure of the toolkit will be built following a containerization model, allowing the use of Kubernetes clusters, Docker Swarm, Ranger, etc. Additionally, the source code of the different components must be provided for future expansions and improvements. The intellectual property of the code will be shared.

3.8. Testing and evaluation

3.8.1. Unitary test

Unitary test must be implemented to verify correct operation. To this end, it is proposed to carry out a test pipeline that checks each of the modules involved in the data calculation process.

3.8.2. KPIs

3.8.2.1. Availability and user's load 99%

The application must be available 99% of the time and be able to support user loads of about 100 users per hour. Although it does not follow a very exhaustive SLA regime, the deployment and restart of the application must be simple, always persisting the data so as not to lose the information.

3.8.2.2. Accuracy and efficiency

The data provided by the application have to be validated by comparing its results with operational photovoltaic and wind real plants. A sufficient efficiency must be respected so that the user does not have to wait a long time to obtain the requested data, maximum of 30 second per call.

3.8.3. Test cases and scenarios

Test cases related to each component and system behaviour.

Photovoltaic test case: A test case will be carried out in an area where a real photovoltaic plant is installed, in order to verify that the data supplied by the application is within the range of +-3% of the real data of the real photovoltaic plant.

Wind test case: A test case will be performed in an area where a real wind turbine is installed, in order to check that the data provided by the application is within +-2% of the real data of the real turbine.

3.9. Toolkit's implementation timeline

The estimated timeline for the project has to be 5 months (4 months of development + 1 of test with stakeholders). The bidder must submit a project implementation plan with detailed phases and action points for implementation.

3.10. Version and maintenance

The project will end when the toolkit has passed all the test cases and scenarios. The maintenance is in charge of the FV.