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Environmental considerations on maritime passenger transport

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ABSTRACT

Maritime passenger transport entails significant risks and threats against the environment. The existing International rules – from the MARPOL 73/78 Convention to the European Regulations and Directives and ISO standards- aim to avoid pollution both in the high seas and in the ports. Concepts such as Green port or Smart port arise from an effort to make better use of the available resources, increasing efficiency, better energy use, use of the information and telecommunications technologies (ICT), and the lowest environmental impact. Furthermore, technics and programmes of energy management have been developed for the same purposes also. This paper reviews the main rules in the matter, as well as the most innovative technologies aiming to improve the shipping performance. All this, together with the investment effort from ports and ships, and the enforcement of a more stringent international legislation, seem to be the key to tackle the impacts brought about by this kind of traffic.

***Keywords*:** Maritime passenger transport, green port, MARPOL

1. INTRODUCTION

The maritime transport of passengers is not free of risks and threats to the environment and must comply with certain standards to prevent contamination, both at sea and in port [1].

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Since a few years ago, international agencies and governments of most developed countries have made progress toward respect and conservation of the natural environment [2]. Claim that human activity in its entirety as less harmful as possible with the environment, which is why this concern must be reflected in all the professional circuits [3].

There are many national and international agencies dealing with the marine environment. The International Maritime Organization (IMO) has a Marine Environment Protection Committee (MEPC) that explores and promotes the prevention of marine pollution by ships [4]. The Marpol 73/78 [5] is the convention more extended and this is a set of international standards that have the objective of preventing pollution from ships [6]. It contains six annex and covers all the possible sources of pollution in the sea and in the atmosphere. In this convention are also considered as certain maritime areas that require special protection, where the rules are more severe [7]. The case is the most exceptional of Antarctica, where is not allowed any type of waste disposal [8].

2. ENVIRONMENTAL POLICIES IN THE MARITIME SECTOR

The European Union encourages the growth of the maritime transport through certain actions, such as the modernization of the infrastructure or the harmonization of equipment and procedures [9]. The increase of the maritime safety and the protection of the marine environment are also a priority [10]. The Treaty of the Union set out in article 2: "The Community will have as its mission to promote a sustainable non-inflationary growth that respects the environment" [11]. To get these goals, you can highlight the framework programs for the environment, which have been developed since 1973 and whose effort has focused on preventing, reducing or eliminating pollution at its source, incorporating the concept of sustainable development with the participation of governments and industrial sectors [12, 13].

The European port sector, grouped in the European Sea Ports Organization (ESPO), has opted for self-regulation. It has generated various tools such as the Environmental Code of Conduct (1994) to comply with environmental legislation [14], to consider measures to improve the protection of the environment, to designate representatives of high level to coordinate policy and action of the environment and the set of different management systems [15].

3. MATERIALS AND METHODS

The following methodology was used to determine the environmental considerations at the passenger terminals and to carry out the study (Figure 1)

4. RESULTS AND DISCUSSION

4. 1. Environmental impact of the ports

Current trends have an impact on the sustainability of the ports, and new concepts such as green ports and smart ports refer to the need to have a better use of available resources [16], greater efficiency, better energy efficiency, use of information technologies, less impact on the environment, and all those concepts that make human life more profitable [17].

Many aspects of the port activity, potentially highly polluting [18], have to do with the industrial processes that are carried out there, but there are other aspects that are common to all the port terminals and that should be considered:

- Structurals: These are derived from the very existence of the port, which modifies the coastline by confining the waters, by modifying the habitat, the coastline and the landscape [19].
- Construction: The dredging, fillers, and derivatives of the engineering works of breakwaters and berths, construction of infrastructure and superstructure, the quarries near the port, the equipments, the waste and so on [20].
- Operational: They are the result of the daily work in all port activities. Among them are own maritime and land traffic, the handling of goods, storage, and all the activities and services that are given in a port [21], including the recreational fishing and the nautical activities [22].
- Accidentals. These include all situations that can happen in a port area in a fortuitous manner, which would generate an environmental impact, as can be fire, toxic emissions, spills or sinking ships [23].

To help in the port management have been developed the environmental management systems, which are the tools of port management that are composed of a set of policies and procedures for action to get a few goals, commitments and responsibilities of the ports with the society and the environment, to carry out their activity, but without prejudice to the environment [24]. At European level these systems are based on the application of ISO 14000 standards and in the regulation of Community Eco-Management and Audit Scheme (EMAS) [25, 26].

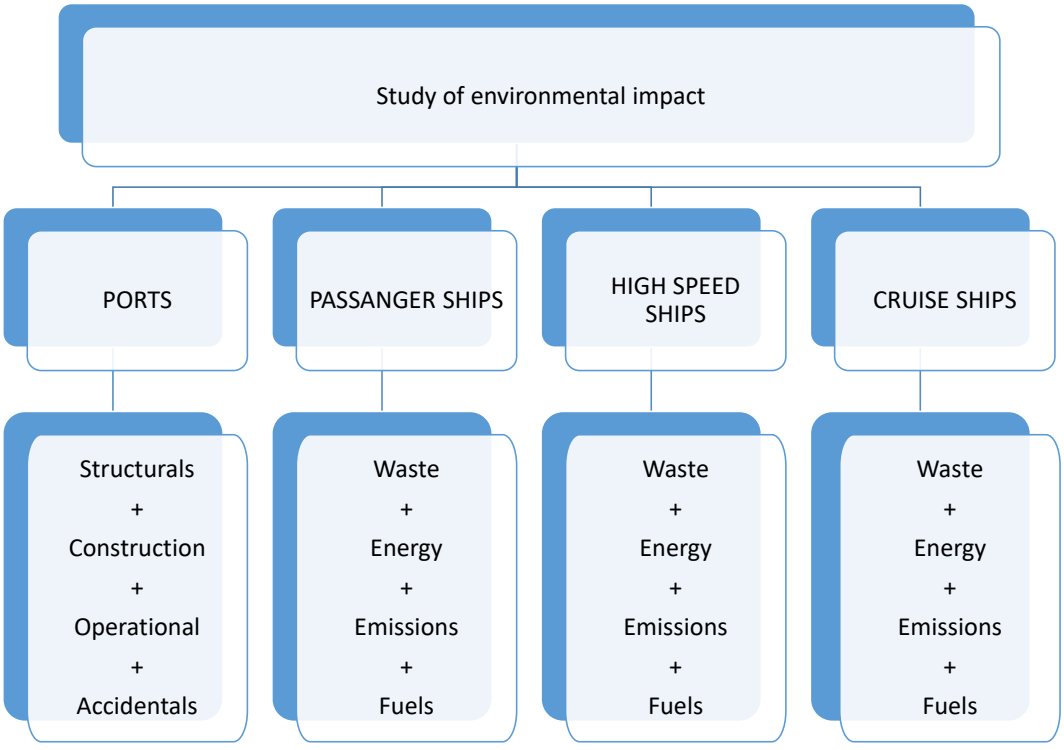

Figure 1. Methodological schedule

4. 2. Environmental impact generated by passenger ships

Although the transport of passengers represents only a small part of the international maritime activity, the associated environmental issues are very significant. Cruise ships and their passengers and crew members generated a significant volume of waste and pollutant emissions, both when they are in transit and when permanently moored to port, with a significant effect also on the coastal areas along the routes of step.

4. 2. 1. Study of the working scenario

The wastes generated by passenger ships are produced mainly by the presence of the crew and passengers, the services provided on board and the machinery of the boat. Table 1 summarizes the main classes of waste.

Table 1. Classes of waste generated by passenger ships.
Source: Various authors

Wastes	Contaminantes	Origin	References
Grey water	Contain phosphates and other nutrients from the detergents and soaps, chlorine or fluoride in toothpastes and pools, pathogenic bacteria, as well as any other potentially harmful substance used for personal hygiene. Also within the gray water are those from the sanitary facilities of the ship.	Water from the showers, toilets, swimming pools, washing machines, and so on.	[27, 28,29]
Sewage	Sewage, bacteria, pathogens, organics, paper, and any other product being thrown into the toilets.	Water from the bathrooms	[30, 31]
Cesspit	Waste oils, several hydrocarbons, and so on.	Of the engines and turbines for propulsion and for supplying energy to all the services of the vessels.	[32,33]
Toxic	They may contain highly toxic substances such as the TBT (tributyltin used as an additive in anti-fouling paints), PCE (perchloroethylene from dry cleaning), heavy metals in paints and inks, chemical compounds of the drugs, acids and heavy metals from the photographic material, PVC and heavy metals from the cables, light bulbs, fluorescent lamps, batteries, batteries, toluene, xylene, benzene and chlorinated solvents, and so on.	Of the photographic processes, the dry cleaners, paints, pharmaceuticals, inks, electronic materials, and so on.	[34,35]
Garbage	Plastics with hydrocarbons and chlorinated compounds, solid waste, organic waste, etc.	Of the food and the daily consumption of all kinds of products	[36,37]

The Annex IV and V of MARPOL 73/78 standards govern the management and discharges to the sea of waste generated in the vessels as a result of their activity and include both liquid substances as the solid ones [38]. As all the international Conventions regulate only basic issues, leaving governments the enactment of additional rules to regulate all the specific aspects of each maritime activity and the obligation to have facilities in ports and inspection services.

The European directives set out the rules of Marpol and laying down plans for the reception and handling of wastes in the ports, the notifications of the ships to the port and the fees for environmental management [39].

Spain considers that the receipt of waste is a port service with their corresponding application rates, being the Port Authorities the guarantors of the service [40]. They are bound to comply with these rules all persons and entities that generate waste, or those who are responsible for your transportation or management. The producer of the waste is responsible for the collection, classification, storage, and delivery to the authorised manager [41].

4. 2. 2. Energy consumed by the ships in port (Onshore Power Supply) OPS

The Onshore Power Supply (OPS), also known as cold ironing, it is a strategy recommended by the World Ports Climate Initiative (WPCI) to reduce the environmental impact of the ships in the ports. The European Directive 2005/33 allows the use of OPS as an alternative against pollution [42].

When they vessels are moored, they continue to require energy to develop activities on board. Today, this energy is usually provided by auxiliary engines, which emit carbon dioxide and pollutants into the air, reducing local air quality that, ultimately, affects both the health of the dock workers such as that of the residents of the area, which in addition are subjected to loud noises that emitted from engines [43]. The system replaces cold ironing, through the provision of electrical energy from earth, the use of the auxiliary diesel engines of the ships when they are moored.

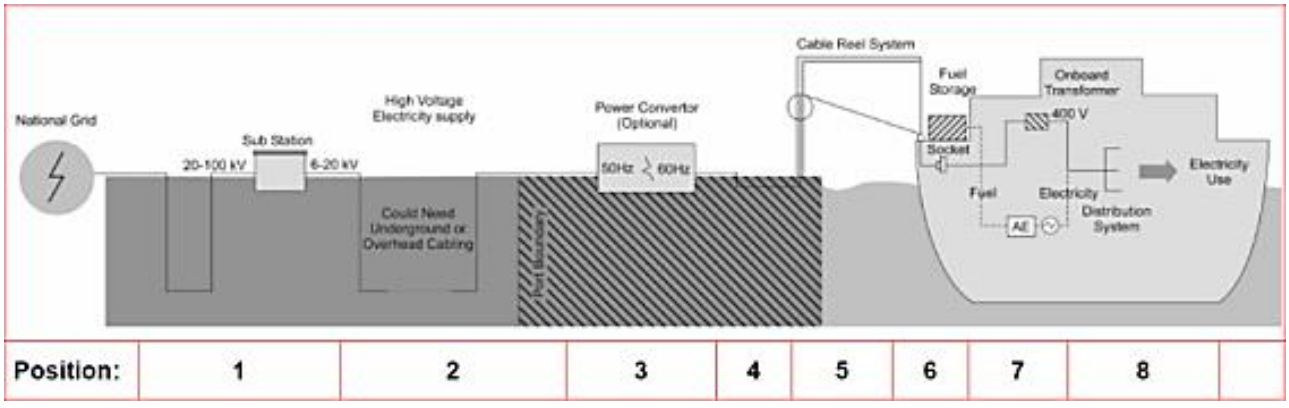

Figure 2. Diagram of electrical connection from port.
Source: UE Recommendations 2006/339/EC

The technique of cold ironing has been used since the 80s for the supply of electricity to commercial vessels [44]. The ferries were the first ships that were connected to the spring for

the supply of energy. The reason for this was that, as always is docked at the pier in the same position, the connection was easy [45]. The port of Gothenburg was a precursor in the practice of supply of energy from earth for ships, mainly in the ferry routes [46].

The European Union has submitted a configuration type of cold ironing [47] in the recommendations 2006/339/EC, this configuration is depicted in Figure 2 and described in more detail in Table 2.

Table 2. Description of the cold ironing configuration. Source: EU Recommendations 2006/339/EC

Position	Description
1	Connection to the national network that carries electricity from 20-100 kV up to a local substation, where it is transformed to 6-20kV
2	Harness to distribute the power of 6-20 kV substation to the port terminal.
3	Power Conversion, when necessary. (The supply of electricity in the European Community in general, has a frequency of 50 Hz. The ship designed for 60 Hz electricity may be able to use 50 Hz electricity in some of their equipment, such as lighting and heating, but not in the motorized equipment such as pumps, winches and cranes. Therefore, a ship that use 60Hz would require that the 50 Hz are converted to 60 Hz).
4	Harness to distribute electricity to the terminal. These can be installed under ground in existing or new conduits.
5	A system of cable reel, to avoid the handling of high-voltage cables. This device can be installed in the spring using a cable reel, winch and structure. The winch and the framework could be used to raise and lower cables to the boat. The reel and frame can be electromechanical actuation and control.
6	Connection on board the ship for the connecting cable
7	A transformer on board ship to transform the high voltage electrical power to 400 V.
8	The electricity is distributed by the ship, and the auxiliary engines are turned off

4. 2. 3. Emissions to the atmosphere generated by ships

Marpol Annex VI discusses the gaseous pollutants generated by ships including sulfur oxides (SOx) and nitrogen oxides (NOx), and prohibits deliberate releases of substances harmful to the ozone layer. Annex VI entered the emission control areas (Emission Controlled

Areas) , ECAS, sea areas in which, for reasons relating to their ecological and oceanographic conditions and because of the maritime traffic that support it, it requires the adoption of special procedures [48] required to prevent the pollution of the sea [49]. Under Marpol, these special areas are equipped with a higher level of protection (Figure 3) [50].

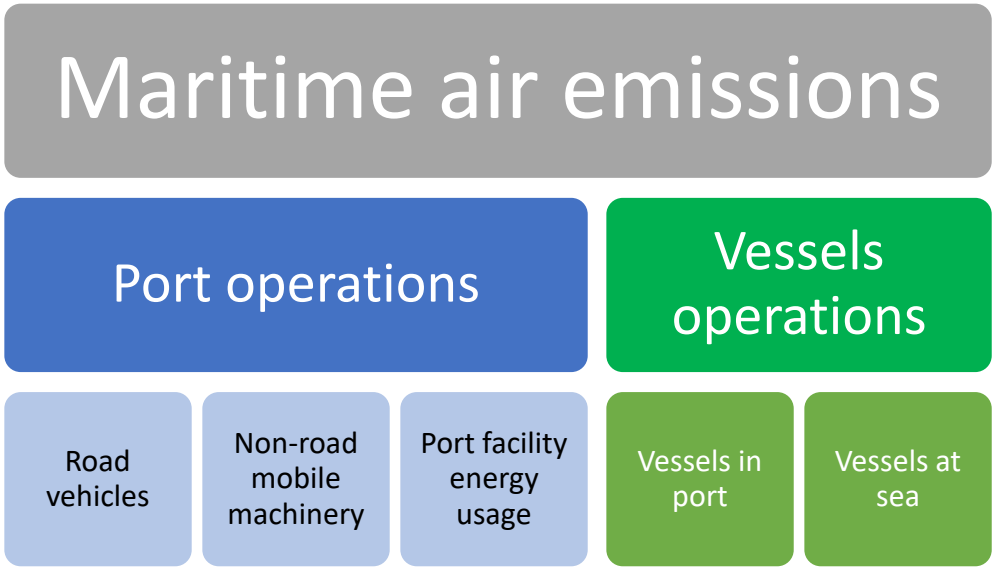

Figure 3. Kinds of Emissions to the atmosphere

In general, the different emissions have geographical repercussions and impacts different [51]. For example, CO2 has a long duration and their effects are global, while the SO2 and NOx pollutants are more local, but that may also have impacts on other areas away if the weather conditions and weather they are transported [52, 53].

It has been shown that the high-speed ships on certain routes can be more polluting than the traditional means of transportation [54]. Ships sailing at speeds of 35 knots have a higher consumption of 5 to 10 times that of conventional transport and CO2and NOx emissions also are from 5 to 11 times higher [55].

4. 2. 4. Fuels

Large ships have a consumption that is equivalent to that of 12,000 vehicles, but with the added that the type of marine fuel is 50 times more toxic. The fuel in the vessels is used, not only for propulsion, but also to power the electrical systems. In the case of the passenger boats and especially of the cruises the spending of electricity for powering lights, refrigeration, air conditioning, shops, discos, and so on , is very high, both on the high seas, such as when is moored.

All vessels require bunkering and for this they will seek the time available to less delay the transport service provided. The supply of fuel can be done in several ways, by fixed pipelines, trucks or barges.

Anyway, you must comply with certain safety standards to prevent spills in the supply, on the part of both the terminal and the ship itself. For this purpose it is necessary that the

responsible for the operational were well qualified to avoid improper handling. Also, inspection and maintenance of the equipment are fundamental in these works.

4. 3. Environmental impact generated by high speed ships

Many high-speed routes have submitted conflicts between operators and the environmental authorities because this mode of transport has environmental consequences more high than others: coastal erosion, air pollution and noise, erosion of the bottom of the sea, the effect of the waves (wake wash), impacts on wildlife habitats and risks for the navigation.

The waves generated by this type of vessels are small compared with the ocean waves, but have a very large period, rapidly increase in amplitude to reach the shallower waters near the shore, and trigger waves whose degree of penetration on the shore is very large. The effect of the waves generated by the wake of the vessels is one of the environmental problems that most concern. In order to reduce the danger, it is necessary a risk assessment of the wake wash in routes prior to the establishment of a new service. This phenomenon depends on many parameters such as:hull shape, length, displacement, type of propulsion, speed, course, water depth, seabed, etc. In order to reduce the danger, it is necessary a risk assessment of the wake wash in routes prior to the establishment of a new service. This phenomenon depends on many parameters such as: hull shape, length, displacement, type of propulsion, speed, course, water depth, seabed, etc. In order to reduce the danger, it is necessary a risk assessment of the wake wash in routes prior to the establishment of a new service.

Depending on the speed of each ship, the acceleration and the depth of the water, defines the critical speed as the worst condition in which you can navigate a ship. For example, a vessel with an operational speed of 40 knots, you will be in condition sub-critical with depths over 50 meters and you will criticism to supercritical fluid when the depth decrease. Conventional vessels sailing close to the critical speed, the wave induces an increase in resistance to the majority of ships do not have enough power/weight ratio to exceed to the supercritical region.

While the high-speed ships have a high ratio, due to their displacement lighter and hull forms thinner, and can easily go to the critical speed.

In some countries, when the amplitudes of these waves have been very large, have been imposed certain restrictions on speed or have required studies of feasibility in terms of risks for fast ships operating in the same. The operators of these ships minimize these effects through changes in the path or in the speed by reducing the critical step.

4. 4. Environmental impact generated by cruise ships

Due to the great increase in the last thirty years of the cruise industry, inevitably have also increased their associated problems. The diversity of activities that a cruise offers to its passengers is associated with hopelessly the generation of a significant amount of wastes on board. It is estimated that a cruise ship for 2,000 -3,000 passengers can generate about 1,000 tonnes of waste a day (Table 3)

Another environmental problem is due to the large amount of ballast water that used the cruises. This is loaded into a port and is downloaded in another one, with the consequent risk of introducing invasive species in the different ecosystems in which they operate cruise routes. Currently, the IMO considers the ballast water as one of the most serious problems that generates the maritime traffic.

Table 3. Description of the cold ironing configuration.

	Solid waste*	**Gray water****	**Sewage****	**Bilge water ****
Theoretical calculation in tourist cruises	3,5 Kg/ pass*day	300 l/ pass*day	40 l/ pass*day	10 l/ pass*day

Atmospheric pollution by fuel consumption is the amount that comes from the processing of the waste incinerated on board. The generation of garbage on board is another problem because the residue generated 24% of the solid waste of the world's maritime traffic [80]. Unfortunately, some scales of the cruise ships do not have facilities for the treatment of this waste and the risk of illegal discharges.

International law only regulates the activities of these cruises, and the residues can be thrown into just a few miles from the coast in place to proceed with the installation of a suitable waste treatment system on board. For this reason, the most visited destinations in many countries begin to introduce more stringent regulations to curb the impact of these vessels, although the issue remains in international waters.

With the goal of reducing emissions to the atmosphere have been developed in recent years techniques and energy management programs applied to the cruise ships. Some of these improvements include:

- New engine designs that vary their power as a function of the existing demand for energy.
- Hulls designs for greater efficiency hydrodynamics.
- Heating, ventilation and air conditioning efficient.
- Reuse systems and recovery of waste heat.
- Lighting through LEDs.

The cruise industry has allocated substantial financial resources for the development and implementation of new technologies with the goal of improving yields. These technologies include:

- Alternative fuels to the present.
- Energy options to the complementary fuels (solar panels, wind turbines on board, and so on.).
- Lining of the hulls to reduce the resistance to forward motion of the ship, its consumption and their emissions.
- Plates of interception (designed to "raise" the stern of the body of the craft, thus reducing the demand for propulsive power and energy consumption) and the "queues of duck" (elongation from the stern of the ship that gives rise to the reduction of the resistance and a lower power requirement of propulsion and power consumption).

- Coatings of windows with the goal of reducing air conditioning needs and save energy.
- Minimisation of water consumption through showers and low-flow faucets and reuse of the same a few uses to others to reduce their total consumption.

5. CONCLUSIONS

The maritime traffic of passengers is one of the major threat to the environment, because it adds to the sources of marine pollution, own of the port and maritime operational, the generation of large amount of waste produced, mainly due to the presence of crew and passengers as well as for services offered on board.

In addition specifically cruise traffic increases this environmental risk, since the vessels require special facilities on the ground in order to provide the tourists the best service. The need for large terminals and maritime stations service the cruisers to significantly alter the coastal areas. The economic effort undertaken by ports and ships, linked to the implementation of more stringent international regulations seem to be the key to curbing the impact caused by this type of traffic.

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