Carbon Footprint of the Port of Monfalcone

Based on the Year 2019

Drafted by: Port Network Authority of the Eastern Adriatic Sea in collaboration with Municipality of Monfalcone

Alberto Cozzi (alberto.cozzi@porto.trieste.it),

Rada Orescanin (Rada.Orescanin@comune.monfalcone.go.it)

Project Partner: PP5

Date: 30 October 2020

CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS

ADSP MAO	Port System Authority of the Eastern Adriatic Sea
AD	Active Data
CH_4	Methane
CO_2	Carbon Dioxide
DEASP	Guidelines for the preparation of Environmental Energy Planning Documents for Port Systems
EEA	European Environmental Agency
EF	Emission Factor
EMEP	European Monitoring and Evaluation Programme
GWP	Global Warming Potential
GHG	Greenhouse Gas
HFCs	Hydrofluorocarbons
IPCC	Intergovernmental Panel on Climate Change
ISPRA	Istituto Superiore per la Protezione e la Ricerca Ambientale
LHV	Low Heating Value
LPG	Liquefied Petroleum Gas
N_2O	Nitrous Oxide
N_2OR	Nitrous Oxide Reductase
NF_3	Nitrogen trifluoride
POD	Point of Delivery
SF_6	Sulphur hexafluoride
TIR	Transports Internationaux Routiers
TJ	Terajoule
UNFCCC	United Nations Framework Convention on Climate Change

1 INTRODUCTION

The Port System Authority of the Eastern Adriatic Sea (hereinafter AdSP MAO) has prepared this study called “Carbon Footprint” relating to the Port of Monfalcone and referred to the base year 2019, in implementation of art. 5 of Legislative Decree 169/2016, and of the “Guidelines for the preparation of Environmental Energy Planning Documents for Port Systems” (DEASP). To this end, the methodologies envisaged by the technical standards ISO EN UNI 14064, the IPCC 2006 Guidelines, EMEP/EEA 2016, the ISPRA National Greenhouse Gases Inventory Report 2019 and the Port Emission Toolkit Guide No. 01 - Assessment of port emissions - have been adopted.

The choices, procedures and results of this study will be illustrated in the rest of this document.

In order to determine greenhouse gas emissions in the Port of Monfalcone, a data collection system was created, aimed at all port users, represented by two online questionnaires developed on the Open-Source platform called “Limesurvey”. One is referred to port users such as terminal operators, entities or activities authorised to access the port and one is specific for road hauliers.

The process of gathering all information took place with the aid of a “Technical Support” activated by the same Port System Authority of the Eastern Adriatic Sea through direct meetings, public dissemination presentations, via telephone and close connection with port users.

In the opening period of the survey, the data relating to most of the users was collected and the overall feedback of completed questionnaires was well above 70%, in addition to a further 7% of users who answered the questionnaire only partially. The remaining users who did not join the survey are mainly represented by companies authorised to carry out port operations or services pursuant to art. 16 of Law 84/1994, as amended, or companies enrolled in the specific register pursuant to art. 68 of the Navigation Code carrying out occasional activities or even non-active during the year 2019. There are also some small concessionaires and some institutional bodies.

In this way, consumption data and the number of accesses (for road hauliers) were collected, and the calculations aimed at determining greenhouse gas emissions in terms of CO_2 equivalent were developed using the appropriate emission factors and GWP (*Global Warming Potential*) indices.

These assessments were carried out with the formulas and methods defined by the technical standards ISO EN UNI 14064 and the aforementioned Guidelines, starting from the activity

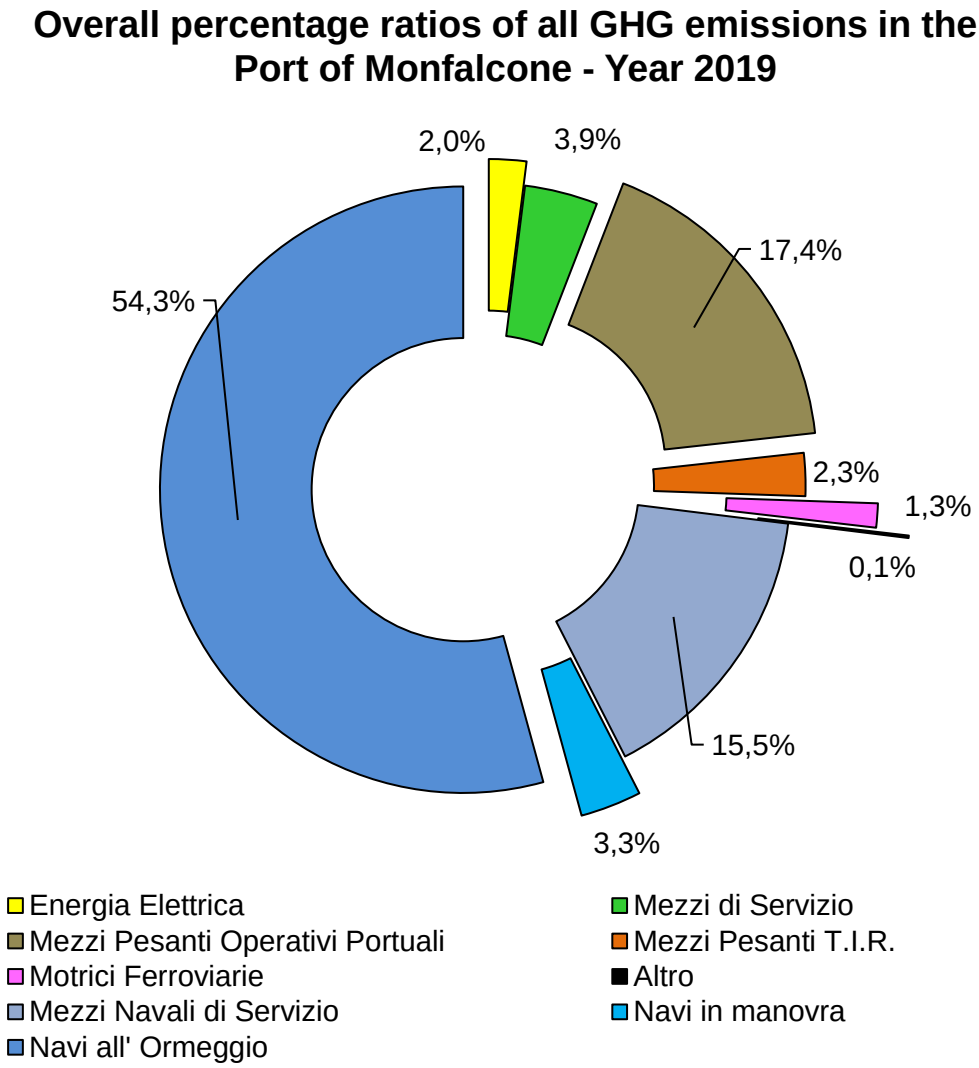
data communicated by users (Tier 3) and using the values of the Emission Factors defined by ISPRA in the document “Italian Greenhouse Gas Inventory 1990-2017 - National Inventory Report 2019” (Tier 2) to determine CO_2 emissions, while to calculate the emissions of CH_4 and N_2O, the emission factors defined by the IPCC 2006 (Tier 1) were considered, as they were not provided by ISPRA.

For the calculation of the emissions referred to the category of road hauliers, the “COPERT” software was adopted, which represents the European standard for calculating vehicle emissions. This calculation method is one of those accepted and envisaged by the DEASP Guidelines.

The conversion values for calculating CO_2 equivalent or the GWP (Global Warming Potential) indices, adopted to “normalise” Greenhouse Gases other than CO_2, on the other hand, are those defined by the “5th Assessment Report of the Intergovernmental Panel on Climate Change” (IPCC).

The following graph summarises the results of the calculations (in percentage terms), divided into categories of emitting objects.

2 VEHICLE TYPE



Electric energy	Service vehicles	Port Heavy Vehicles
Heavy trucks (TIR)	Railway engines	Other
Service vessels	Manoeuvring ships	Moored ships

Figure 1 - Overall percentage ratios of all GHG emissions in the Port of Monfalcone - Year 2019

The results of the study show that most of the emissions are due to maritime traffic. Indeed, if we add up the emission components due to moored ships, ships in manoeuvre and naval service or support port vehicles, we reach 73.1% of the total emission of greenhouse gases.

In particular, a substantial share is due to bulk carriers and general ships, which are those with the greatest number of calls.

The second overall emission source is that constituted by heavy port vehicles (stackers, port tractors, forklifts, etc.).

On the other hand, heavy goods vehicles (T.I.R.s) represent only 2.3% of the emission of greenhouse gases within the port of Monfalcone.

In this regard, the graph below shows CO_2 emissions produced by road freight and calculated using the COPERT Software. The emissions are divided by type and vehicle size.

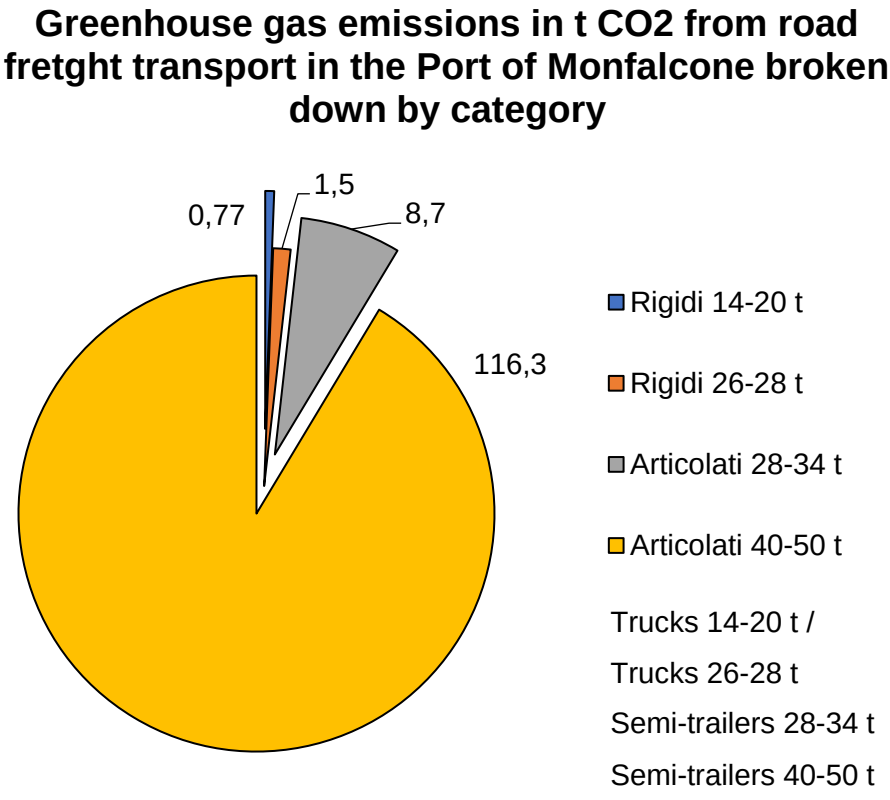


Figure 2 - CO_2 emissions from to road freight transport obtained from the COPERT Software and broken down by vehicle type

3 TYPE OF EMISSION

The Guidelines for the preparation of Energy-Environmental Planning Documents for Port Systems - DEASP identify the following greenhouse gases:

- Carbon dioxide (CO_2)
- Methane (CH_4)
- Nitrous oxide (N_2O)
- Hydrofluorocarbons *(HFCs)*
- Perfluorocarbons *(PFCs)*
- Sulphur hexafluoride (SF_6)
- Nitrogen trifluoride (NF_3).

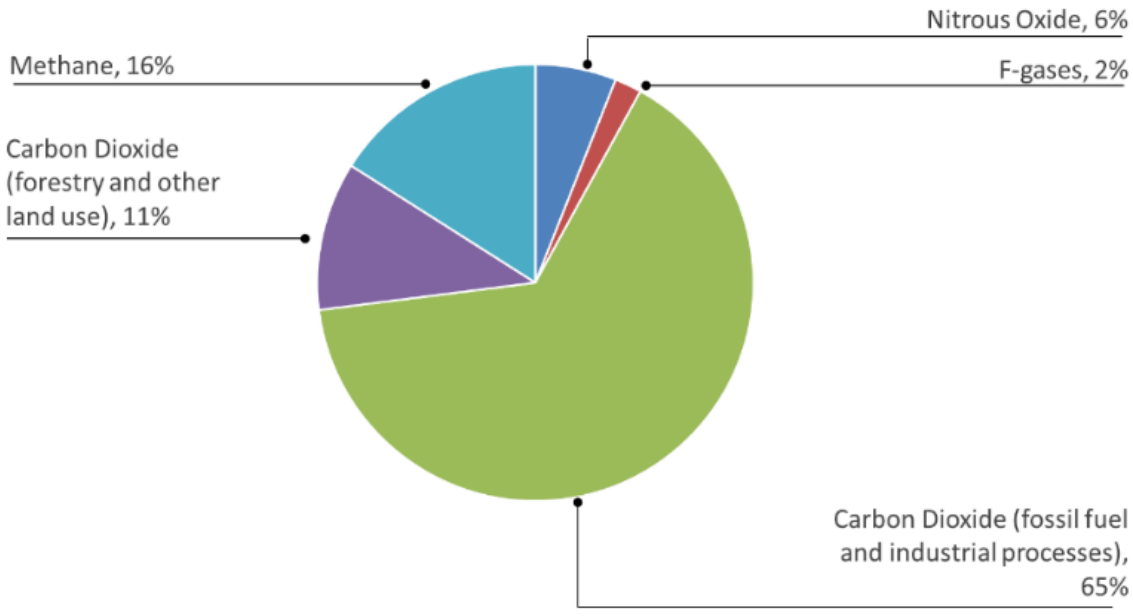


Figure 3 - Graph with the breakdown of the main gases responsible for global greenhouse gas emissions - data source: IPCC

Carbon dioxide, methane and nitrous oxide are present in nature but humans, with their activities, increase their presence in the atmosphere, destabilising the delicate balance of the system. Human intervention in the production of these gases is represented by processes or activities such as combustion, industrial transformation, or the use of land for agriculture, livestock and landfills. On the other hand, fluorinated gases, called “F-gases”, are exclusively

of anthropogenic production and are not found in the natural state. Their use as refrigerant fluids or as propellants is being progressively reduced thanks to their replacement with other gases that have less impact on climate change.

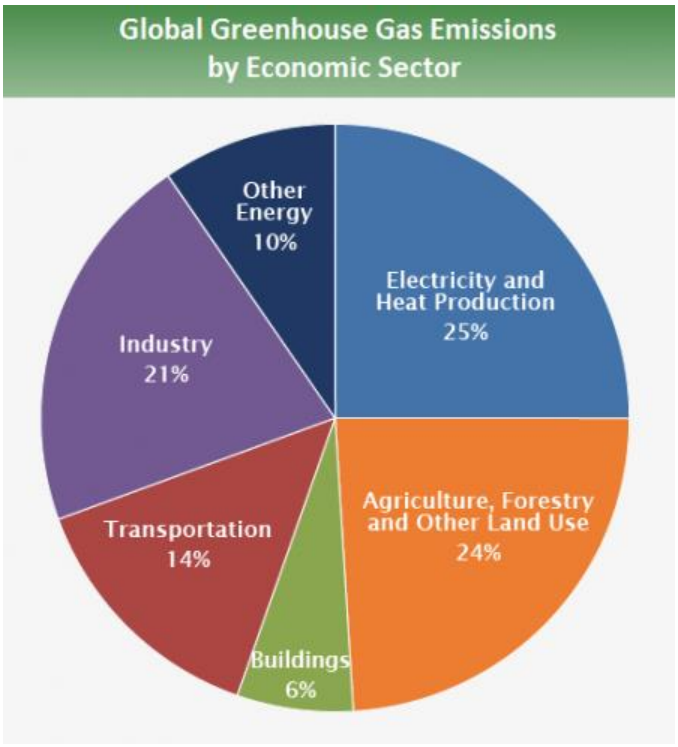


Figure 4 - Graph of greenhouse gas emissions by economic sector - data source: IPCC

However, fluorinated gases have a much higher greenhouse effect than the standard CO_2 effect and they are still used as refrigerants, propellants and solvents *(HFC),* in industrial processes and fire prevention systems *(PFC)*, but also as insulators in electronics (SF_6) or in the production of microcircuits and photovoltaic cells (NF_3).

The 5th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) has prepared conversion coefficients between the various gases called Global Warming Potential (GWP). These indices represent the ratio between global warming caused in a given period of time by the various greenhouse gases identified by the UNFCCC (United Nations Framework Convention on Climate Change) and the warming caused by the same amount of carbon dioxide - CO_2 - used as a reference and measurement unit.

Table 1 - GWP indices of some greenhouse gases - source: IPCC 5th Assessment Report

Greenhouse Gas	Symbol	GWP value (5th Assessment Report) at 100 years
Carbon dioxide	CO_2	1
Methane	CH_4	28
Nitrous oxide	N_2O	265
Sulfur hexafluoride	SF_6	23,500
Nitrogen trifluoride	NF_3	16,100
HFC 23	CHF_3	12,400
HFC 125	CHF_2CF_3	3,170

Table 1 shows, by way of example, the GWP indices of the main gases responsible for the "Greenhouse Effect" referred to an impact time of 100 years. This period is considered a standard time in the IPCC reports and has therefore been taken as a reference also in the calculations referred to in this report. This enables a normalisation of the results for possible comparison with other similar studies.

The goal of the calculations is determining the CO_2 eq, adopted as a reference and measurement unit of the greenhouse effect.

4 GEOGRAPHICAL COVERAGE

The plan representing the Port of Monfalcone.

Figure 5 - Territorial area of the Port of Monfalcone (solid blue line) as defined by the Urban Plan of the Port of Monfalcone at the time of the transfer of responsibilities from the FVG Region to AdSP MAO

5 INVESTIGATION PERIOD

The survey and data collection concern the year 2019. For this year it was possible to collect the necessary data in full, facilitating subsequent comparisons with similar studies that will be carried out in the years to come.

6 IDENTIFICATION OF THE METHODOLOGY FOR COLLECTING INFORMATION AND DATA FROM THE EMISSION SOURCES

6.1 CALCULATION OF THE EMISSION DUE TO COMMERCIAL LAND TRAFFIC

With regard to commercial land traffic, or goods handled by heavy road vehicles (trucks) to and from the Port of Monfalcone, the emission of the various gases was calculated based on the number of transits and by type of vehicle, using the European "COPERT" software that performs the classic calculations with emission factors once the previously acquired data in terms of consumption have been entered.

6.2 METHODOLOGY FOR CALCULATING THE EMISSION OF GREENHOUSE GASES DERIVING FROM COMBUSTION

The following formula is used in all the texts taken as reference:

$$\boldsymbol{Emission_{(g,s,f)} = AD_{(s,c)}\ x\ EF_{(g,s,c)}}$$

which evaluates the emission (quantity) of "g" gas, produced by a certain emission source "s", from fuel "f".

The value AD or Activity Data is the information relating to the activity (more simply the total consumption or the energy produced), referring to a certain time period within which the activity under analysis takes place, of a certain fuel "f", used by the emission source "s".

The coefficient EF or Emission Factor quantifies the emission (or removal) of the gas "g" analysed, referring to the AD activity taken into consideration, at the source "s" and for a certain fuel "f". These coefficients are measured, updated, and collected in tables made available by various institutes such as ISPRA, IPCC and EMEP/EEA. The Emission Factors used approximate the carbon oxidation coefficient to 1. This approximation is acceptable, considering that on average the quantity of non-oxidized carbon represents less than 1% of the total.

This is envisaged by IPCC 2006: "Guidelines for National Greenhouse Gas Inventories", which read: "CO_2 emissions depend almost entirely on the carbon content of the fuel, though a small amount of carbon is un-oxidized (less than 1%) … During the combustion process, most carbon is immediately emitted as CO_2 regardless combustion technology … By default, the 2006 IPCC Guidelines assume a complete combustion process (100% carbon conversion or oxidation fraction is 1)".

Having verified that almost all tabulated EF coefficients are given in terms of tons of CO_2 for each TJ (Terajoule) of fuel (instead of the quantity of fuel), it was necessary to use the LHV (Lower Heating Value) as well as the standard densities for liquid and gaseous fuels, in order to preliminarily transform the consumption of a certain fuel into energy produced by its combustion.

Indeed, in order to obtain the energy expressed in TJ it is necessary to multiply the quantity of a certain fuel consumed, expressed in kg or tons, by the LHV (Lower Heating Value), expressed in TJ per ton.

The density and lower heating value parameters were also obtained from official ISPRA or IPCC publications.

From the multiplication of AD expressed in TJ by the corresponding coefficients EF, expressed in t CO_2eq for each of the three gases produced (Carbon Dioxide, Methane and Nitrous Oxide), the Emission value (quantity) of the 3 gases considered is obtained, referring to the type of fuel, the specific emission source, and the reference period.

These quantities of greenhouse gases emitted are converted into CO_2eq via GWP indexes (Global Warming Potential, taken from the document "AR5" issued by the IPCC. The amount of CO_2eq calculated, therefore represents the overall emission of greenhouse gases originating from the consumption of fuels in the geographical area (port area) and time (year 2019) considered.

This method was used for all emissions linked to combustion, parametrising the consumption data with the corresponding Emission Factor referred to the particular emission source.

6.3 METHOD FOR CALCULATING THE EMISSION OF GREENHOUSE GASES DERIVING FROM ROAD FREIGHT TRAFFIC

The calculation of the emissions from freight trucks (TIR) transited in the Port of Monfalcone area during the year 2019 was carried out by collecting information on consumption (general questionnaire) and on the number of transits (truckers' questionnaire and interviews).

For port users not registered as road hauliers, owning and using heavy means of transport for goods within the port area, the greenhouse gas emissions were calculated using the methods and formulas described above, starting from the consumption declared in the general questionnaire.

On the other hand, for road hauliers the greenhouse gas emissions were calculated using the COPERT software with Tier 3 detail, by entering the transit data, vehicle type and EURO category. This data was collected through the questionnaire dedicated to them.

7 LAND EMISSIONS FROM THE PORT OF MONFALCONE

This paragraph reports the results of the study carried out on the greenhouse gases emitted in 2019 as a result of direct and indirect consumption in the port area, as defined by the Urban Plan of the Port of Monfalcone, with the exception of activities located at sea (ships, service boats, pleasure boating, etc.). To this end, the study has considered all emissions of direct competence of AdSP MAO, its subsidiaries, concessionary users, tenants or terminal operators, institutional public bodies present in the port area and subjects carrying out port services and operations, pursuant to article 16 of Law 84/1994, as amended, or art. 68 of the Navigation Code. Therefore, this excluded large maritime traffic, small service port maritime traffic and recreational boating were excluded and will be analysed later.

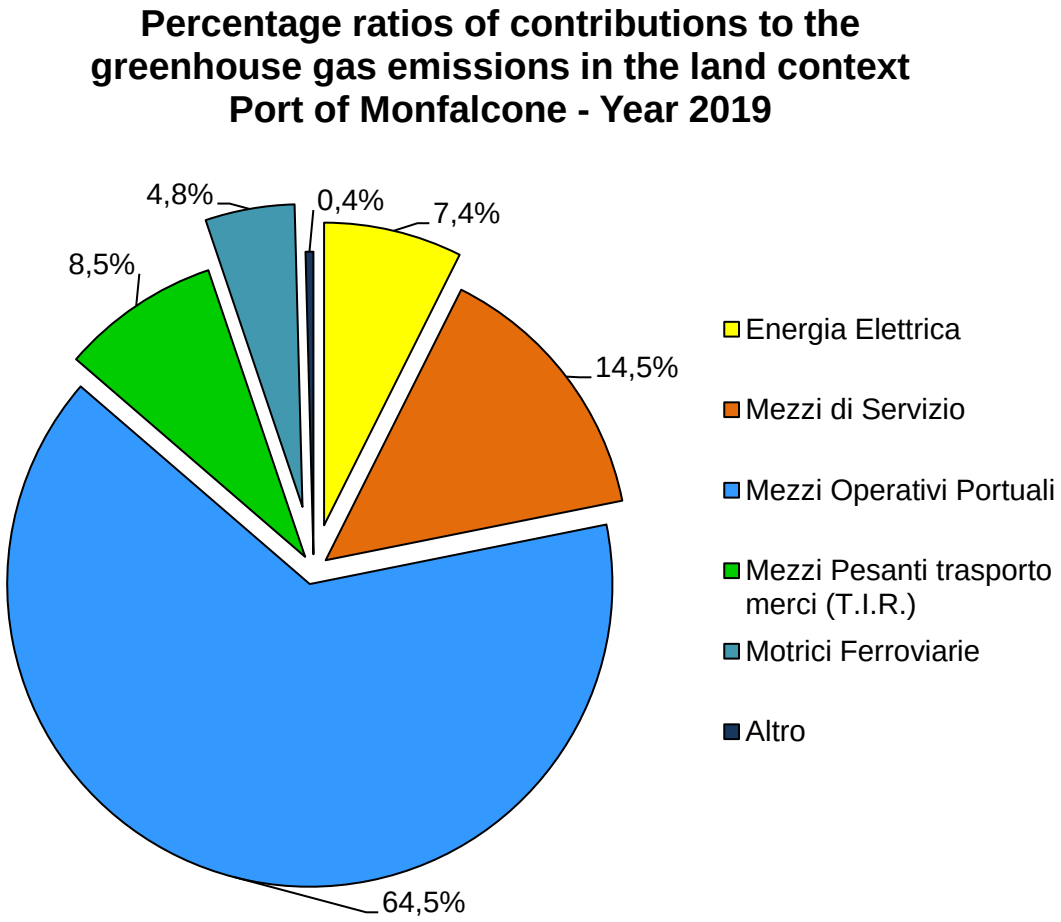
Table 2 - Quantity of greenhouse gases (in t CO_2eq) emitted on land in the port of Monfalcone, in 2019

Summary of the contributions of the Port of Monfalcone to the production of Greenhouse Gas on land in 2019		
	t CO2 eq	**%**
Electric energy	386.3	7.4%
Service vehicles	755.0	14.4%
Port Operating Means	3,368.7	64.4%
Heavy goods vehicles (TIR)	443.4	8.5%
Railway engines	249.1	4.8%
Other	21.7	0.4%
TOTAL	5,224.3	100%

The source of the data and the calculation methods of the various emission categories are summarised below:

- Electricity: collection of the declarations of the (Point of Delivery) POD readings of the various users.
- Heating: Calculations based on the data provided by users relating to the consumption of fuels burned in heat generators for air conditioning in the workplace.

- Service vehicles: Calculations based on user declarations referring to the consumption of fuel for transport in the port area.
- Port Heavy Vehicles: The means of transport used in carrying out typical port activities, such as: stackers, excavators, forklifts, port tractors, etc. Also, in this case we based our calculation on the statements provided by the users through the questionnaire.
- Heavy Vehicles (TIR): This category includes emissions from trucks passing through the port. The value is given by the calculation made through COPERT for the number of transited trucks declared in the haulers' questionnaire (35,207 units), and by the consumption declared by other users in the general questionnaire.
- The railway engines support the logistics and movement of goods within the Port up to the connection with the national railway network. Also, in this case our calculations are based on user declarations referring to the fuel consumption of railway engines, used within the limits of the port area.
- The "Other" field includes emissions from: Boilers, current generators or actuators, refills of air conditioners, consumption of other gases not included previously (methane and LPG for domestic use) and consumption deriving from any companies that manage secondary activities under a concession pursuant to art. 45-a of the Navigation Code.



Electric energy	Port vehicles	Railway engines
Service vehicles	Heavy vehicles (TIR)	Other

Figure 6 - Emissions chart referring to the Port of Monfalcone, land side

8 THE RESULTS OF THE QUESTIONNAIRE DEDICATED TO HAULIERS

The information obtained from the data collection of the questionnaire for road hauliers referring to the port of Monfalcone is reported below.

In total 35.207 heavy vehicles used by road transport companies transited through the port, divided as follows:

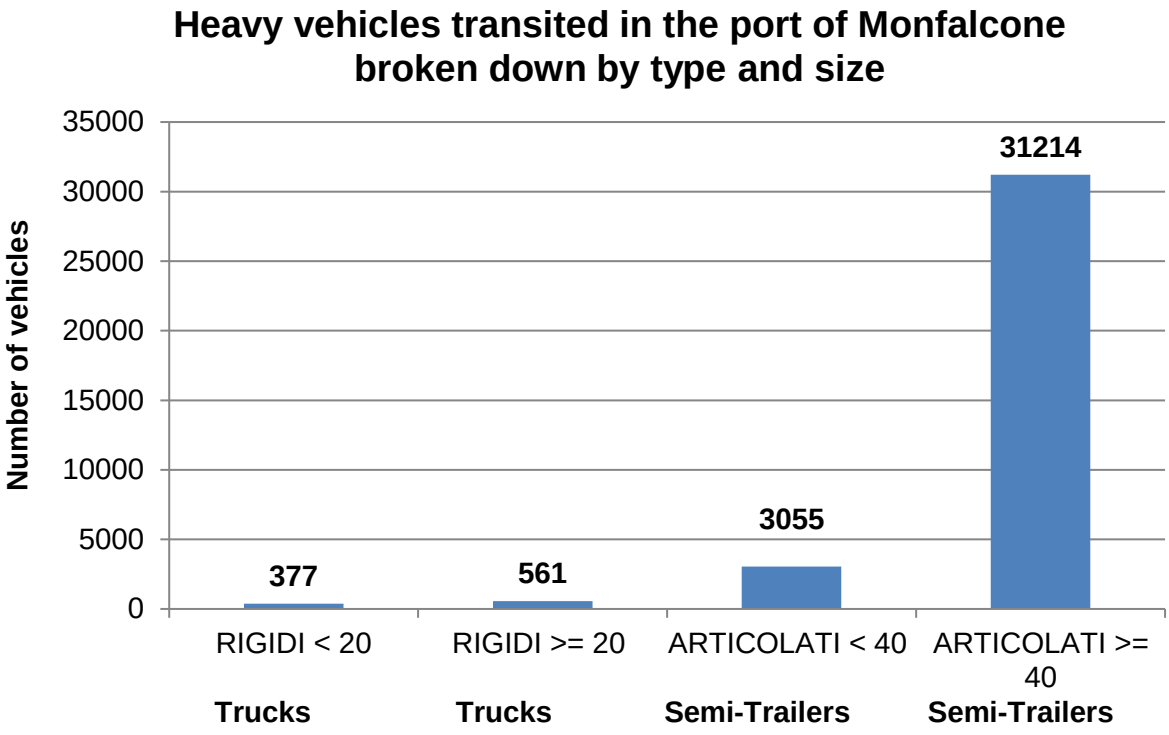


Figure 7 - Breakdown of heavy vehicles transited through the port of Monfalcone in 2019

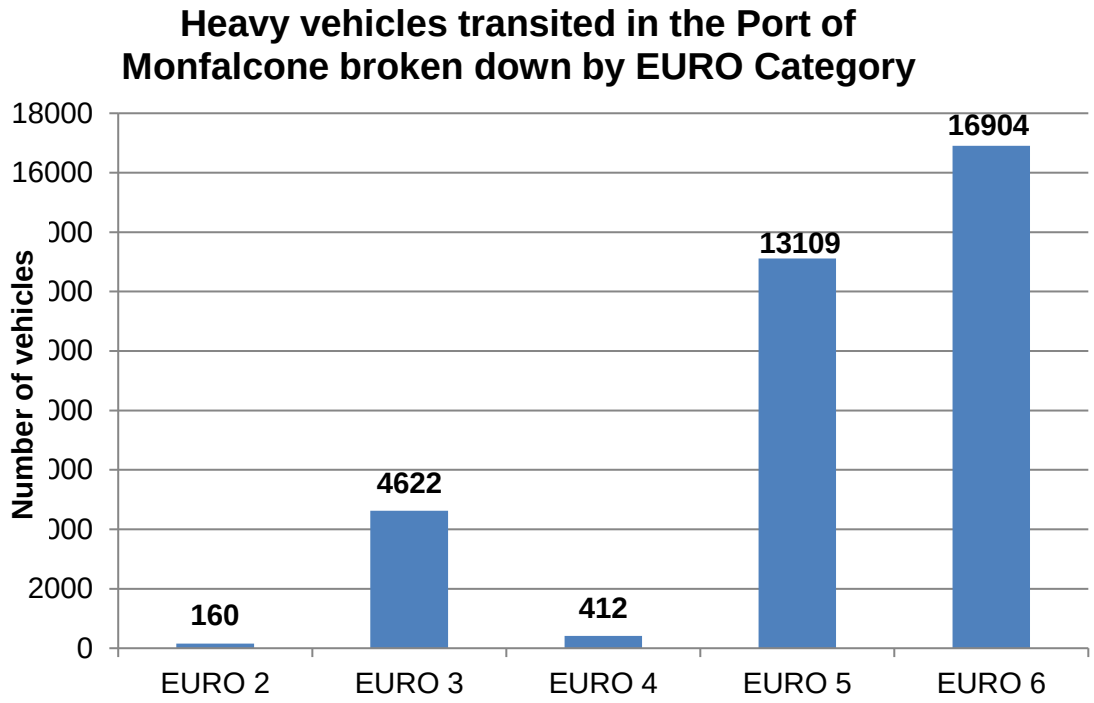


Figure 8 - EURO category of heavy vehicles transited through the port of Monfalcone in 2019

By entering the collected data in the COPERT Software, with Tier 3 detail, the following results were obtained in terms of emissions, after also entering the average temperature and humidity values for each month and the average distances travelled within the port of Monfalcone.

Table 3 - Results in terms of greenhouse gas emissions obtained by the COPERT Software

	t CO_2	t CH_4	t N_2OR	t CO_2eq
Trucks 14-20 t	0.8	/	/	0.8
Trucks 26-28 t	1.5	/	0.0001	1.5
Semi-trailers 28-34 t	8.7	0.0001	0.004	8.7
Semi-trailers 40-50 t	116.3	0.002	0.005	116.3
TOTAL	**127.3**	0.002	0.005	127.3

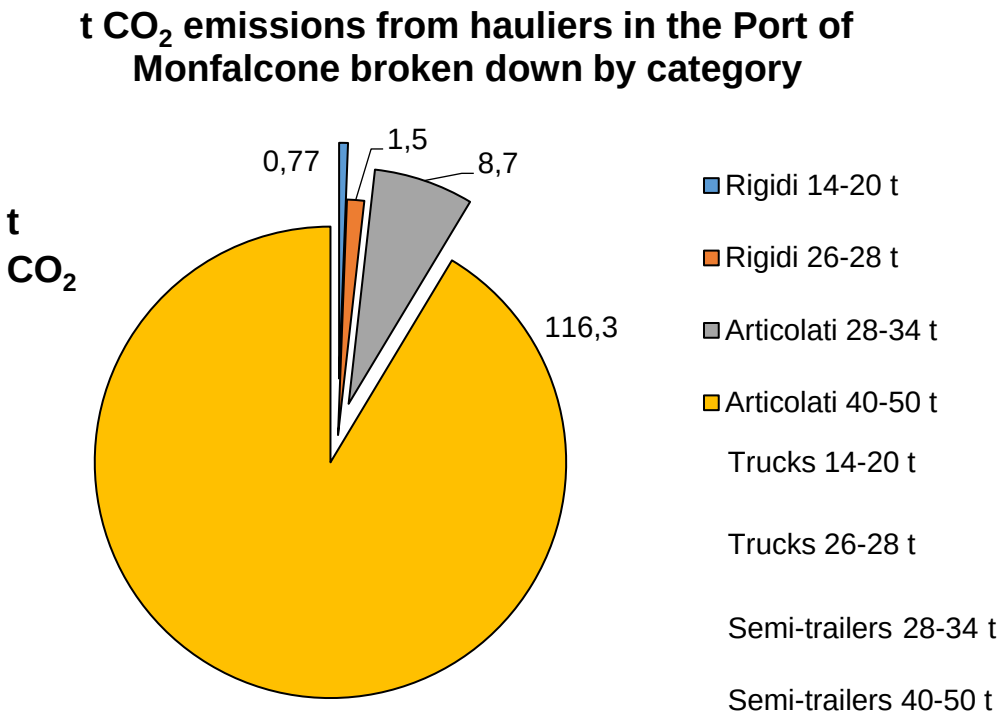


Figure 9 - CO_2 emissions from hauliers, obtained from the COPERT Software, divided by vehicle tonnage

The emissions calculated from the consumptions declared in the general questionnaire were added to the emission value defined by the COPERT software (314.5 t CO_2eq), for a total of 443.4 t CO_2eq produced by heavy road vehicles within the Port of Monfalcone.

With regard to the emissions calculated from the data received through the general questionnaire, i.e. the one not dedicated to actual road hauliers, it should be noted that 245.8 t CO_2eq derive from the bunkering of ships by tankers, while the remainder is due to road freight transport activities carried out by authorised port companies.

8.1 TOTAL GREENHOUSE GAS EMISSIONS IN THE PORT OF MONFALCONE

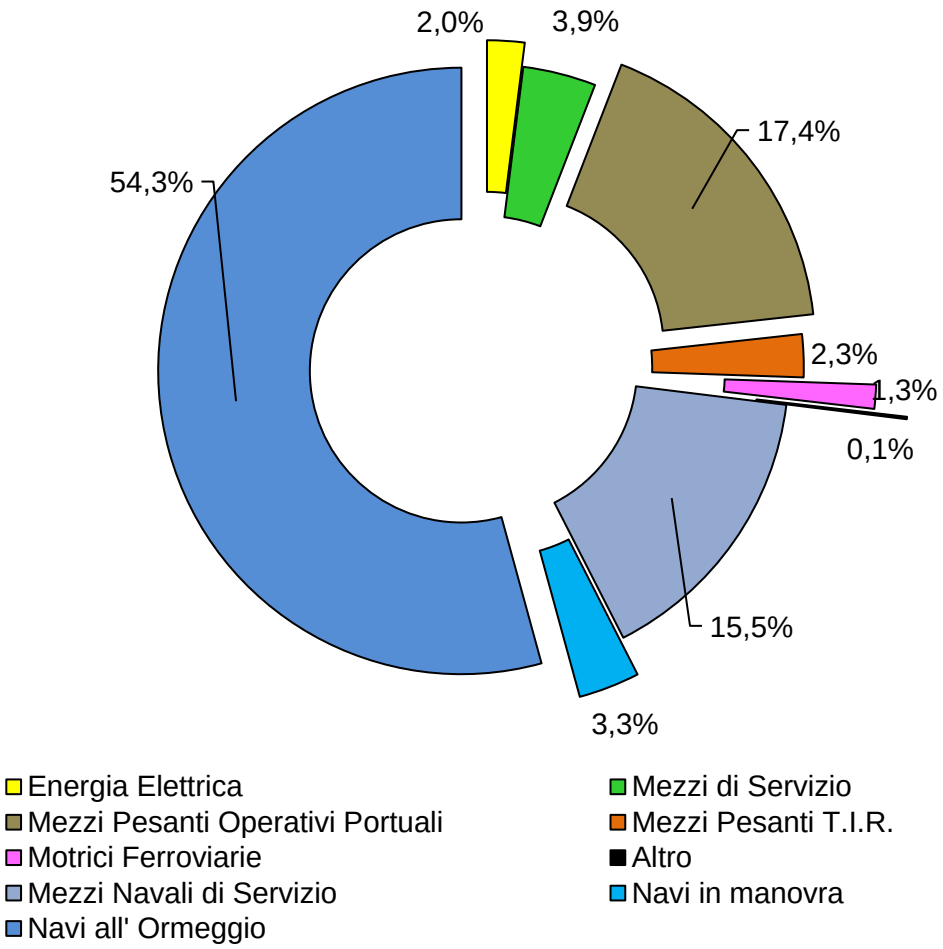
Finally, we report the total emissions of Greenhouse Gases, broken down by category and activity.

The “other” field includes: heating, refills of air conditioners, power generators or actuators, consumption of any companies that manage secondary activities under a concession pursuant

to art. 45-a of the Navigation Code and other greenhouse gases not included in the categories covered by the questionnaire.

Table 4 - Summary table of direct and indirect emissions from the Port of Monfalcone, broken down by categories and activities, for the year 2019

Total greenhouse gas emissions in the Port of Monfalcone in 2019		
Category	**t CO_2eq**	**%**
Electric energy	386.3	2.0%
Service vehicles	755.0	3.9%
Port heavy vehicles	3,368.7	17.4%
Heavy goods vehicles	443.4	2.3%
Railway engines	249.1	1.3%
Other	25.4	0.1%
Service vessels	3,011.3	15.5%
Ships in manoeuvre	631.6	3.3%
Moored ships	10,521.6	54.3%
TOTAL	**19,392.4**	**100%**



Electric energy	Service vehicles	Port Heavy Vehicles
Heavy trucks (TIR)	Railway engines	Other
Service vessels	Manoeuvring ships	Moored ships

Figure 10 - Overall percentage ratios between categories of greenhouse gas emissions from the Port of Monfalcone in 2019

9 ANALYSIS OF THE RESULTS

9.1 ANALYSIS OF THE EMISSION BREAKDOWN

The most impacting activity in terms of greenhouse gas emissions, as shown in the diagram of *figure 15* "*Overall percentage ratios of all GHG emissions in the Port of Monfalcone - Year 2019*", which shows the breakdown of emissions by type, is that resulting from moored ships. Indeed, this category of emissions represents 54.3% of the total.

The second category in quantitative terms is represented by port vehicles (17.4%), closely followed by port service vessels (15.5%).

Heavy goods vehicles (T.I.R.) represent only 2.3% of the emission of greenhouse gases within the port of Monfalcone.

9.2 LAND EMISSIONS

Total greenhouse gas emissions on land amount to 5,224.3 t CO_2eq and represent about 26.9% of the overall emissions in the Monfalcone port area.

The most relevant emission category in this area is represented by heavy port operating vehicles, which produce 3,368.7 t CO_2eq and thus represent 64.5% of land emissions (*Figure 9: Percentage ratios of contributions to the production of greenhouse gas in the land area for the Port of Monfalcone - Year 2019*), or 17.4% of the total (*Figure 15: Overall percentage ratios of all GHG emissions in the Port of Monfalcone - Year 2019).* This category includes different types of vehicles such as port stackers (Reach Stackers), port tractors, fifth wheels, diesel forklifts, lifters and any other vehicle used for carrying out the port activity taking place on the quay including the handling and loading/unloading of goods.

The remaining share of direct emissions in the land context, therefore excluding the consumption of electricity, i.e., indirect consumption, is due to the operation of boilers, generators, refills of air conditioners, use of service vehicles, trucks for freight transport, railway engines, etc. These direct emissions added together amount to 1,469.2 t CO_2eq and represent 28.1% of the total emissions occurring on land, or 7.6% of the total emissions of the Port of Monfalcone in 2019.

Therefore, it appears that heavy goods vehicles (trucks) impact on the emission of the Port of Monfalcone in a marginal way, with just 443.4 t CO_2eq or 2.3% of the total emissions for 2019.

10 TRANSFERABILITY OF FINDINGS

The study of the “Carbon Footprint for the Port of Monfalcone - 2019” highlighted a good performance of the same in terms of greenhouse gas emissions, considering its size but also its intense port activity.

The present “criticalities” are common and similar to those of the other ports, in which electrical connection systems for moored ships have not yet been implemented and made operational.

Indeed, the study shows that the activities that generate the highest emissions in absolute value are precisely the ones from **moored ships and, “Land Side”, the traffic of heavy port operating vehicles.**

In this sense the actions to be taken, **which are also applicable to other ports,** must aim at implementing and encouraging **the electrical connection of moored ships and the progressive replacement of the heavy vehicle fleet and harbour tugboats with similar units equipped with electric propulsion systems, with the simultaneous construction of accumulator recharging infrastructures.**

Suitable measures will have to be adopted for combating and reducing these types of greenhouse gas emissions, such as the use of “**Cold ironing”, i.e. the shutdown of the on-board machinery of large ships once moored on the quay through the connection to the national electrical grid (or produced locally with low-impact methods), and the progressive replacement of the fleet of heavy operating port vehicles, currently powered with diesel fuel (fossil fuel with medium-high emissions), with electric or hybrid vehicles, or powered by natural gas (methane) or biofuels.**

11 ADDITIONAL REMARKS

The Municipality of Monfalcone, in collaboration with the Port Authority, will organise the specific stakeholder- partner meeting in order to share project activities, present data research and subsequently identify potential for improvement of practical solutions.