

## AIR EMISSION INDUCTION ANALYSIS OVERVIEW FROM MARITIME TRANSPORT SECTOR

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**Abstract-** The maritime sector is one of the dynamic sectors regarding development and innovations. In the last decades, the sector has experienced energetic development, regarding ship size, the economy of scale, and efficiency. Even though shipping represents more than 90% of the global trade, maritime transport accounts for only 3% of the world’s greenhouse gas (GHG) emissions. With no measures taken to reduce the emission of the GHG, this figure will be increased by 50% to 250% therefore the International Maritime Organization has decided to reduce CO<sub>2</sub> emission by 40% by 2030 and continue to cut down to 70% by 2050, compared to 2008. This objective aligns with SDG 13 of the UN to take immediate action to address climate change and its consequences. Being a maritime country, Albania has the obligation to implement all international obligations that derive from conventions and other international instruments where it adheres. Albania is part of the MARPOL 73/78 IMO Convention and has rectified Annex VI of this convention. In this paper, we will present the challenges of the Albanian Maritime Administration that must face in practical implementing the Annex VI provisions of the above-mentioned Convention.

**Keywords:** MARPOL, Annex VI, Air Emissions, Marine Fuels.

### 1. INTRODUCTION

Air pollution is among the most significant concerns regarding the environment. Climate change has been one of the 17 (SDG) of the UN and one of the contributors to climate change is carbon emissions [1]. With no measures taken to reduce the emission of the GHG, this figure will be increased by 50% to 250% [2] therefore the International Maritime Organization has decided to reduce CO<sub>2</sub> emission by 40% by 2030 [2-4], committed to reducing to 70% by 2050, versus 2008. This objective satisfies SDG 13 of the UN to take immediate action to address climate change and its consequences [1]. European Union adopted very ambitious targets to curb down carbon release up to 55% by 2030 in comparison to 1990 emissions values. According to the EU report on CO<sub>2</sub>

emissions for 2019, maritime transport in the EU [5] is responsible for more than 3% of total CO<sub>2</sub> emissions and they are likely to grow in the future, thus reinforcing the need for reduction efforts. The biggest share of the emissions comes from container ships, and 13% comes from bulkers [5]. The Figure 1 depicts the shipping air emissions and their impacts.

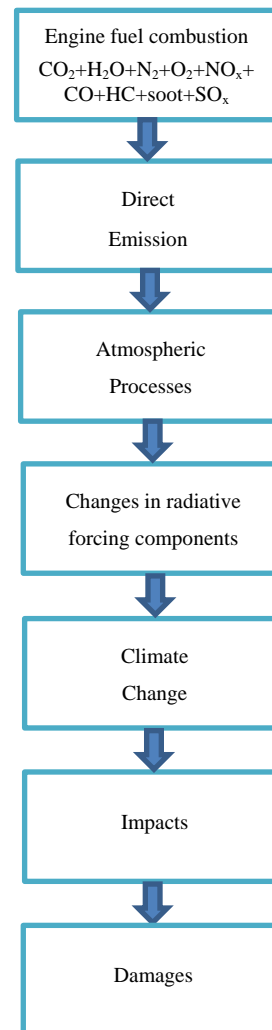


Figure 1. Shipping air emission and impacts

In 2015 the amount of CO<sub>2</sub> emitted by ships [6] was 932 million tonnes and Figure 2 shows the distribution of CO<sub>2</sub> from total shipping and most of the pollution was generated by the following types of ships.

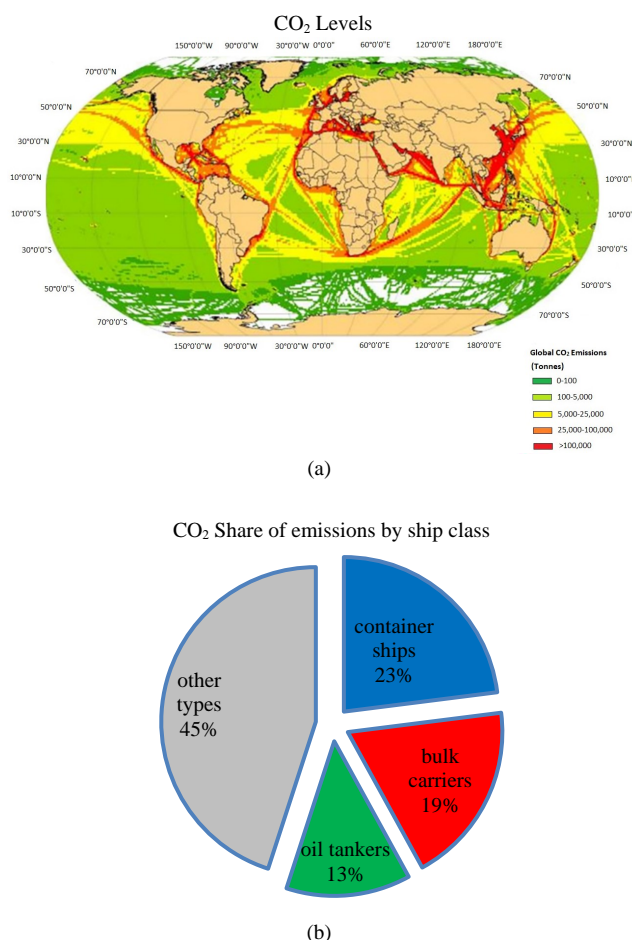


Figure 2. (a) Global CO<sub>2</sub> emissions, (b) ship class CO<sub>2</sub> emissions [6]

MARPOL Annex VI regulates ship emissions of greenhouse gases and forbids the purposeful release of ozone-depleting chemicals and volatile organic compounds. The main objective of MARPOL Annex VI are as follows [4]:

- Create awareness among the maritime community (shipowners and crews) regarding the importance of preventing air pollution and its consequences on climate change,
- Set the levels of compliance regarding the requirements defined in Annex VI of MARPOL,
- Create awareness among maritime administrations (Flag State and Port State control) that enforcing these requirements is a high priority,

Following other annexes of MARPOL which address pollutions coming from oil liquids that are toxic, Hazardous compounds are transported in packaged form, sewage, waste, the last Annex of the Convention addresses pollutions coming from air and energy efficiency [4]. The main provisions of Annex VI of MARPOL are four main sections [9]:

- I. Deals with general provisions such as application, definitions, exceptions, exemptions, and equivalents (Reg. 1-4)
- II. Defines the main obligations of Flag State and Port State Control, starting with surveys, certification, and means of control (Reg. 5-11) [7].
- III. Sets the requirements for control of emissions. It sets the requirements for onboard required equipment and installations as well as the requirements for reception facilities and fuel oil availability and quality (Reg. 12-18)
- IV. Sets the requirements for energy efficiency and regulations EEDI, SEEMP, DCS (data collection), and technology transfer (Reg. 19-23).

This paper will be focused on the effects of MARPOL Annex VI provisions in the limitation of air emissions generated by ships in Albania. To this purpose, a gap analysis is done to determine the existing gaps and challenges in the practical implementation process of the provisions of Annex VI by the Albanian maritime administration. This process is divided into three steps which are as follows:

- Firstly, a gap analyses in defining the alignment level of the Albanian rules and regulations regarding the implementation of Annex VI of MARPOL,
- Secondly, identification of the administrative resources required for the enforcement of the requirements of Annex VI of the convention,
- Thirdly, the evaluation of the proper infrastructure regarding reception facilities and fuel oil availabilities in Albanian ports.

## 2. CURRENT SITUATION AND ANALYTICAL RESULTS

In terms of air emissions in Albania, the energy sector is the major contributor to greenhouse gas emissions (GHG), accounting for 44%, followed by agriculture at 27,12%. Transport is the sector that is rapidly increasing the air emissions. Figure 3 shows the CO<sub>2</sub> emissions per capita in Albania from 1992 up to 2020 [17].

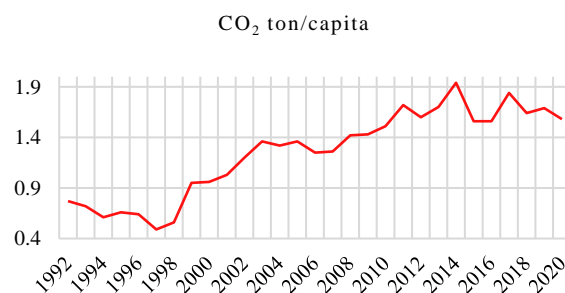


Figure 3. CO<sub>2</sub> emissions per capita in Albania 1992-2020

Albania is a coastal country with a coastline of 296 miles and along its coast, there are 6 commercial ports, 3oil ports, 4 fishing ports, and several marinas under construction [12]. Maritime transport in Albania represents 59.2% of total export imports and Durres remains the most important port of Albania through which more than 91% of the seaborne cargoes nationwide are handled [18].

The type of traffic is different from port to port. Durres is the biggest port in the country, counting for most ships calling this port. There are two other ports north of the existing port one dedicated to LNG and the other is an MBM type port handling liquid bulk (oil port). Shengjin is more a commercial port mainly handling general cargo vessels and fishing port. Vlora is a passenger port and there is an oil port as well. Saranda is more a touristic port with a cruiser berth, and it has daily connections (passenger liners) with the neighbor port of Corfu.

Regarding the traffic observation in Albania [7], Ro/Ro and passenger ships are the most frequent vessels calling the port (60.93%) followed by general cargo vessels (12.53%), bulkers (4.44%), and container ships (3.69%). The overall number of calls in Albanian ports during the year 2021 was 5774, including touristic yachts. Out of these numbers, 3500 calls were from Ro/Ro and passenger ships which are performing daily trips between Albanian ports (Durres, Vlore, Sarande) and Italian ports (Bari and Brindisi) and Greek Port (Corfu). Figure 4 are shown the share of ships calling Albanian ports according to their class. According to the figures provided by authorities, vessels calling Durres port are of bigger size, and their air emission counts for most of the air pollution coming from ships.

Types of ships calling albanian ports - 2021

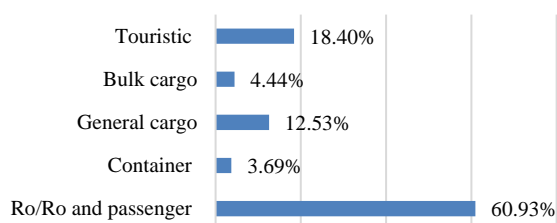


Figure 4. Maritime traffic in Albania according to ship type

The number of ships flying the Albanian flag is very limited (only 8 ships are registered under the Albanian flag), therefore almost all cargoes arriving to and transported from Albanian ports are carried by foreign flagships.

To reduce air pollution and the pollution generated using fuels, in 2019 Albanian Government approved a DCM (No. 429 date 26.06.2019) "on the quality of certain fuels for thermo, civilian and industrial use as well as for the use from waterborne crafts (maritime, and inland waterways - lakes and rivers)". Chapter IV of this DCM defines the upper limits of sulfur presence in fuels used by ships entering territorial waters of the Republic of Albania, EEZ, and in the areas of pollution control of Sox and from passenger ships. Tables 1 and 2 have shown the allowed environmental indicators for fuels which would be allowed to be used by ships in Albania [13].

Table 1. Allowed environmental indicators for fuels according to DCM 429/1 [13]

Fuel Type	Unit	Kerosene	Gasoil < 0.1	Gasoil > 0.1
		A	B	C
Flash point	°C	bigger 28	bigger 55	bigger 52
Volume mas	Kg/m <sup>3</sup>	770-830	815-875	815-875
Distillation				
in 150 °C	% v/v	-	less 2	less 2
in 210 °C	% v/v	less 90		
in 250 °C	% v/v	less 65	less 65	
in 300 °C	% v/v			less 60
in 350 °C	% v/v		bigger 85	less 85
Nickel + Vanad	mg/kg			
PCB (Polychlorobiphenyl)	mg/kg	less 15	less 15	less 15
Polychloroterphenyl	mg/kg	less 10	less 10	less 10
Coloring		P2	P2	P2

Table 2. Environmental indicators for marine fuel according to DCM 429/19 [13]

Indicators	Unit	Limit	Products			
			DMX	DMA	DMZ	DMB
Volume mass, 15° C	Kg/m <sup>3</sup>	Max	-	890	890	900
Flashing point	° C	Min	43	60	60	60
Index of cetan	-	Min	45	40	40	30
Sulphur content	%(m/m)	Max	1.00	1.00	1.00	1.5
Sulphured hydrogen content	mg/kg	Max	2.00	2.00	2.00	2.00
Carbon residuals	%(m/m)	Max	0.3	0.3	0.3	

Table 3. Emission limits according to DCM 429/19 [13]

Sulphur content in marine fuels	Emissions of SO2 (ppm) CO2 (% v/v)
3.50	151.7
1.50	65.0
1.00	43.3
0.50	21.7
0.10	4.3

Equivalent values of pollutant emissions in air for marine fuel is given in Table 3.

These values are in line with Annex VI provisions. Regulation 18 of Annex VI defines [14]: "The following requirements apply to fuel oil for ignition purposes provided to and utilized onboard ships to which this Annex applies:

- Fuel oil must be a mixture of hydrocarbons produced from the refining of petroleum.
- The fuel must be acid-free.
- The fuel must not contain any additional substances or chemical waste of any kind.
- Endangers the safety of the ships or reduces the efficiency of the machinery, or
- Does not present any danger to the crew, or
- Contributes to increased air pollution in the long run.
- Must not be over the defined sulfur limit set forth in Reg.14 of the relevant Annex (6) of the Convention
- Must not exceed the limits of NOx release from the engine as described in Reg 13
- Shall not contain inorganic acid.

Table 4 depicts the limits of the Sulphur content decided by IMO [14].

Table 4. limits of Sulphur content decided by IMO [14]

Global sulfur limits m/m	Time applied	ECAs Sulphur limits	Time applied
4.5%	Prior to Jan. 1st 2012	1.50% m/m	Prior to Jan. 1st 2012
3,50%	On or later January 1st 2012	1.00% m/m	On or later Jan. 1st 2012
0,50%	On or later Jan. 1st 2020	0.10%	On or later January 1st 2015

Annex VI sets forth the standards of emissions to engines onboard ships and was reviewed in 2008. Significantly tightening the allowed emission limits of NO<sub>x</sub> by introducing additional control rules applicable to ships built recently. Tiers of control are based on the ship's build year and NO<sub>x</sub> emission restrictions are presented as overall weight in g/kWh dependent on the engine rpm. When ships operate in Emission Controlled Areas (ECA) Tier 3 applies. Table 5 presents emission limit values according to tiers and ECA-s.

Table 5. Emission limits value according to tiers and ship construction date [14]

Tier	Ship built date (On or later)	Total weight of NO <sub>x</sub> emission limit value g/kWh		
		rpm<130	rpm = 130-1999	rpm>2000
I	Jan. 1st 2000	17.0	45n <sup>-0.2</sup>	9.8
II	Jan. 1st 2011	14.4	44n <sup>-0.23</sup>	7.7
III	Jan. 1st 2016	3.4	9n <sup>-0.2</sup>	2.0

Albania has become part of MARPOL 73/78 since 2006 and has rectified all annexes of this convention. The institution responsible for monitoring and enforcing the standards outlined in Annex VI is the General Maritime Directorate. Within the structure of the General Maritime Directorate (GMD), there is the Port State Control department, Flag State Control department, and the department of Maritime Environment. General administration must organize surveys to all ships of 400 GT and above, on air pollution prevention measures taken from them under the provisions of the convention on pollution prevention. Before the ship is put into service first survey is to be performed [15]. The ship is subject to an intermediate survey. This survey is affected twenty-seven months after the date of the initial survey. For ships flying the Albanian flag, surveys may be performed by the Recognized Organization (RO) (Albanian Register of Shipping). Figure 5 depicts NO<sub>x</sub> emissions limits following Tier and ECAs.

Port state control officers should control the IEEC certificate if the ship should have one. Referring to Regulation 13 of Annex 6 "every diesel engine with an output over130 kW is built or undergoes considerable transformation, on or later than 1 January 2000, as well as any device or equipment designed to be utilized only in an emergency is subject to emissions control" [15]. PSCO must ensure that no ozone-depleting compounds are intentionally released.

Except for limited releases connected when an ozone-depleting substance is captured or recycled, purposeful

harmful substances release includes emissions that happen during the maintenance, repair, or disposal of pieces of machinery.

Regulation 17 requires Albanian port authorities to ensure that suitable port collecting facilities are available to fulfill the demands of ships using their port/terminal where the discharge of exhaust gas cleaning residues into the maritime environment is forbidden by Annex 6 provisions, for the reception of exhaust gas cleaning residues from approved exhaust gas cleaning systems [14] [15].

Ships laid down on or later than 1 January 2000 can install incinerators on board according to provisions of Appendix IV of Annex VI [24]. PSCO should identify the crew responsible and evaluate how the person is trained. Incinerators should be operated only in allowed areas.

Another requirement PSCO must observe is the SEEMP. The plan for Energy Efficiency of the Ship (SEEMP) is required to be part of the ship documentation set for all ships of 400 GT upwards and this will become part of the ISM system [10].

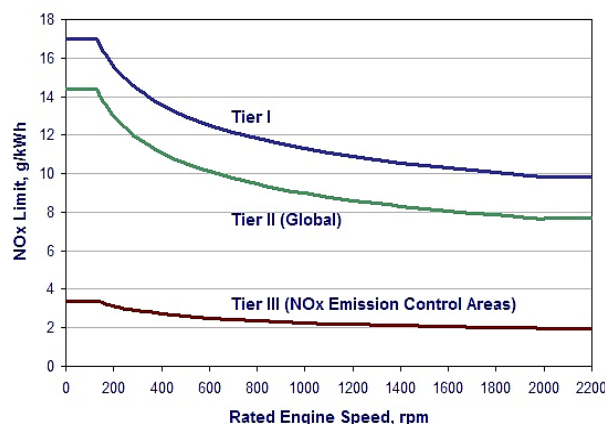


Figure 5. NO<sub>x</sub> emission limits according to Tiers and ECAs [14]

A big challenge today remains the ability of the market to offer Marine Fuel Oils (MFO) with a sulfur content of 0.50% m/m, and this standard has come into effect since 1 January 2020.

This challenge is more present in ECAs where this standard is 0.10% m/m [23]. The Adriatic and the Ionian Sea are not part of the ECAs; therefore, the required limit is 0.50 m/m. Observing the traffic in the Albanian ports, it is noted that 95% of the ships calling Albanian ports are older than 11 years old, and refitting the engines is costly. The alternative remains using exhaust gas cleaning systems (EGCs).

The only advantage of EGCSs is that it avoids refitting the ship's engines. To reduce Sulphur content in MFO by more than 0.50% to this limit results in energy, and again this energy is produced by fossil fuel. On the other hand, using low sulfur content MFOs generates less CO<sub>2</sub> emissions. Because of the implementation of the EEDI (energy efficiency design Index) by 2025, it is calculated that the CO<sub>2</sub> emission will be reduced by 30%.

## 6. CONCLUSIONS

Climate change and air pollution is the main global concern in today's world. Supporting UN sustainable development goals IMO is committed to undertaking and implementing all necessary steps to reduce NO<sub>x</sub> emissions [17]. Its objectives are to cut down the overall emission of GHG by a minimum of 50% by 2030 versus 2008. The strategy has an explicit reference to a CO<sub>2</sub> emissions reduction pathway that is in line with objectives set forth from Paris Agreement

To limit air emissions of GHG in Albanian Exclusive Economic Area, territorial waters and in Ports, the Albanian government has started the implementation process by adopting the Decision of the Council of Ministers No. 429 date 26.06.2019 "On the quality of some fuels for thermos, civilian and industrial use as well as for the use from waterborne crafts (maritime, and inland waterways - lakes and rivers" whereby it sets forth the standards of marine fuel and emission levels. These steps are in line with Annex VI of the MARPOL 73/78.

Referring to traffic observations, most ships arriving and departing from Albanian ports are flying foreign flags, therefore Albanian maritime authorities must enhance Port and Flag State Officers' capabilities to be able to check the implementation of the requirements of Annex VI of all ships calling Albanian ports. The overview of these new regulations and standards has had a significant effect on the shipping industry, ship owners, and port administrations to provide adequate ship reception facilities [22].

Proper implementation of these measures will contribute to an emission reduction of NO<sub>x</sub> generated by ships making this mode of transportation more environmentally friendly. Transposition of the NEC Directive, focusing on reliable emission inventories and projections [19, 20].

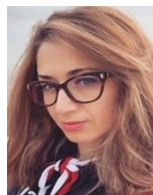
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### **BIOGRAPHIES**



**Osman Metalla** was born in Durres, Albania, on 17 July 1964. He received the B.Sc. and M.Sc. degrees in Mechanical Engineering and Public Administration from Albanian Naval Academy and University of Tirana in 1986 and 2006, respectively. He received the Ph.D. degree in Transport Management from Tirana University, Albania, in 2010. Currently he is the Dean of Professional Studies Faculty at Durres "Aleksander Moisiu" University, Albania and holds the academic title of Associated Professor. His main field of research is port sector, shipping, management, transport and logistics.



**Marsida Klemo** was born in Durres, Albania, in 1982. She graduated in Physics for five years from Faculty of Natural Sciences, Tirana University, Albania, in 2010 and received Ph.D. degree in 2014. Since 2008 until now she works as a Physicist lecturer at Professional Studies Faculty, "Alexander Moisiu" Durres, University, Albania. From 2014 till now she holds the position of the Head of Applied and Natural Sciences Department. Her main field of research is applied physics and biophysics. Currently, she is working as a lecturer. She has also have been engaged with scientific activities such as conferences, journals and projects.