



**MEDITERRANEAN ACTION PLAN (MAP)
REGIONAL MARINE POLLUTION EMERGENCY RESPONSE CENTRE FOR THE
MEDITERRANEAN SEA (REMPEC)**

Regional Workshop on Ratification and Effective Implementation
of MARPOL Annex VI

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Agenda Item 8

**EURO MED COOPERATION ON MARITIME SAFETY AND PREVENTION OF POLLUTION FROM
SHIPS (SAFEMED IV PROJECT)**

Note by the European Maritime Safety Agency (EMSA)

SUMMARY

Executive Summary: This document provides information on the activities that the European Maritime Safety Agency (EMSA) has performed within the domain of the protection of the marine environment that are of relevance to the ratification and effective implementation of MARPOL Annex VI.

Action to be taken: Paragraph 7

Related documents:

Background

1 As maritime safety, maritime security and protection of the marine environment are common concerns of the EU MS and Non-EU countries bordering the Mediterranean Sea, the European Maritime Safety Agency (EMSA) is implementing the Euro Med Cooperation on Maritime Safety and Prevention of Pollution from Ships Project (SAFEMED IV project), a project for technical assistance bringing together national, European and international stakeholders with the aim to raise the safety, security and protection of marine environment standards.

2 The project is funded by DG NEAR and has an overall budget of 4 million Euros. The project started on 16 March 2017 and will last up until 31 March 2021.

3 The beneficiary states are: Algeria, Egypt, Israel, Jordan, Libya, Lebanon, Morocco, Palestine, and Tunisia. With a view to implement the maritime aspects of the Union for the Mediterranean (UfM) Regional Transport Action Plan 2014-2020, the overall objectives of the project, are:

- .1 improved maritime safety;
- .2 improved security of ships and port facilities;
- .3 reduced pollution to the marine environment;
- .4 improved level of maritime training and qualification of seafarers;
- .5 improved living and working conditions on board ships; and

- .6 improved cooperation between institutions and agencies with related competencies in coast guard functions in the Mediterranean to facilitate multilateral cooperation on a wide range of issues such as maritime safety, security and environmental protection activities.

4 The project has 9 components namely: Flag State Implementation, Port State Control, Vessel Traffic Monitoring and Information Systems, Protection of the marine environment, Human Element in maritime safety, Security of ships and port facilities, Mediterranean Coast Guard Functions Forum, Bilateral activities and Communication.

5 Under Component 4 (Protection of the Marine Environment) activities are performed focusing on raising awareness of the need of the beneficiaries to accede to and implement those international conventions to which they are still not Parties, to fully implement those to which they are already Parties, and to enact legislation with approximation to the EU acquis, to provide them with the necessary technical assistance and support in the process as well as to provide the beneficiaries with operational support in the area of marine environmental protection.

6 With a view to examining potential synergies with other ongoing or expected activities in the Mediterranean region, thus avoiding duplication of work and effort, the current document describes a series of activities that the European Maritime Safety Agency (EMSA) has performed within the domain of the protection of the marine environment that are of relevance to the Regional Workshop on ratification and effective implementation of MARPOL Annex VI and in particular with:

- .1 Building up of the necessary national capacity for the implementation of relevant legal acts, as set out in **Annex I** to the present document;
- .2 Studies performed by EMSA on alternative fuels and abatement technologies, as set out in **Annex II** to the present document; and
- .3 Emission Inventories in support of examining the possibility of designating the Mediterranean Sea as SECA under MARPOL Annex VI, as set out in **Annex III** to the present document.

Action requested by the Meeting

7 **The Meeting is invited to take note** of the information provided in the present document.

ANNEX I

Capacity building in the field of marine environmental protection

Background

The European Maritime Safety Agency (EMSA) has been established under Regulation (EC) No. 1406/2002 of the European Parliament and of the Council for the purpose of ensuring a high, uniform and effective level of maritime safety and prevention of pollution by ships. Article 2.3 of Regulation (EC) No. 1406/2002 as amended, prescribes a core task for EMSA to “organise, where appropriate, relevant training activities in fields which are the responsibility of the Member States”.

The EMSA provides EU Member States with the necessary means to act effectively to enhance overall maritime safety and ship pollution prevention rules. In this respect EMSA is supporting the building up of the necessary national capacity for the implementation of relevant legal acts of the Union through:

- Training through in-house, regional and national trainings or seminars;
- Guidance, recommendations and best practices developed by the competent personnel of the Agency;
- Enhancement of existing tools and development of new tools such as MaKCs, THETIS and RuleCheck.

As part of the projects for technical assistance funded by the European Commission (EC), EMSA offers cooperation and assistance in the fields of maritime safety and security, prevention of pollution from ships and marine environmental issues to:

- EU candidate and potential candidate countries
- Non-EU Mediterranean countries beneficiaries of the SAFEMED IV project;
- Black and Caspian Sea Project.

Training sessions

The Agency develops and delivers training activities and through its training programme assists the beneficiary countries.

For the last three years EMSA has been organising training activities in relation to:

- Directive (EU) 2016/802 Sulphur content of marine fuels. The course provides an overview of the ship’s inspection process, including the inspection of ships’ documentation and on-board spot sampling and eventual reporting of the inspection as foreseen by the relevant Directive and the Guidance for Sulphur Inspectors developed by the Agency;
- EMSA Guidance on LNG Bunkering to Port Authorities/Administrations. The training course is primarily intended to provide a general overview of the EMSA Guidance on LNG Bunkering to Port Authorities/Administrations, including a collection of best practice elements in the different aspects of LNG bunkering with the objective to support Port Authorities and Administrations in the selection of the best applicable framework to define and implement adequate support and control measures, like Environmental best practice, different applicable Regulatory frameworks, Safety Distances and Simultaneous Operations;
- Exhaust Gas Cleaning Systems. This training focuses on highlighting and understanding the principles behind EGCS technology driven by international sulphur emissions obligations with the global 0.50% limit for 2020, implementation of Directive (EU) 2016/802, the inspection of ships under PSC/Sulphur Inspection with emission abatement technology installed and preparing PSC/Sulphur inspectors for the practical aspects of EGCS installations;

- Training on Monitoring, Reporting & Verification of carbon dioxide emissions from maritime transport, & amending Directive 2009/16/EC. The training aims to facilitate the understanding of the EU MRV Regulatory Framework towards a harmonised as well as effective implementation and enforcement. It will also provide the opportunity from a Member State user perspective, to provide familiarisation with THETIS-MRV - the dedicated information system in support of the EU MRV Regulation.

Guidance

- Sulphur Inspection Guidance: Intended to provide guidance for a harmonised approach to the inspection of ships, ascertaining their compliance, identifying non-compliances and applying control procedures for the enforcement of Directive (EU) 2016/802 (codification of Council Directive 1999/32/EC), as regards the sulphur content of marine fuels.
- Guidance on LNG Bunkering to Port Authorities and Administrations. Prepared in close cooperation with the European Commission (DG MOVE), EU Members States and Industry within the context of ESSF, it aims to support port authorities and administrations backing the use of LNG as ship fuel, as part of a joint effort to increase safety and sustainability.
- EMSA Guidance on the inventory of Hazardous Materials. It provides best practice guidance and a harmonised approach to the development and maintenance of inventories of hazardous materials in accordance with Article 5 and Article 12 of the Regulation (EU) 1257/2013 of the European Parliament and the Council on ship recycling. The document has been prepared on the basis of current knowledge and experience from the Member States, the industry and EMSA and other stakeholders. Furthermore, the document provides guidance for a harmonised and effective approach to the inspection of ships ascertaining their compliance, to identifying non-compliances and to applying control procedures for the enforcement of the Regulation as regards the development and maintenance of an IHM on board ships.
- Guidance for ship inspections under the Port Reception Facilities Directive (Dir 2000/59/EC). The goal of the Guidance is to provide a harmonised approach to the enforcement of Directive 2000/59/EC on Port Reception Facilities for Ship-Generated Waste and Cargo Residues (hereafter referred to as 'the PRF Directive'). The guidance has been developed to facilitate Ship Inspections that are presently being undertaken by the European Union Member States (hereafter referred to as MS) to enforce the PRF Directive.

EMSA guidance are available for download at the Agency website.

Tools

- RuleCheck. It is a web-based decision supporting tool originally designed for the competent PSC authorities in the Paris MoU domain, and is an up-to-date repository of maritime legislation. RuleCheck facilitates the work of the Port State Control Officers (PSCOs) by filtering the applicable requirements of the international instruments and regional procedures for a specific ship according to its type, construction date, size etc. or through the correlation of an identified deficiency code with applicable reference from an international convention. The search function gives PSCOs ready access to relevant and targeted information, avoiding the need to consult hard copies. Access to RuleCheck has been extended to all staff from maritime administrations from the EU Member States.
- MaKCs. It is a web-based platform offering distance learning through pre-developed eLearning modules. A catalogue of online courses is currently available to facilitate users within maritime administrations to implement and enforce IMO and ILO relevant instruments

- THETIS. It is an inspection data base, developed, maintained and hosted by EMSA that supports the Port State Control inspection regime foreseen by Directive 2009/16/EC as amended and its four implementing regulations. THETIS also interfaces with a number of other maritime safety-related databases including THETIS EU. THETIS EU caters provisions related to Port State Control which are not included in the PSC Directive and facilitate Flag State Control requirements. THETIS EU since 1st of January 2015 serves as a platform to record and exchange information on the results of individual compliance verifications performed by Member States as foreseen, for instance, by Directive (EU) 2016/802 on the reduction in the sulphur content of marine fuels, and since April 2016 serves as a platform to record and exchange information on the results of inspections foreseen by Directive 2000/59/EC on port reception facilities. Non-EU MSs which are beneficiary of one of the three EU financed projects for provision of technical assistance to Enlargement and Neighbouring countries could get access to THETIS-EU if they on voluntary basis decide to implement the relevant EU legislation.

- THETIS-MED. It is being developed by EMSA within the context of the SAFEMED IV project to provide the MEDMOU on PSC with an updated database enabling its Members to fully implement the adopted MEDMOU procedures. THETIS-MED is supposed to replace the current MEDMOU database by 1 January 2020 and will also allow a further harmonisation between PSC inspections carried out in the European and Mediterranean regions.

Following the above States could take valuable input in relation to the implementation of forthcoming or newly adopted International / EU Legislation and initiatives on the reduction of SO_x and NO_x emissions, the technical developments related to alternative fuels for ships including abatement methods, the Implementation of the EU MRV CO₂ Regulation as well as in the International context on future policy developments in this area.

ANNEX II

EMSA Studies on Alternative Fuels

1. Biofuels Study (Service Contract EMSA/OP/03/2011) - Main Outcomes

- Study developed with ECOFYS covering the wide scope of possible biofuel applications for ships, addressing technical aspects, production, sustainability and safety of the use of different bio-sourced alternative fuels.
- The study concluded that there is currently a market for biofuels to be used on-board ships based on current policy and support schemes, high operational costs and environmental benefits, having identified the most promising Biofuels for on-board use: Biodiesel, Straight vegetable oil (SVO), Bio-ethanol, Bio-LNG/methane, Pyrolysis bio-oil and Di-methyl ether (DME).
- Biofuels are a sustainable alternative to conventional marine fossil fuels. Its use would contribute towards lower carbon intensity values while improving local air quality standards.
- The most relevant parameters limiting its potential are: availability, technological uptake R&D, on-board technical integration and operational consequences.
- From a market perspective, market-driven incentives are also available. Introduction of biofuels is however still limited.
- Map created with all locations throughout Europe where Biofuels are produced (Bioethanol and Biodiesel). A remarkably relevant map produced in the context of the EMSA study on biofuels has been the production in the EU (for both biodiesel and bio-ethanol). Availability would be no problem, based on the comprehensive coverage of production sites for these two fuel products.

2. Study on Standards and Rules for Bunkering of Gas Fuelled Ship (Service Contract EMSA/OP/06/2012) - Main Outcomes

- The Study on Standards and Rules for Bunkering of Gas Fuelled Ships, where EMSA worked closely with Germanischer Lloyd, focused on the evaluation of the regulatory frame for LNG as fuel for shipping, having been one of the first studies addressing the relevant barriers, gaps and specific needs for the development of the specific EU framework for LNG as fuel for shipping.
- Specific focus on bunkering and ship-to-shore interface where some controversial barriers could be found.
- Gap Analysis results - All Gaps identified were analysed and recommendations to close these gaps also provided. Through the support to the EC, Member States, participation in the ESSF and IMO, EMSA has been working close to all different stakeholders. The 20 Gaps identified have evolved to 40 in the EU 4 LOT study on LNG, with
 - Gap 1 Regulation of LNG as Marine Fuel
 - Gap 2 Standard on LNG Bunkering
 - Gap 3 LNG Bunkering Process/ Responsibilities
 - Gap 4 Distinction LNG as Cargo VS LNG as Fuel
 - Gap 5 Portable LNG Fuel Tanks
 - Gap 7 Inland Waterways limitation on use of LNG fuel
 - Gap 8 Standards for Small Scale LNG missing
 - Gap 9.1 Common Risk Assessment approach & criteria
 - Gap 9.2 SIMOPS
 - Gap 9.3 Harmonized Safety Distances
 - Gap 9.4 Accreditation for Bunker Suppliers
 - Gap 9.5 Emergency Plans
 - Gap 10.1 Training – Crew inland waterways
 - Gap 10.2 Training/Competencies LNG fuelled IMO/STCW
 - GAP 11 Standard on LNG fuel quality
 - Gap 13 Standard LNG fuel sampling
 - Gap 14 Compatibility of communications/ESD
 - Gap 15 Gas measurement procedures/equipment
 - Gap 16 Guidance to avoid Methane Release
- The EMSA Study Evolved to a larger Study by the European Commission divided into 4 LOTS. More Gaps have been identified, Recommendations and Policy Options designed to assist the uptake of LNG as Fuel.

- The study was object of analysis and decision support to the European Sustainable Shipping Forum on LNG as a Marine Fuel. Understanding the complex framework for LNG as a marine fuel, the ESSF LNG has identified the clear need to provide Port Authorities and Administrations with adequate guidance on the development of the adequate control measures for LNG bunkering. EMSA has been mandated for the development of such guidance by the ESSF and the European Commission. Following the inclusion of the project in EMSA's Work Programme for 2016, the work was initiated having been published, on its first version, on the 6th February 2018.

3. Study on the use of Ethyl/Methyl Alcohols for Shipping (Service Contract EMSA/OP/06/2012) - Main Outcomes

- The Study on the use of Ethyl-Methyl alcohols in shipping was developed in cooperation with SSPA Sweden and looked for a variety of aspects regarding the economic feasibility and safety of the use of ethyl/methyl alcohols as alternative fuels. The study is divided into:
 - Fuel Quality & Availability
 - Environmental Potential
 - Engine Technology
 - Economical Aspects/ Business Case
 - Methanol vs HFO+Scrubber/ LNG
 - Safety Assessment
- Incorporated experience from first world Methanol fuelled Ship (MV STENA GERMANICA), an EU co-funded project considered as a main milestone for the use of methanol as fuel for ships. Elements from the project were included in the study which made specific focus to the aspects related to the methanol tanks, fuel containment system, inertization through tank blanketing and specific safety related aspects.
- Comparison of Environmental Potential between ethyl/methyl alcohols produced from renewable resources and those originated from fossil fuels. "Well-to-Wake" approach used to evaluate the complete environmental impact of ethyl/methyl alcohols.
- The study has been presented in Brussels, at the ESSF in January 2016 and in London, IMO CCC3, in September 2016, having been positively received through and INF paper which has then been used for the support to the development of the relevant provisions for the Interim Guidelines for ships using ethyl/methyl alcohols as fuel. These IMO Guidelines have just been concluded at CCC5 sub-committee, earlier this month.
- A Safety Assessment covered the relevant typified hazards, taking into consideration different possible general arrangement on generic designs for RO-PAX and cargo ship. Risk Matrices were produced following a Qualitative Risk Assessment based on a HAZID Workshop where a large variety of stakeholders were present.
- The results from the study have confirmed the good potential of ethyl/methyl alcohols as alternative fuels for shipping, constituting an excellent way to endure mitigation of air pollutants and, in case of green bio-sourced ethyl/methyl alcohols, an excellent candidate fuel to support shipping towards an as low as possible carbon footprint.

4. Fuel Cells Study (Service Contract EMSA/OP/03/2011) - Main Outcomes

- The Study on the use of Fuel Cells in shipping was developed in cooperation with DNV-GL having covered the technology of different Fuel Cell types, different chemistries and working principles with the aim to select, through a multi-criteria analysis, the three most promising technologies for applications in shipping. Proton-Exchange Membrane (PEM); High Temperature PEM (HT-PEM) and Solid Oxide Fuel Cell (SOFC) have been selected taking into account different criteria such as efficiency, safety or power density.
- Different EU co-funded projects were evaluated with a view to identify the major achievements and state-of-the-art technology and, in particular, to have a general overview of the benchmark in terms of installed power.
- A Safety Assessment was conducted considering applications of the three selected technologies, as mentioned above, into the general arrangement of a RO-PAX (all-electric) and an LNG Carrier (using Fuel Cell groups for secondary power production). The results of the Risk Assessment have then been translated into individual Risk Matrices that mapped different hazards. Risk Scenarios evaluated and Risk Matrices developed with risk ranking for different situations.

- Hydrogen has been considered as the only fuel option for PEM technology – leading to challenging Safety Assessment, in particular for the storage and bunkering of either compressed or liquefied hydrogen. Reforming options were considered for all other FC technologies.
- It was concluded that FC technology is still very much limited to lower power ranges (in the order of kW). Higher installed power applications should be sought with a view to increase the attraction of such energy production technology.
- Results of the Study submitted to IMO CCC4 in support to IGF Code 2nd Phase development.

ANNEX III

Inventories of shipping emissions

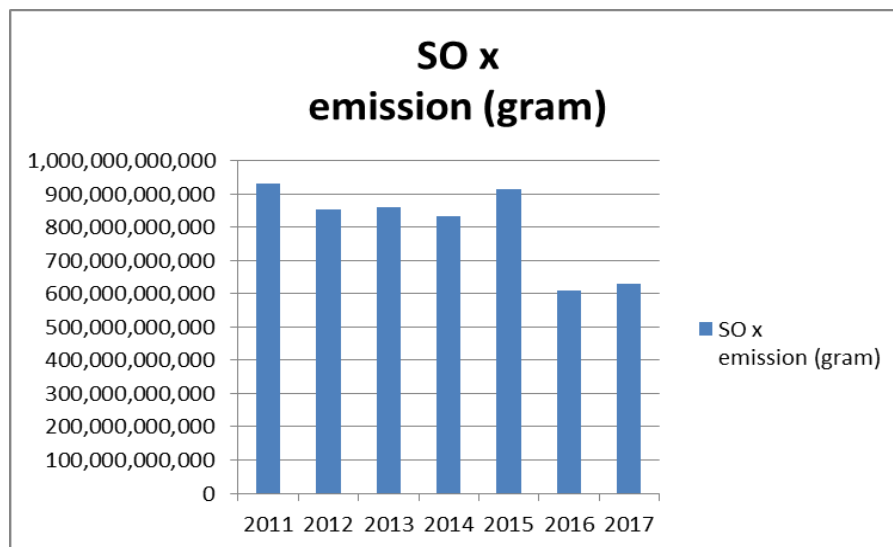
The European Maritime Safety Agency (EMSA) under a cooperation Agreement with the European Commission, DG Environment (DG ENV) has developed a tool and has calculated shipping emissions covering the waters lying within the North Western Sulphur Emission Control Area, and those outside it, limited to the Economic Zones of Member State. The calculations were based on historic Automatic Identification System (AIS) provided by SafeSeaNet and Long Range Identification and Tracking (LRIT) shipping activity data available in house and under the authority of the Member States for the period 2011-2017.

Over the course of 2016, the shipping emission modelling functionality (AEC) was developed. The AEC was developed on the basis of the available data fields, a number of assumptions, the available and internationally agreed EEZ and SECA. The AEC plots each transmitted ship position within the boundary of a certain area, subject to the interest of the user. The following position is plotted again. In case the boundary of the area is crossed, the crossing point is taken as end, respectively starting point. Between two positions belonging to the same ship, the difference in time and distance is established. This creates a view of the performance over a segment of the total trajectory. Each segment is then assessed as to whether it meets the various criteria for movement. The speed calculated accordingly is then used in the formula which relates the ratio service speed versus actual speed to a ratio between installed power and used power. Ultimately, power used returns values for fuel consumed over each segment. The integration of all the segments for the ship leads to its total fuel consumed figure, which is eventually complemented with the respective figures for other ships in the same geographical area and within the same timeframe of interest of the user.

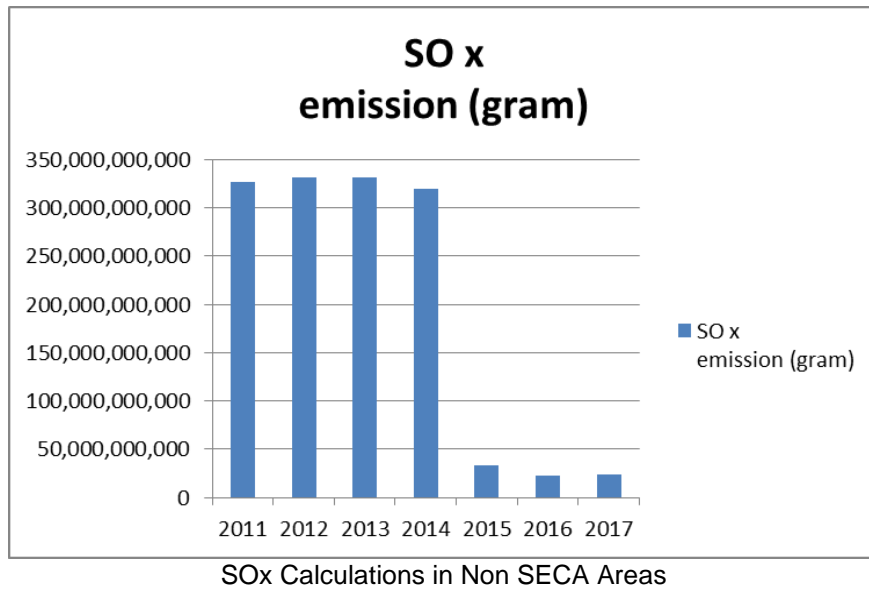
A first set of emission inventories attributed per Member State in their relevant sea areas (covering territorial seas, Exclusive Economic Zones, Pollution Control Zones, Sulphur Emission Control Areas, where applicable) for the period 2011-2015, was delivered to DG ENV in November 2016.

The shipping emission modelling functionality (AEC) was further enhanced in 2017, allowing more detailed and focused per area calculations (geographic grids). Relevant historic data for the years 2016 and 2017 were retrieved enabling the presentation of comparative calculations for the full period 2011-2017.

Some samples of the graphical results of the study are presented below:



SOx Calculations in Non SECA Areas



A detailed report is attached as Appendix to this Annex.

Appendix:

1. Executive summary

This paper presents the results of calculations done in accordance with the provisions of the Cooperation Agreement 070201/2015/714227/ENV.C3 signed on 06/10/2015 between the European Commission, DG Environment (DG ENV) and the European Maritime Safety Agency (EMSA).

The paper focuses and presents in graphical form the inventories of shipping emissions covering the waters lying within the North Western Sulphur Emission Control Area, and those outside it, limited to the Economic Zones of Member State. The calculations are based on historic Automatic Identification System (AIS) and Long Range Identification and Tracking (LRIT) shipping activity data provided by the Member States for the period 2011-2017.

The original report from which the graphs are abstracted does not analyse the outcome of the inventories nor does it draw any conclusions. It has been decided that the deliverables are to be used as the basis for an assessment of existing practices in determination of current level and evolution of Air Emission from Ships (SO_x, NO_x, primary and secondary PM and Black Carbon, and other relevant substances) by the ESSF Sub-group on Air Emissions from Ships.

The used methodology is not proprietary or bound to certain areas only. Subject to the availability of movement data, localised calculations can be made where emissions are attributed to any given area.

2. Background Information

The European Commission in 2015 deemed important to assess whether the cost-effective strategy of the Commission and the Member States put in place for monitoring of compliance and enforcement concretely resulted in the achievement of the environmental and health objectives of Directive 2016/802/EU. Having considered that EMSA at the time:

- provided technical and scientific assistance to DG ENV in the areas of prevention of pollution from ships and in particular for the implementation of Directive 2016/802/EU as regards the sulphur content of marine fuels;
- was hosting a set of maritime applications providing access to relevant data (THETIS, THETIS-EU, SafeSeaNet, MARINFO);
- proved its technical expertise in the field of Air Emissions through the development and hosting of the dedicated Union information system (THETIS-EU), available to Member States from 1 January 2015, which serves as a platform to record and exchange information on the results of individual compliance verifications under Directive 2016/802/EU;
- provided technical contribution to the third IMO Green House Gas study (3rd IMO GHG study) where inventories of SO_x, NO_x and PM have been calculated at the global level by IMO;

A cooperation agreement was signed between EMSA and DG ENV for the development of inventories of shipping emissions based on shipping activity data for domestic, short sea and international shipping through a new functionality in THETIS-EU. The Agreement amongst other foresees that EMSA shall:

1. Ensure the development of the bottom-up shipping emission modelling functionality with EMSA's contractor for maintenance and enhancement of THETIS and THETIS-EU;
2. Calculate and analyse inventories of shipping emissions covering the waters per Member State based on historic AIS shipping activity data provided by SafeSeaNet using the shipping emission modelling tool and functionality to cover the period 2011-2017;
3. Host, maintain and support the shipping emission modelling functionality;
4. Further enhance the shipping emission modelling functionality to provide almost real time inventories of shipping emissions covering the waters per Member State;
5. Cooperate with relevant organisations recognised for air pollution modelling, to have, in parallel, the evaluation of emission inventories for the same period in order to calibrate and validate the results of the model developed by EMSA and its contractor;

In order to meet the objectives stipulated in the Cooperation Agreement, EMSA engaged in a Specific Contract to acquire the technical solution. At the same time, agreement for the use of historic Automatic Identification System (AIS) data made available by the Member States through SafeSeaNet, with THETIS-EU having already access to the core of such data, was obtained. In due course, Member States provided their consent and historical Long Range Identification and Tracking (LRIT) data were also made available and used.

Over the course of 2016, the shipping emission modelling functionality was developed. A first set of emission inventories attributed per Member State in their relevant sea areas (covering territorial seas, Exclusive Economic Zones, Pollution Control Zones, Sulphur Emission Control Areas, where applicable) for the period 2011-2015, was delivered to DG ENV in November 2016.

The shipping emission modelling functionality was further enhanced in 2017, allowing more detailed and focused per area calculations (geographic grids). Relevant historic data for the years 2016 and 2017 were retrieved enabling the presentation of comparative calculations for the full period 2011-2017.

3. Methodology, considerations

3.1 Data Fields

A number of data fields are pre-requisite in order to be able to perform calculations. These data were incorporated to the AEC through EMSA's relevant maritime applications.

- Historic AIS shipping activity data were provided by SafeSeaNet following the consent of the High Level Steering Group (HLSG) of the SSN. The data provided entails latitude, longitude, date and time, ship identifier and some other fields which are typically transmitted by each ship equipped with an AIS transmitter and subsequently received by dedicated stations provided by coastal stations in the Member States.
- Ship particulars were provided by Marinfo¹: The particulars used were:
 - keel date of the ship;
 - ship type as determined for Port State Control purpose;
 - design summer draught;
 - Gross Tonnage (as precursor of deadweight or cargo carrying capacity);
 - main engine information;
 - number of main engines (for propulsion);
 - type of engine with respect to number of strokes;
 - type(s) of fuel;
 - maximum continuous rate (MCR);
 - Service Speed (speed at 75 % MCR);
 - Availability of Exhaust Gas Cleaning Systems.
- Historic LRIT shipping activity data were provided by the LRIT data centre hosted by EMSA, following the consent of all individual Member States in their capacity as owners of the data. The data provided entails latitude, longitude, date and time, ship identifier and some other fields which are typically transmitted by each ship equipped with a LRIT transmitter and subsequently received by the station hosted by EMSA and made available to the Member States.
- Shapefiles defining EEZ areas have been used from <http://marineregions.org/>. It has to be noted that the shapefiles for EEZ as available on the specific site are widely accepted and recommended for their accuracy on the seaward side and in particular for the accuracy in which international Treaties and Agreements defining boundaries have been included.
- Emission Factors² (EF) were retrieved from the 3rd IMO GHG study.

¹ In effect, datasets proved to be complete for all IMO numbers encountered except from the fields detailing engines, MCR and service speed. For these fields assumptions had to be made for the eventual ship encountered, which are stipulated under chapter 4 of this reports.

² The established relation between fuel and emission is defined as Emission Factor (EF) and can be used to convert a unit of fuel to the emission the latter produces.

3.2 Area definitions for EEZ and SECA

The project explicitly aimed at producing emission inventories per Exclusive Economic Zone (EEZ) for each Member State. An EEZ is defined in the United Nations Convention of Law of the Sea (UNCLOS) as “*an area beyond and adjacent to the territorial sea, extending seaward to a distance of no more than 200 nautical miles (370 km) out from its coastal baseline*”. The respective EEZ per Member State was loaded to the AEC from <http://marineregions.org/> (see section 3.2).

Furthermore, the relevant Sulphur Emission Control Areas (SECAs) have been defined into the AEC using the internationally and EU agreed geographical area.

The calculations have established a relation between the transmitted historical ship positioning signal and the geographical area and in particular by matching the position data transmitted and the defined EEZ and SECA shape files or digital maps.

3.3 Fuel Consumption

Studies have demonstrated that for classical hull-shapes of ships, fuel consumption and speed are connected through logarithm rather than linear. Increase in speed requires a cubic factor in fuel more, dictating that high speeds require very high volumes of fuel. This consideration is of critical importance for the assessment of the amount of emissions produced and is therefore factored in.

3.4 Exhaust Gas Cleaning Systems and abatement

Exhaust Gas Cleaning Systems (EGCS) and abatement as way to address air emission is only applicable for operation of ships after the entry into force of the 0.1 % Sulphur content requirement on 01 January 2015. Furthermore, EGCS and abatement are also considered only to address the Sulphur related pollutants, being Sulphur Oxides (SO_x) and Particulate Matter (PM).

A limited number of ships worldwide – approximately 200 – are known to have EGCS installed, and the availability of such equipment has been added to their respective records in the data source.

4. Assumptions

In order to calculate the emissions as accurately as possible, a number of assumptions had to be made in various areas. These assumptions are listed below.

4.1 Assumption 1: Mapped MMSI to IMO

AIS signals always include the MMSI number, but not always the IMO number of the ship. Since MMSI numbers are not unique, mapping to unique IMO numbers had to be performed. Mapping of MMSI numbers to IMO numbers meant that over 48.000 ships worldwide could be identified. On the contrary, mapping could not be done for close to 800.000 ships which have been detected by the EU AIS system in the years 2011 – 2015. A crosscheck using various sources demonstrated that the vast majority of the unmapped MMSI numbers have been issued by pleasure yachts, fishing vessels and inland craft operating on the landward side of the EEZ baseline.

Considering that these unmapped ships are quite small in size, with low size engines and normally using MGO, it has been assumed that unmapped ships are not substantial emitters and therefore not relevant for the Air Emission project.

4.2 Assumption 2: Fuel quality inside SECA

Fuel quality inside the SECA is determined by the legal limitation on Sulphur content imposed by Directive 2016/802/EU. In this respect the following limitations were considered:

- 1% of Sulphur content in fuel was used by ships within SECAs between 01 January 2011 and 31 December 2014;
- 0.1% of Sulphur content in fuel was used by ships within SECAs since 01 January 2015.

The figures stipulated by the legal requirements are supported by the analysis of the Bunker Delivery Notes (BDN) as recorded in THETIS EU since 01 January 2015. During this period 14000 inspections took place on almost 10000 individual ships, making the total available information a representative sample but not a complete view.

The pertaining details of over 5000 recorded BDN concerning HFO and IFO have been analysed and represent an average Sulphur content of 2.42% in 3.1 million tons recorded. Similarly, the details of 10000 recorded BDN stating MGO have been analysed. The average Sulphur content for MGO as per BDN is 0.08 % on a total volume of 1.48 million tons.

To this end the following assumptions have applied with respect to Fuel Quality when performing the calculations:

- ***The 1% threshold was achieved by operating on Marine Diesel Oil (MDO) or Marine Gas Oil (MGO);***
- ***The 0.1% threshold was achieved by operating on Marine Gas Oil (MGO), or an alternative fuel such as Liquefied Natural Gas (LNG) or by using EGCS;***
- ***All ships within reach of the SECA boundary and entering the area and without alternative fuels or EGCS changed over to MDO, to meet the 1% threshold and change over to MGO to meet the current 0.1% threshold respectively;***
- ***Any ship exiting the SECA and identified in the data source as technically capable of using residual fuels such as HFO and IFO has been considered to change over from the very clean MGO to the fuel type recorded in the data source and not considered to prolong the use of clean fuel whilst not legally required;***
- ***Ships where EGCS were installed or were using LNG as fuel have been considered equally to ships using compliant fuel;***
- ***Gross deviation from the legal thresholds does not occur.***

4.3 Assumption 3: Missing values for service speed and installed power

A number of missing values for service speed and installed power could have created issues in relation to the calculations if the ships in question would have been omitted. In order to avoid this, an analysis of the available speed and installed power for propulsion of the various ship types, using ship types as determined for Port State Control, has been performed. The analysis has rendered a separate formula for each ship type which allowed determination of the “most probable” speed and power for the ship under investigation based on the known characteristics of similar ships. Simulations using the formulae on ships with known details return figures with a high grade of accuracy. Details on the formulae used can be found in Annex I.

For the purpose of calculating the total emissions per area, the availability of probable data rather than exclusion of a number of movements were considered to be favourable, therefore applied.

4.4 Assumption 4: Behaviour at sea, auxiliary machinery

Whilst at sea, at anchor or even in port, ships may run at any given time a variety of engines installed on board. This creates issues for the true assessment of emission by ships with multiple engines for propulsion, but also for any assessment of emission as consequence of the use of one or more auxiliary engines or shaft generators for the production of electricity. In addition, oil tankers may operate inert gas installations which are mostly based on exhaust gas producing installations while the use of Dynamic Positioning in many of the ships employed in the offshore industry may give a false sense of “no movement, no fuel consumption”.

It has therefore been assumed that auxiliary machinery, Inert Gas installations and DP features are not relevant for the Air Emission project

4.5 Assumption 5: AIS coverage and movement of ships

AIS consists of signals transmitted in the VHF band and as a consequence has a limited range. The signal does not follow the curvature of the earth but takes a straight line from the transmitting antenna. The range can be extended by raising the transmitting antenna to the highest point available, and the reception coverage can be equally improved by elevating the receiving antenna. Still, in spite of preventive measures, gaps remain.

Also, message quality can be affected by weather conditions, programming by the operator and other uncontrollable causes. All this affects the availability of a peck-less picture which would ensure certainty over historic movements.

To overcome the element of uncertainty, another data source in the form of LRIT based positions was added to the dataset. This will not have the same issues as AIS signals of a ship on a given moment in time being a different way of communication, although also LRIT is subject to operator error. Moreover, LRIT does not apply to all ships with an IMO number and will therefore only partially address AIS quality issues.

AIS data quality affects availability of position information and therefore the calculation of consumed fuel. Consequentially, a number of safeguards had to be applied in the calculations to ensure that speed and distance covered is as realistic as possible.

The following safeguards (assumptions) have been applied:

- ***If the gap between two positions of the same ship exceeds 4 hours, the calculation stops and restarts. This is done in particular to avoid crossing over landmasses, and***
- ***If the calculated speed exceeds 150% of the service speed, the service speed is taken. Although subjective, this is done to mitigate the effect of disturbed transmissions.***
- ***AIS movements leading to a calculated speed of less than 2 km/hr have been taken to indicate that the vessel was in port or at anchor.***

4.6 Assumption 6: Weather, current, ice coverage

The adverse or favourable effects of wind and waves swell and (tidal) currents as well as the adverse effects of ice-coverage have not been taken into account during calculations since the calculations were performed ***on the assumption that higher speed is considered as caused by a higher engine output, and a lower speed as caused by a lower engine output and not by weather, current or ice coverage.***

4.7 Assumption 7: Displacement

Cargo, fuel and ballast conditions and combinations are influencing factors on fuel consumption. However, these conditions vary widely and there is no unambiguous source to retrieve data per ship, per voyage and per event.

It has therefore been assumed that the actual displacement is not relevant for the Air Emission project until further details come available.

5. The calculation

In order to calculate the emissions, the movement of known objects (ships) needs to be analysed. The movement in terms of time and speed is a precursor of the amount of effort which has engaged into making that movement possible. The amount of effort translates in the load or power required from the engine for propulsion of the ship which in itself translates to the amount of fuel which was necessary to produce the required load or power.

Noting that the calculation does not take any reference or standard information from the area where the ship was, it had to be conducted starting at the individually identifiable ship. A number of assumptions which pertain to the methodology had to be made. A detailed description of these assumptions may be found in Chapter 4.

For the calculations, the AEC plots each transmitted ship position within the boundary of a certain area, subject to the interest of the user. The following position is plotted again. In case the boundary of the area is crossed, the crossing point is taken as end, respectively starting point.

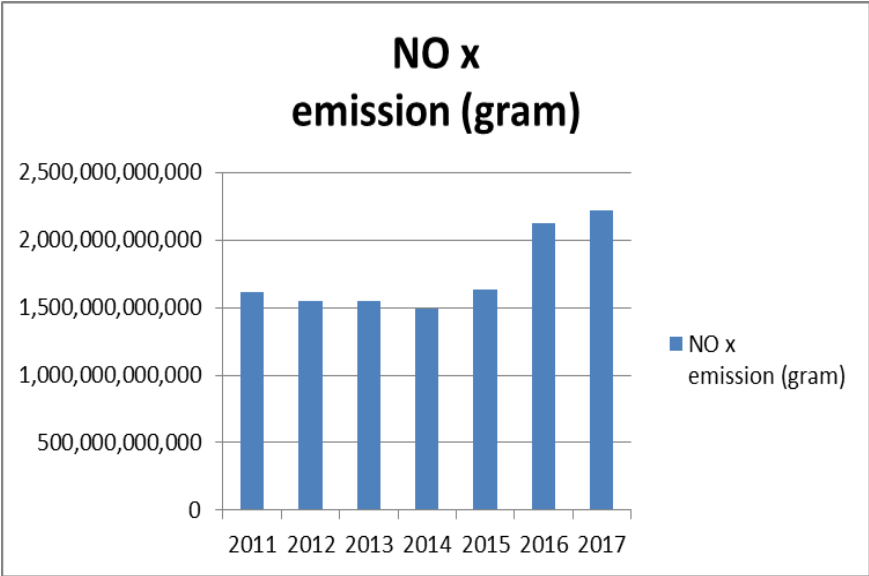
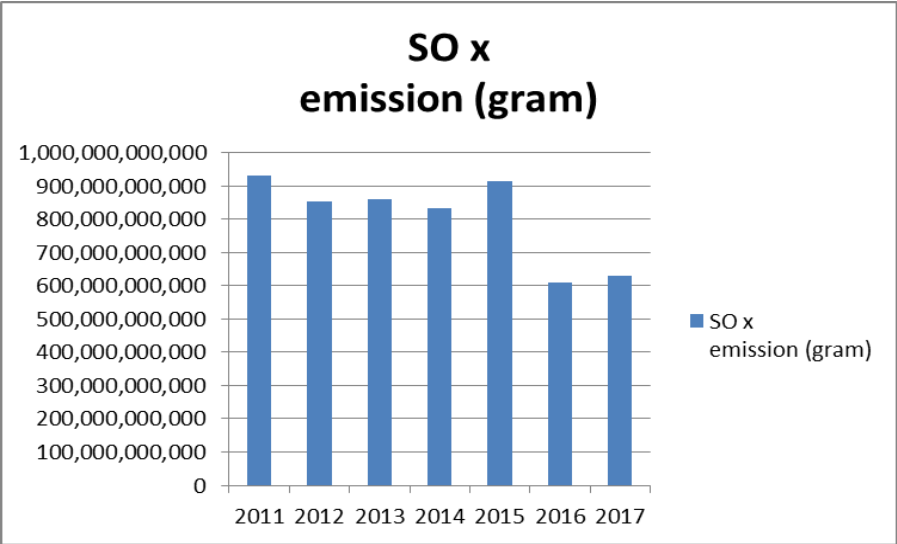
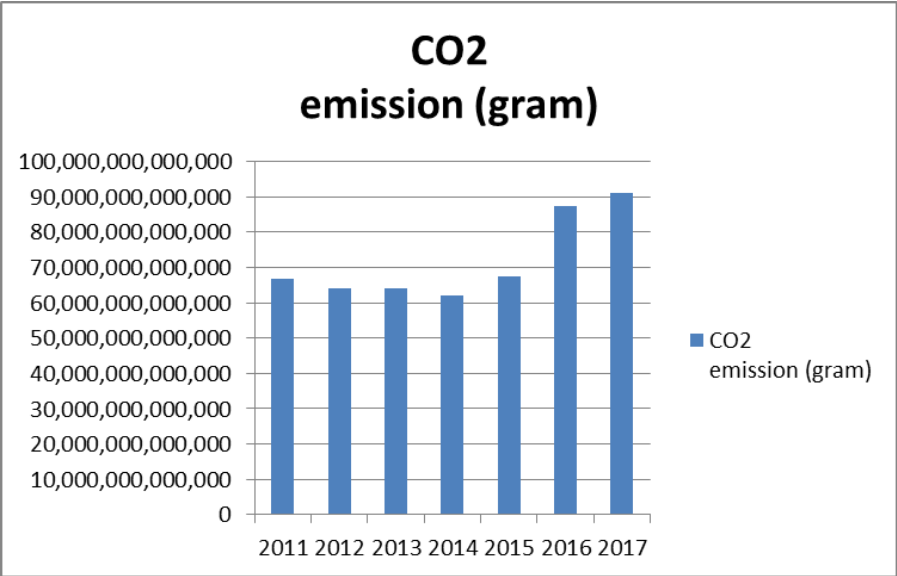
Between two positions belonging to the same ship, the difference in time and distance is established. This creates a view of the performance over a segment of the total trajectory. Each segment is then assessed as to whether it meets the various criteria for movement. The speed calculated accordingly is then used in the formula which relates the ratio service speed versus actual speed to a ratio between installed power and used power. Ultimately, power used returns values for fuel consumed over each segment.

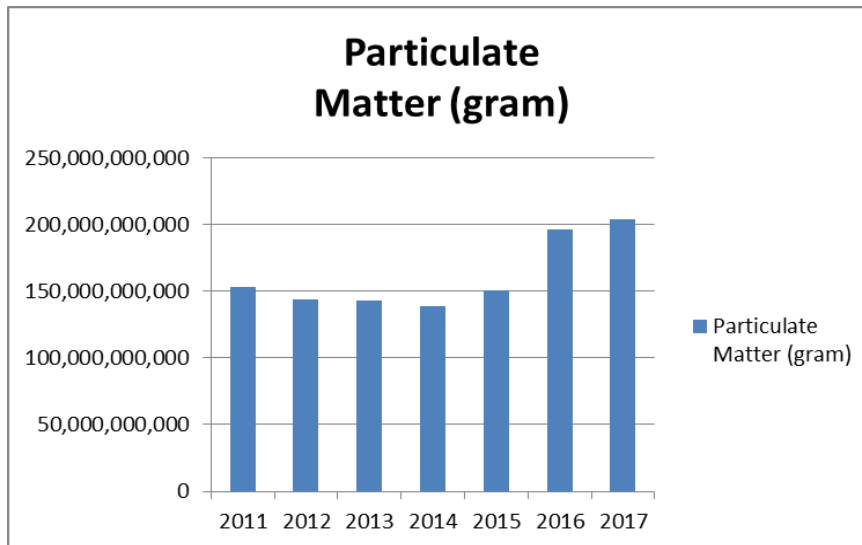
The integration of all the segments for the ship leads to its total fuel consumed figure, which is eventually complemented with the respective figures for other ships in the same geographical area and within the same timeframe of interest of the user.

6. Pollutant Calculations

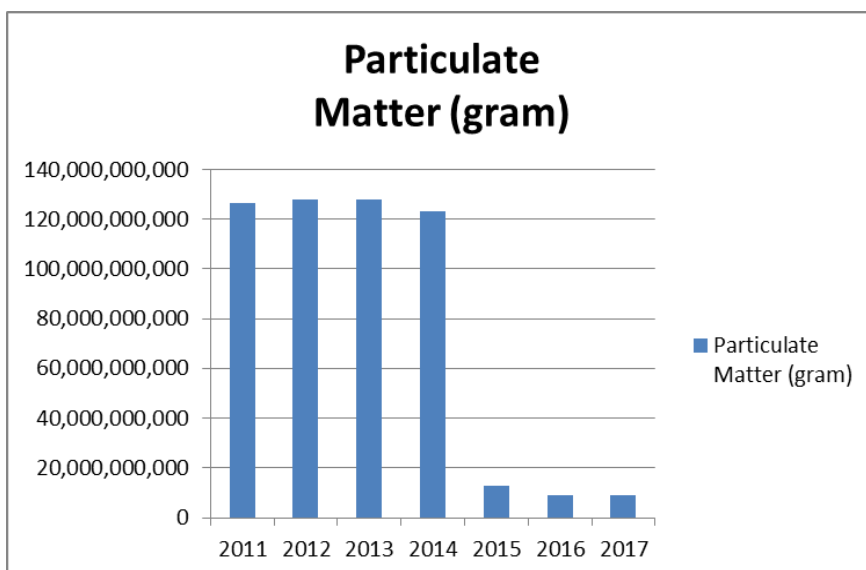
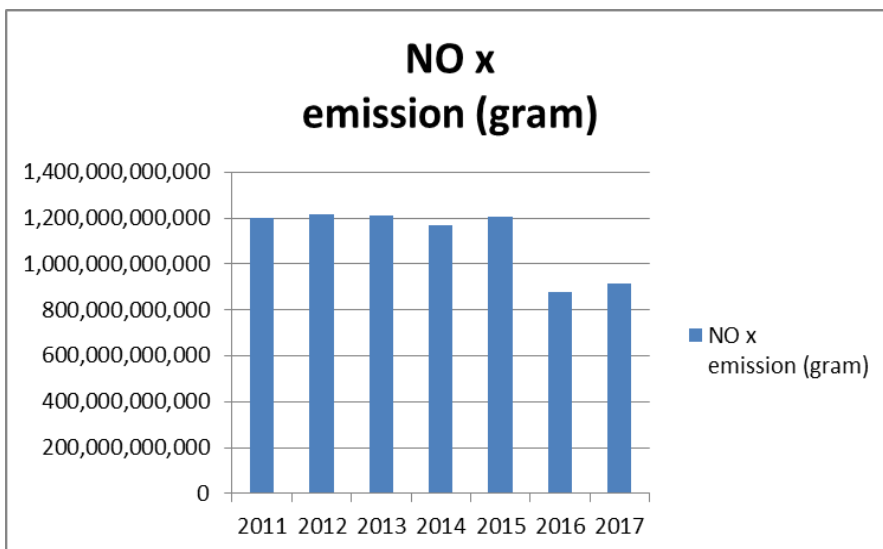
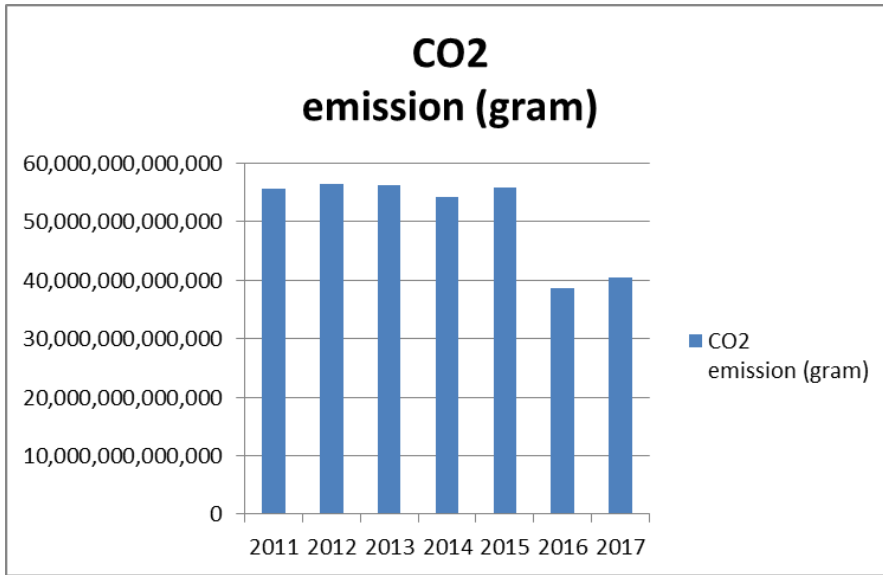
In order for the emissions modelling functionality to make the appropriate calculation of emissions, the amount of consumed fuel needed to be translated to emitted pollutant. The specifications on the basis of figures given in the 3rd IMO GHG study have been. It should be noted that the figures presented in table 33 in the 3rd IMO GHG for SO_x and PM per gram for MDO and MGO had to be adjusted in order to meet IMO and EU threshold values for fuel consumed inside the SECAs.

NON SECA





SECA



, as set out in **Annex I** to the present document

