Local action plan for the port of Ravenna

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Introduction

The action plan of each port involved in the SUSPORT project is conceived starting from the analysis of carbon footprint and of the best practices realized within Activity 3.1 and aims to define the measures that in the medium and long term can solve the critical issues from the environmental point of view identified in the SWOT that is part of the Carbon footprint carried out within the Territorial needs assessments (TNA) of the Ravenna Port (D.3.2.1). Data included in the TNA are referred to 2019, in order to allow to have a precise and updated framework of the environmental and energy performances of the Port.

It is also useful to underline that this document is based on the common methodology developed by WP Leader and it illustrates the action plan for environmental sustainability and energy efficiency of the Port of Ravenna Authority, carried out as part of the SUSPORT project, co-financed by the Interreg Italy-Croatia Programme.

So, the scope of this Action Plan is to understand how the state-of-the-art situation in terms of various emissions in the port area of Ravenna can be improved by specific interventions, as specified in the Document of environmental and energy planning of the Port of Ravenna (DEASP).

The main goal of these interventions would be the achievement of an improvement of the environmental and energy performances of the Ravenna Port, to guarantee a sustainable development of the area at both economic and social level.

Furthermore, it is important to draw the attention on the fact that some of these specific interventions will be carried out within the SUSPORT project as part of the pilot actions that are foreseen in the Work Package 4.

Weaknesses and Threats of the SWOT analysis included in the TNA tackled by this Action Plan

A specific SWOT analysis of the Port of Ravenna has been carried on within the TNA in the last months, as part of the Deliverable D.3.2.1 of the SUSPORT project. That analysis was conducted by a deep analysis of the activities carried out in the Port and by the data and experiences shared by the main stakeholders of the port. Here below it is reported that SWOT analysis, in order to have a clearer view of the environmental and energetic current situation in the Port area:

	Positive Impact	Negative Impact
Internal Factors	STRENGTHS	WEAKNESSES
	1. 2. Several stakeholders of the Port of Ravenna own photovoltaic systems for the selfproduction of electricity. Such facilities should be supported and other stakeholders encouraged to use them. The service vehicles in the port area do not travel great distances and the impact is reduced. It could still be reduced if hybrid or electric vehicles are used.	1. Most of the operational port vehicles are powered by diesel fuel (fuel which has a higher impact than other fuels). Being machines with a long useful life and very expensive, they could not be replaced as a whole but eventually every time the useful life of one of them ends with another not fueled by diesel.
External Factors	OPPORTUNITIES	THREATS
	1. 2. The average age of the fleet of ships is 11 years and the engines are less polluting than older ships. LNG as a fuel is starting to appear in the supply of ships and its use should be encouraged. Part of the goods handled arriving or leaving the port travels by train. This means of transport should be encouraged as far as possible, i.e. where the infrastructure exists to transport the goods to the final recipient.	1. Most of the emissions generated come from ships at berth. Even if the impact that authorities and stakeholders may have on these emissions is minimal, emission reduction policies could be implemented at the managers of incoming ships or a reduction in the average time at berth with the engines running. A valid alternative could be cold ironing, since it would allow the engines of ships at berth to be turned off. 2. Most of the goods leaving or entering the store arrive by truck (more polluting means of transport than the train). If it is not possible to use a different means of transport, policies of replacing older means of transport with new ones that are less polluting could be encouraged at transport companies.

Table 1: the SWOT analysis included in the TNA

What is very clear, when examining the SWOT analysis, is that the mean weakness is that most of the operational port vehicles are powered by diesel fuel, this meaning that the carbon footprint of such vehicles is very high and difficult to reduce in a short period of time.

As already explained in the SWOT Analysis, these machines have a long useful life and high costs, therefore their replacement with machines with reduced emissions could be not very effective, especially at an economic level. Therefore, one might think of starting to replace some with more efficient ones as they reach the end of their life.

Service vehicles are used by both dealers and the port authority. The Action plan will concentrate on emissions coming from service vehicles, owned directly by the Port of Ravenna Authority, this meaning that it will be possible to intervene directly on them within the SUSPORT project. Here below it is reported a table from the TNA showing the km traveled by the service vehicles in the Port of Ravenna:

vehicle fuel	km traveled in 2019
Diesel (dealers)	1,377,993
Petrol (dealers)	194.421
Diesel (Port Authority)	21,880
Petrol (Port Authority)	14,900

Table 2: Services vehicles km

In order to try to improve the Co2 emissions deriving from service vehicles, the concrete actions that will be carried out and that are also part of the pilot of the SUSPORT project will focus on the reduction of the emissions coming from vehicles (diesel and petrol fueled).

Then, the main threat emerging from the SWOT analysis is the fact that Most of the emissions generated come from ships at berth. Here below the table of the overall CHG emissions from the port of Ravenna:

Table of the overall percentage ratios of all GHG Emissions from the Port of Ravenna in 2019		
Category	**t CO2eq.**	**%**
Electric Energy	3,671.86	3.4
Service Vehicles	55.68	0.1
Operational Port Vehicles	12,388.00	11.5
Heavy Vehicles	3,981.37	3.7
Railway Tractors	407.25	0.4
Ships Manoeuvring	32,261.46	30.0
Moored Ships	54,836.33	51.0
Total	**107,601.95**	**100**

Table 3: Table representing the overall emissions

As can be seen in the table, about 80% of the emissions generated are due to the maneuvering and mooring of ships. This is attributable to the large amount of fuel consumption of the ships and the number of hours that are in the mooring phase.

As underlined in the SWOT, a possible solution to reduce such emissions would be the implementation of cold ironing facilities in terminals, since it would allow the engines of ships at berth to be turned off.

Actions for environmental sustainability and port energy efficiency

The SWOT analysis carried out within the TNA underlined that the main weaknesses and threats at the Port of Ravenna from the environmental point of view are the following:

- High GHG emissions from port vehicles that are powered by diesel and gasoline fuel;
- High GHG emissions generated from ships at berth in the port terminals.

The future concrete actions that will be carried out at the port of Ravenna will try to improve that state of the art (some of them will we realized as pilot actions of the SUSPORT project), as also specified in the Document of environmental and energy planning of the Port of Ravenna (DEASP). This document, is compulsory by law (Law n.84/1994 as amended by the Legislative Decree n.169/2016).

Clean vehicles and photovoltaic system

First of all, speaking about the emissions of service vehicles, the emissions completely under control by the port authority concern those deriving from the use of service vehicles. Although the overall emissions deriving from this source is not among the highest, the implementation of improvement actions could give immediate and significant results for the port area. The pilot action of the SUSPORT project, foresee the replacement of two diesel and gasoline vehicles with other hybrids or electric ones. Moreover, also as part of the Pilot Action to be carried out within WP4, an electric photovoltaic system will be designed and installed in the parking lot of the Port of Ravenna Authority headquarter. The system will be also equipped with columns to allow the recharge of electric vehicles with the solar energy produced. Such a facility will allow to help to reduce the emissions coming from the electric consumption of the Port of Ravenna Authority headquarter but also to have a green source of energy for the electric and hybrid car purchased by the Port of Ravenna Authority within the SUSPORT project.

In this specific case, we intend to propose the installation of a photovoltaic system on a shading canopy near the building that houses the headquarters of the Port Authority. It is assumed that the shelter has a sloping roof facing east, with azimuth equal to + 70 ° and an estimated tilt angle of 15 °. The publication "Atmospheric emission factors of greenhouse gases in the national electricity sector and in the main European countries" of 2020 reports the updated emission factors for the main pollutants, expressed per kWh of gross electricity produced by the Italian thermoelectric park.

EMISSIONS FACTORS [g/kWh_electric energy]						
	NO_X	**SO_2**	**VOC**	**PM**	**CO_2**	**CO**
Value	0,218	0,058	0,083	0,003	427	0,094

A withdrawal of 15 kWh, for a distance of 100 km, means an emission into the atmosphere of 15 kWh * 0.427 kg / kWh = 6.41 kgCO2. On the contrary, the avoided consumption of diesel fuel leads to a reduction of CO2 emissions equal to 5.5 l * 2.61 kgCO2 / l = 14.36 kgCO2

Where the diesel emission factor was determined starting from the value reported in the document "Analysis of CO2 emission factors from the transport sector - 2003" and equal to 3.159 tCO2 / t, multiplied by the oxidation factor 0.99 and converted into kgCO2 / l assuming a diesel density of 0.835 kg / l. The overall effect of the intervention in terms of CO2 emissions, for each vehicle, is summarized below.

Vehicle	**Consumption/ 100 km**	**Cost/ supply**	**Cost for 100 km [€]**	**CO2 Emissions for 100 km [kg]**	**CO2 Emissions on 35.000 km [kg]**
Electric	15 kWh	0,150 €/kWh	2,3	+6,41	+805
Diesel	5,5 l	1,4 €/l	7,7	-14,36	-5.027

The possibility of powering a car with electricity replacing diesel fuel allows a net reduction in greenhouse gas emissions which would amount to 4.22 tCO2eq per single vehicle, for a total of 8.44 tCO2eq.

Compared to the total emissions of the site, equal to 108,272.63 tCO2eq, the reduction is 0.008%.

ELECTRIC VEHICLE – SUMMARY		
Actual situation	Foreseen saving	State of project
[tCO_2eq]		
108.272,63	**8,44**	108.264,19
100%	**0,008%**	99,992%

Table 4: tCO2eq savings

Figure 1: Example of the photovoltaic system in a parking lot

Nevertheless, the deployment of a wall-box in the garage of the Port of Ravenna Authority, can allow to recharge the vehicles also when they are parked in the garage. The wall-box also uses green energy, since it is nourished by the photovoltaic panels installed in the last years on the rooftop of the Port of Ravenna Authority.

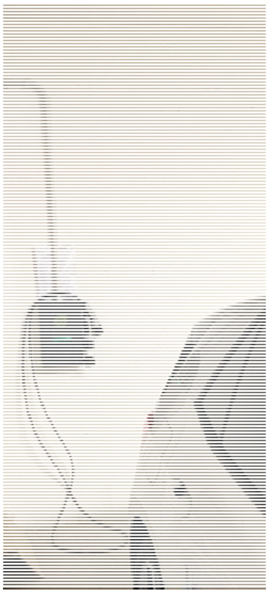

Figure 2: Wall-box installed

So, considering the purchase of hybrid plug-in and full electric vehicles that will be recharged at the facility deployed thanks to the SUSPORT project the emissions will be sensitively reduced.

In order to calculate the reduction of Co2 emissions, it has been considered a distance covered of 35.000 km per year for each vehicle. Then, in order to foster the electric recharge, it would be preferable to install an electric column of at least 2x22 kW of power.

Then, regarding the photovoltaic system in the yard here below it is presented the Co^2 reduction that will be achieved.

PORT AUTHORITY PHOTOVOLTAIC		
Actual situation	Saving foreseen	State of project
	[tCO_2eq]	
730,37	**11,55**	718,82
100%	**1,58%**	98,42%

Table 5: tCO2eq savings

Cold ironing facility

Secondly, as foreseen in the DEASP, even if not part of the SUSPORT's project, it will be implemented a quite important initiative in the docks that allows to reduce the consumption of electricity, such as cold ironing that could provide shoreside electrical power to a ship at berth while its main and auxiliary engines are turned off.

During the "hotelling" phases of the ships on the quay, the need for electricity to guarantee the operation of all the on-board equipment is met by using the auxiliary engines of the ships themselves, which work essentially as generators of electricity. The use of auxiliary engines on the quay is still a widespread practice in all world ports, which however brings with it a number of disadvantages such as:

- increase in the hours of use of the auxiliary engines and the corresponding maintenance costs
- environmental problems of emissions of combustion products into the atmosphere
- noise
- etc.

As an alternative to the self-production of electricity through the ship's internal combustion engines, and therefore through the use of traditional fuels such as fuel oil or marine diesel oil, for example, it is possible to create a connection between the quay and the ship of a non-fixed type and called "cold ironing" (also known by the acronyms AMP - Alternative Maritime Power, S2SP - Shore to Ship Power or HVSC - High-Voltage Shore Connection), in order to power the ship via the shore network.

The use of a Cold ironing facility permits emergency equipment, refrigeration, cooling, heating, lighting and other equipment to receive continuous electrical power while the ship loads or unloads its cargo and it's moored at berth. Supplying electric power to vessels is of strategic importance, in particular for cruisers. In fact, the port of Ravenna extends along the Candiano canal between the town of Ravenna and the sea, but the cruise terminal is located right in the heart of a touristic village (Porto Corsini) and very close to the twin of the latter (Marina di Ravenna) and vessel emissions seriously impact the quality of air. For that reason, the first Cold ironing facility of the port will be installed at the cruise terminal of the Ravenna Port. The cruise terminal regards about a 125.000 sqm, it has two piers which depth is mt 11,5. Located nearby the more important Italian motorways and roads. Easily reachable from all Italian cities and borders, and directly connected to Bologna

Airport (80 km, 50 minutes by car) and Rimini Airport (60 km from Ravenna, 50 minutes by car). The cruises terminal has a 473 mt pier, two parking areas of 50000 and 52546 sqm for 350 ranks.

Then, it’s important to underline that this terminal will be equipped in the next years with the new maritime station and a new park that will contribute to improve the environmental sustainability of the terminal but also the quality of service for the passengers.

Figure 3: Site of the future cold ironing facility

Figure 4: Rendering of the new maritime station at the Cruise terminal

The DEASP upgrading study identifies the following power needs for the cruise facility:

1) Estimated Power Consumption in Port Cold Area (MW):7.5-10
2) Estimated Power Consumption in Port Warm Area (MW): 10-12 Shore Power Voltage/Frequency: 11kV 60Hz
3) Shore Power Switchboard Rated Power (MVA/MW): 16MVA / 14MW
4) Shore Power Switchboard Rated Short Circuit: 31.5kA 1 sec
5) Shore Power Standard for Cruise Vessels: IEC/IEEE 80005

25 MW electric power has to be supplied at both berths of the cruise pier.

The characteristics of the shore-based electrical system for powering the different types of ships are specified in detail by IEC 80005-1.

A simplified scheme is shown below.

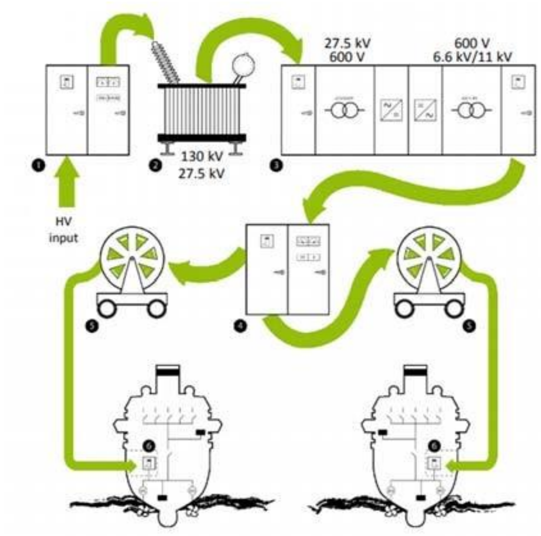

Figure 5: Example of a cold ironing facility

Going further into detail, the Porto Corsini Cruise Terminal located in Porto Corsini can host the biggest cruise ships now in use worldwide (two of the four existing berthing quays allow to host vessels up to 350 mt length with a 10,50 mt draught). The 301.20 mt long pier, wide 40 mt, has a project of 11,50 mt depth and perpendicularly inserts with the shore pier. Decided the types of considered vessels for this analysis, it is necessary to identify the auxiliary engines medium range power, those engines are employed during the berthing phase and used to supply the electrical devices on board. The three lines indicate the 3 types of vessel Big, Medium, Small:

Estimated Power Consumption in Port Cold Area (MW)	Estimated Power Consumption in Port Warm Area (MW)	Shore Power Voltage/Frequency	Shore Power Switchboard Rated Power (MVA/MW)	Shore Power Switchboard Rated Short Circuit	Shore Power Standard for Cruise Vessels
7.5-10	10-12	11kV 60Hz	16MVA / 14MW	31.5kA 1 sec	IEC/IEEE 80005
6 - 8	8 - 10	11kV 60Hz	16MVA / 14MW	31.5kA 1 sec	IEC/IEEE 80005
2-5	2-3	6.6kV 60Hz	TBA	TBA	IEC/IEEE 80005

Table 6: Resume Tables – power of engines and energy needs
Source: Port of Ravenna

	Richiesta energetica media [kW]	Richiesta energetica di picco [kW]	Richiesta energetica di picco per il 95% delle imbarcazioni [kW]
Container feeder-sea	170	1000	800
Container deep-sea	2000	8000	5000
RO/RO - Veicoli	1500	2000	1800
Crocieristiche <200m	4100	7300	6700
Crocieristiche >200m	7500	11000	9500

Table 7: Resume Tables – power of engines and energy needs
Source: Ericsson 2008

Ship class	Capacity bin	Auxiliary engine load (kW)			
		At berth	At anchorage	Manoeuvring	At sea
Cruise	0–1,999	450	450	580	450
	2,000–9,999	450	450	580	450
	10,000–59,999	3,500	3,500	5,460	3,500
	60,000–99,999	11,480	11,480	14,900	11,480
	100,000–+	11,480	11,480	14,900	11,480

Table 8: Resume Tables – power of engines and energy needs
Source: IMO 2015

Regarding the cruise ships, the mentioned sources report a variable medium power (for the bigger ships) from 7.500 to 12.000 kw.

Then, concerning the supply frequency and tension it is necessary to say that the vessels cannot be “recharged” with the direct electricity but the electricity must be transformed in function to the vessel to be charged; as a matter of fact, frequencies can be 50 or 60 hz, tensions may be 6 kv o 11 kv. The 11 kv tension e 60 hz frequency are common standard for the cruise vessels, modern cold ironing systems are able to produce electricity for each user.

Many studies indicate instructions about the charging according to the different types of vessels, the results of such studies are often contradictory even if it is possible to identify the most common case on which we can base necessary hypothesis for this study.

Regarding the medium berthing time for vessels in object, we used the 2019 data about the berthing times supplied by the Port of Ravenna Authority (see table below).

TIPO NAVE	DURATA TOTALE ORMEGGIO						NUMERO NAVI	DURATA MEDIA ORMEGGIO PER NAVE				
	anni	mesi	giorni	ore	minuti	h_totali		mesi	giorni	ore	minuti	h_totali
Nave da crociera			24	2	21	**578**	34			17	0	17

Table 9: Time of berth

It is important to stress that, to calculate the future emissions, it will be not correct to consider the entire amount of berthing hours to be done by connection to "cold ironing" system. Probably a part of these hours will need the employment traditional propellers for example during the berthing and departure phases.

Coming then to the impact of this intervention on the carbon footprint, the first step will be the calculation of the emissions of the considered vessels in terms of:

- NO_x
- SO_2
- VOC
- PM
- CO_2
- CH_4
- N_20

The general formula to calculate the polluting emissions is: hereinafter the CO2 formula:

Q_CO2 [g_CO2] = F [g_fuel] × EF [gCO2/g_fuel]

Here below, it's possible to find a resume of the current situation:

PRESENT EMISSIONS [kg]								
	NO_X	SO_2	VOC	PM	CO_2	CH_4	N_2O	CO
Ship cruises	48.152	1.749	1.924	2.949	3.444.081	44	171	2.602

Table 10: Current emissions fort berthed vessels

The electricity charging of the vessel, the COLD IRONING, allows to completely cancel the emissions caused by the fossil fuel but we have to consider that the electricity supplied by the public service has its consequent implications in terms of emissions due to the system of production of electricity itself.

Previous studies show that the thank the Cold Ironing the reduction falls from 89% to 97% (figure 14). Publication "*Fattori di emissione atmosferica di gas a effetto serra nel settore elettrico nazionale e nei principali paesi europei*" in 2020 reports however updated results on the production by the Italian thermoelectric park (figure 15) and this source will be adopted.

Tabella 21 Percentuali di abbattimento delle emissioni

Sistema di abbattimento	(%) di riduzione (-) o incremento (+) delle emissioni per imbarcazione			
	SO_2	NO_x	PM	VOC
SSE (2,7%S RO fuel)	-96%	-97%	-96%	-94%
SSE (0,1%S MGO)	0%	-97%	-89%	-94%

Table 11: "cold ironing" Emissions Reduction percentages
Source: "Analisi tecnico-economica della elettrificazione del Porto di Civitavecchia" – July 2006.

FACTORS OF EMISSIONS [g/kWh_electric energy]						
	NO_X	SO_2	VOC	PM	CO_2	CO
Value	0,218	0,058	0,083	0,003	427	0,094

Table 12: Italian Thermoelectric emissions production

It is possible to calculate the polluting emissions for the electric energy production collected by the service to be used for Cold Ironing which can be added the polluting emissions caused by the fossil fuel per hour supposed to manage the berthing operation/exiting (period in which the offloading has not started yet). So, the following two table will show the result in terms of emission reduction:

FUTURE EMISSIONS [kg]						
	NO_X	**SO_2**	**VOC**	**PM**	**CO_2**	**CO**
Cruise ship	11.714	514	599	699	1.561.789	778
reduction	*-75,7%*	*-70,6%*	*-68,9%*	*-76,3%*	*-54,7%*	*-70,1%*

Table 13: future emission using the cold ironing

	REDUCED EMISSIONS							
		NO_X	**SO_2**	**VOC**	**PM**	**CO_2**	**CO**	**[tCO2eq] savings**
Cruise ships	[kg]	36.439	1.235	1.325	2.250	1.882.292	1.824	**9.918**
	[g/kWh]	7,50	0,25	0,27	0,46	387,45	0,38	

Table 14: emissions reduction

To conclude, the design of such infrastructure will be finalized at latest by the end of 2024 (possibly with a CEF co-financing); and works will start in the same year. The works related to that facility at the cruise terminal of the port have been included in the list of activities to be proposed by the Italian Government in the framework of the EU Recovery Plan.

Timeframe and possible sources of funding

Here below are listed the relevant information regarding the expected timeframe and possible sources of funding of the interventions here above mentioned:

INTERVENTION	TIMEFRAME	POSSIBLE SOURCE OF FUNDING
Purchase of electric and hybrid plug-in cars by the Port of Ravenna Authority	Action will be completed by the end of 2022	ITA-CROATIA PROGRAMME
Design and Realization of a photovoltaic system in the yard of the Port of Ravenna Authority headquarter	Action will be completed by the end of 2022	ITA-CROATIA PROGRAMME
Design and Realization of a cold ironing facility at the Cruise Terminal of the Port of Ravenna	Design will be completed by the end of 2024 with subsequent start of works in the same year	Possibly CEF programme EU Recovery Fund

Consistency with environmental sustainability and energy efficiency policies

As already stated, the initiatives here presented, are part of the Document of environmental and energy planning of the Port of Ravenna (DEASP). As already stated in the previous sections of this document, the DEASP is compulsory by the Law n.84/1994 as amended by the Legislative Decree n.169/2016. The DEASP of the Port of Ravenna was drafted in accordance with what as defined in the document: "Guidelines for Environmental Energy Documents for Port Systems", issued in agreement with the MIT, which objective is to develop alternative and green energies in a strategic area of the country in order to minimize the levels of pollution.

Moreover, at the national level these initiatives are consistent with Legislative Decree no. 93 of June 1, 2011, Legislative Decree no. 28 of March 3, 2011, Ministerial Decree of March 15, 2012, Law no. 96 of August 6, 2013, Legislative Decree no. 102 of July 4, 2014, SEN (National Energy Strategy), SNACC (National Strategy for Climate Change Adaptation) and the National Integrated Energy and Climate Plan (PNIEC), through which the objectives of the present document are established. the national targets for the reduction of CO2 emissions to 2030, providing that the most significant contribution will be represented by the transport and civil sectors.

At EU level, then, it is clear that the purposes of this document are consistent with the implementation of the Paris Agreement and the adoption of the "Climate-Energy Package 2030", stating of a set of directives and regulations directed to achieve the objectives to 2030 (-40% CO_2 + 32% RES +32.5% EE). Furthermore, in addition, in 2019 the EU Commission presented the Green New Deal, planning to increase the EU's 2030 target to reduce GHG emissions to at least 50-55 %. Within this overall framework of European and national targets and policies, the contribution that maritime transport can make to reducing emissions is potentially high. The interventions and measures reported in this document are focused at reducing the environmental impact associated with maritime traffic and port activities and are consistent with the strategies and objectives identified by EU policies.

In conclusion, the proposed interventions and measures are consistent with the strategies and objectives described by the energy and environmental planning documents drawn up at regional, national and european level.

Conclusion

As already seen in the presentation of the results of the carbon footprint of the Port of Ravenna, the main CO2 emissions are attributable to the maneuvering and mooring phase of the ships entering the port. Port authorities and other port stakeholders have a small margin of impact in deciding how to reduce these emissions. Actions for the reduction of these emissions must involve authorities and subjects at the highest level (eg. as European and International bodies).

Regarding that first point, the Action plan foresees the implementation of some initiative in the docks that allows to reduce the consumption of electricity, such as cold ironing facilities. Such instruments would allow to provide shoreside electrical power to a ship at berth while its main and auxiliary engines are turned off. Cold ironing permits emergency equipment, refrigeration, cooling, heating, lighting and other equipment to receive continuous electrical power while the ship loads or unloads its cargo. This will have an important positive effect at environmental level and will also have positive effects on the life quality of the citizens living in the nearby of the port terminals concerned.

Other imported emissions concern operational port vehicles since most of them are powered by diesel. As already explained in the SWOT Analysis, these machines have a long useful life and high costs, therefore their replacement with machines with reduced emissions could be not very effective, especially at an economic level. Therefore, one might think of starting to replace some with more efficient ones as they reach the end of their life. The Action Plan regarding this point is focused on the vehicles owned by the Port of Ravenna Authority.

One of these would concern the replacement of diesel vehicles with other hybrids or electric ones. In particular the pilot action foresees the substitution of a diesel fulled vehicle with an electric one and the purchase of a hybrid plug-in vehicle.

Although the overall emissions of these vehicles are not among the highest in the port area, the implementation of improvement actions could give immediate and significant for the port area and be a good practice to be followed by the port’s stakeholders and companies.