

## ENVIRONMENTAL IMPACT ASSESSMENT OF THE MARINE TRAFFIC IN PORT OF TARANTO: A PRELIMINARY STUDY

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**Abstract:** In the last ten years town of Taranto (Italy) is living a decisive phase of its own history, since is torn between the presence of some big hazardous industrial plants and the strong demand of eco-sustainable development. The increasing of manufacturing industries has led an undeniable economic and social growth, but, at the same time, has exposed the whole area to great environmental stresses. This concern is particularly true also for the Port of Taranto (PoT) because the harbor area is very close to the city, contributing to expose people to risk of serious health hazards. Although the PoT activity had not a relevant impact on total pollutant emissions in the area, its location makes mandatory an environmental requalification.

The purpose of this study is to gather and analyze the data associated with the berthing operations and resulting emissions to better define the potential for emissions reductions and to suggest some possible strategies for bringing pollutants down, in order to reach a wealth based on environmental preservation.

**Keywords:** Environmental pollution, emission reduction, power supply, environmental monitoring and control systems.

### 1. INTRODUCTION

PoT is the second most important Italian port with a throughput of about 50 million tons in 2006. Actually the port acts as a transshipment center or a facility serving the near industrial plants. Moreover PoT's container terminal is an important hub for services to the Near, Middle and Far East, the Americas and the Europe. Throughput has grown steadily from 150,000 Teu in 2002 to about 900,000 Teu in 2006 [1]. Its goal, for the next future, is to become one of the main Mediterranean logistics platform linked directly with production and transport chains.

Environmental pollution in the PoT area comes from a lot of sources, therefore the pollutant abatement problem have to be engaged from different points of view. As well known, one of main reason for air pollution in the harbors is the operation of the on-board auxiliary diesel engines to supply electric energy for a number of different systems such as lightning, load movement, air conditioning, control, etc. while the vessel is at the dock (referred to as *hotelling*).

This kind of diesel electric group commonly emits noxious gases, likely:

- nitrogen oxides NO<sub>x</sub> and sulphur oxides SO<sub>x</sub>;
- carbon monoxide (CO) and carbon dioxide (CO<sub>2</sub>);
- particulate matters PM (in particular PM10);
- the volatile organic compounds (VOCs - benzene, formaldehyde, toluene, etc.).

This situation could become dangerous if we consider that PoT is located near the heart of its own city, having an extension of about 2.700.000 m<sup>2</sup> and about 10 km of total berth length [1]. Non negligible factor is that the population growth had strongly increased the request of high level quality of life by people living in the surrounding area. To address to this issue and to monitor the air quality, about ten years ago, many environmental monitoring stations have been installed all around the city of Taranto; at the same time a lot of modeling studies have been carried out to manage polluting emissions and to forecast emergency events [2], [3].



Figure 1 Port of Taranto

At moment the sea transport sector business in Italy represents about 3% of total manufacturing activities; the relevant greenhouse gases emissions is less than 3% for CO<sub>2</sub>, less than 15% for NO<sub>x</sub> and around 5% for SO<sub>x</sub>. Most part of these emissions is released during sailing, then it could be considered low harmful. Nevertheless, a more in depth analysis has to consider the whole scenario since the territory of Taranto is already very stressed by a combination of different pollutants arising from lots of manufacturing activities, therefore the air pollution in PoT is

a not negligible environmental hazardous factor. For all these reasons any possible effort to reduce the environmental impact at PoT is desirable.

This paper is structured as follows: after a review of environmental rules and regulation, an estimate of pollutant emitted from hotelling ships related to some traffic information is presented and possible strategies to reduce air pollution are specified. Finally, some technical and economic consideration about shore-side power supply have been made in order to evaluate the feasibility and to assess the possible expected reduction of environmental impacts.

## 2. ENVIRONMENTAL REGULATIONS FOR PORT AREAS

During the last decades, several regulations have issued to regulate  $\text{NO}_x$  and  $\text{SO}_x$  emissions from ships e.g. IMO/MARPOL and EU set absolute limits on sulfur content in fuel and sulfur oxide and nitrogen oxide emissions from ships [4].  $\text{NO}_x$  emissions from marine diesel engine are closely related to a set of parameters representing the use of the engine, mainly: the fuel type, the temperature of combustion and the cruise speed. The Annex IV of MARPOL 73/78 [4] sets the following thresholds for  $\text{NO}_x$  emissions, depending on marine engine *rpm* values:

**Table I.**  $\text{NO}_x$  thresholds from marine engine

Date	Engine speed	Emission thresholds (g/kWh)
till 2011/01/01	<i>rpm</i> < 130	17.0
	130 < <i>rpm</i> < 2000	$45.0 \text{ rpm}^{-0.2}$
	<i>rpm</i> > 2000	9.8
from 2011/01/01 to 2016/01/01	<i>rpm</i> < 130	14.4
	130 < <i>rpm</i> < 2000	$44.0 \text{ rpm}^{-0.23}$
	<i>rpm</i> > 2000	7.7
after 2016/01/01	<i>rpm</i> < 130	3.4
	130 < <i>rpm</i> < 2000	$9.0 \text{ rpm}^{-0.2}$
	<i>rpm</i> > 2000	2.0

The main changes to Annex VI of MARPOL 73/78 are: *i*) a global progressive reduction in emissions of  $\text{SO}_x$ ,  $\text{NO}_x$  and particulate matter, and *ii*) the introduction of the Emission Control Areas (ECAs), defined as zones (such as ports close to big town) where admissible emission limits are highly reduced. Worldwide the threshold limit for  $\text{SO}_x$  that arising from the combustion process is < 4.5 %. The Annex VI of MARPOL 73/78 reduces this limit for port areas to the following values:

- < 1.0 % till 2015/01/01
- < 0.1 % after 2015/01/01

The deadline for the latter threshold has moved up to January 1<sup>st</sup> 2005 by EU Directive 2005/33/EC, that limits the amount of sulfur to 0.1% in all marine fuel used while at berth for more than two hours in European ports and by vessels on inland waterways [5].

## 3. EMISSION REDUCTION ANALYSIS

The Task 2 of the European Commission contract on Ship Emissions focused the attention on the measures and on the abatement technologies for main and auxiliary engines installed on ships [6]. In order to assess the resulting reduction, the cited work [6] presents general or common underlying assumptions and methods that can be useful in all the cases where available data are particularly limited or are affected by significant measurement uncertainty. For the sake of clarity, in Table II we have compared the emission factors arising from auxiliary engines using 0.1% sulphur fuel extracted from Task 2 with those carried out from a typical Italian electrical system.

**Table II.** Comparison between emission factor from low-sulphur fuel and electrical systems

Pollutant	Emission factor from Auxiliary engines using 0.1% sulphur [g/kWh]	Emission factor from a typical Italian electrical system [g/kWh]
$\text{NO}_x$	11.80	0.35
$\text{SO}_2$	0.46	0.46
$\text{CO}_2$	700	406
PM	0.30	0.03

It means that using electrical system to power supply the ships at berth will implies a reduction of about 94% for  $\text{NO}_x$ , 42% for  $\text{CO}_2$  and 90% for PM emissions.

In the first phase, this study focused on the estimation of environmental pollution due to the marine traffic at PoT for a two-years period (2010-2012) considering the vessel types and their relevant Gross Register Tonnage (*GRT*) in order to assess the emission of main pollutant during the berthing. Table III reports relevant data for each dock, giving a clear representation of analysis results.

Since not enough data were available about the Power Consumption (*PC*) for each ship, a rough value was estimated considering the approximate proportionality between the *GRT* and *PC* by means of a Power Tonnage Ratio (*PTR*):

$$PC = GRT \cdot PTR \quad (1)$$

Moreover, the auxiliary engines Average Power (*AP*) consumption during hotelling can be estimated by means of

$$AP = PC \cdot LF \quad (2)$$

where *LF* is the Load Factor that practically is a percentage of the *PC*. We hypothesized for this work a  $PC = 0.2$  kW/ton and a berthing  $LF = 0.45$ , values commonly accepted in technical literature [6].

## 5. POLLUTANT REDUCTION STRATEGIES

As well known, the limitation of  $\text{SO}_x$  can be achieved using low sulphur fuel while the  $\text{NO}_x$  reduction can be obtained only using high performance or new generation engine. For this reasons, a suitable technology has to be considered, aimed to limit the air pollution in harbor areas:

we considered the so-called Cold-Ironing (CI). CI technology is the process of powering a vessel with shore based electrical power in lieu using its on board auxiliary engine generator when the vessel is at the dock. This innovative technology will undoubtedly lead to a massive reduction of air pollutants from ships at berth since the on board diesel electric generators can be switched off and avoiding emission of noxious substances during hotelling.

The EU Commission suggested to Member States to promote the shore-side power supply particularly in ports where the industrial activities are predominant [7]. The high cost for low sulphured fuels and the opportunity to obtain tax benefits on shore-side power supply could subsidize navigation companies to retrofit their on-board electrical power plants in order to allow a suitable electrical connection of the ships to the berth. Since CI is a project with generally high initial costs, a technical analysis is required to derive the cost effectiveness of the infrastructure based upon the total emissions reduced for all pollutants over the expected life of the project; the aim of such analysis

techniques [8], [9], [10]. This approach will make Port Authority able to distinguish more pollutant sources and specific contribution of each activity.

A preliminary analysis suggests focusing further project hypotheses only about technically feasible docks, or better, about those with:

- higher power demand
- relevant higher pollutants emissions
- routinely of traffic.

The gathering data point out a negligible traffic for some berths and a significant number of ships for piers #2, #3 and #5 and the Oil and Container terminals (the latter located on the Multipurpose Pier). Obviously, there is a certain proportionality between traffic and power demand for a given dock. This is the underlie reason because pier #2 and #3 exhibit the greater mean daily power demand for each ship. It could be observed that even if pier #5 has a lower daily traffic, it needs a huge daily power since the high *GRT* of hotelling vessels.

The analysis suggests to limit the CI feasibility study to

**Table IV Analysis results for each dock**

<i>Dock</i>	<i>2-year period number of vessels</i>	<i>AP [kW]</i>	<i>Mean time of hotelling [h]</i>	<i>Vessel per day [n°/day]</i>	<i>Power demand dock/day [MW/day]</i>	<i>Estimated energy consumption [TWh/year]</i>
Quay #1	35	27 504	1 122	0.0	0.0	205 247
Pier #1 - Seaward end	14	8 001	507	0.0	0.0	7
Pier #1 - West side	215	330 029	10 425	0.3	0.2	1
Quay #2	182	177 022	8 415	0.2	0.1	774
Pier #2 - East side	464	2 771 551	21 600	0.6	1.7	335
Pier #2 - Seaward end	10	6 001	423	0.0	0.0	13 470
Pier #2 West side	150	368 524	6 048	0.2	0.2	1
Quay #3	147	88 516	6 708	0.2	0.1	501
Pier #3 - East side	586	1 036 598	22 575	0.8	0.6	134
Pier #3 - Seaward end	80	70 509	2 688	0.1	0.0	5 265
Pier #3 - West side	644	932 602	30 444	0.9	0.6	43
Quay #4	2	1 000	108	0.0	0.0	6 388
Pier #4 - East side landward	116	58 012	4 746	0.2	0.0	0
Pier #4 - East side	183	2 245 029	9 711	0.3	1.4	62
Oil Terminal	975	3 991 190	41 490	1.3	2.5	4 905
Buoy Moornings	54	810 011	2 229	0.1	0.5	37 259
Pier #5	1164	2 575 205	40 233	1.6	1.6	406
Multipurpose Pier	1154	8 771 230	41 238	1.6	5.4	23 312
Quay #5	83	367 515	3 324	0.1	0.2	81 384

is to identify the most convenient docks to be wired.

In order to correctly assess the environmental impacts of the harbor activities on the air quality indexes for the residential area located close to the PoT is needed suitable decision-making tools based on data acquired by a suitable and efficient environmental monitoring system, a process control system and the relevant Source Apportionment

three piers: the Oil Terminal, the Container terminal and the Pier #2; this approach permits a tradeoff between the air pollution reduction and the economic effort. Therefore the proposal to limit the number of docks to cold-iron and to design of an analytic environmental monitoring and control system, was the first step in rational direction for purposes of environmental requalification of PoT.

On a pier basis, the emissions reduction achieved per year by employing shore side electricity can be expressed as:

$$ER = AP \cdot UR \cdot 365 \cdot 24 \cdot ERF \quad (3)$$

where *UR* is the Utilization Rate of shore-side electricity at berth (here it is considered the worst case, so *UR* = 1), and *ERF* is the specific Emission Reduction Factor (expressed in g/kWh). Table V reports an estimate of pollutant reduction for the dock chosen for the CI power system project when  $ERF_{NOx} = 11.8$  g/kWh and  $ERF_{CO_2} = 700$  g / kWh [11] - [12].

**Table V - Estimate of pollutant reduction from the CI power system project**

	<i>NO<sub>x</sub> reduction</i> [ton / year]	<i>CO<sub>2</sub> reduction</i> [ton / year]
Container Terminal	676	15 400
Oil Terminal	218	5 621
Pier #2	203	4 665
<b>Total</b>	<b>1 097</b>	<b>25 686</b>

The environmental results obtainable by CI could be further improved using renewable power sources (i.e. photovoltaic or eolic ones). In such a case a careful analysis should be carried out in order to evaluate the actual availability of large areas and the possible negative impact on harbor operations.

It is worth to note that the on-board power system should be compatible with the dock-system; unfortunately there is no a standardization between voltage and frequency levels for marine power systems, so differences can arise depending upon the country where the ships were manufactured. Consequently, ships have to be retrofitted for the shore side power supply, therefore this additional cost must be taken into account.

## 6. CONCLUSIONS

With growing awareness for sustainable development is increasing the people sensitivity in the matter of both pollutant and particulate emission from manufacturing; this is cause for a deep social anxiety. The requalification of the whole territory of Taranto has to consider the negotiation between the production requests and the sustainability of new activities. Monitoring the noxious emissions by berthing ships at PoT is an undoubtedly necessary condition to fulfill this objective.

In this study a preliminary analysis with some technical considerations was made by cold ironing technique, and the most convenient docks to be powered were identified, then the relevant reduction of pollutant was assessed.

CI is only a first milestone to make an eco-sustainable port; a lot of measurements are necessary to complete the requalification process, e.g., the use of renewable power sources, the implementation of the smart grid paradigm to manage the power of whole electrical system, the design and implementation of an advanced monitoring and control

system for air pollutants and so on. In order to make a successful and feasible CI project, it is also essential to establish a general agreement between Port Authority, berth leaseholders and ships owners.

It should be expected that in the next years EU Community will focus its attention on harbor emission, so on one hand new regulation should be issued to impose the CI to the Port Authorities, on the other hand founding programs to support requalification actions for harbors should be strongly provided.

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