Is the utilization of methane gas, the solution of air pollution in difuse sectors?. The case of Port of Castellón

Francesc Xavier, Martínez de Osés
Dpt of Nautical Science and Engineering
Universitat Politècnica de Catalunya
Barcelona, Spain
Fmartinez@cen.upc.edu

José María Gil Aizpuru
General Manager of Commercial Dpt.
Gas Natural, S.A.
Barcelona, Spain

Abstract— **Within an scenario of highly sensitivity on environmental questions, followed by an international regulation body, that is restricting the emission levels from ships in ports with the future possibility of more stringent local regulations; the challenge for the world's fleet are not only technical but economic and logistical. From one side, there are different technical alternatives affording to accomplish the nowadays international regulations. Even avoiding on board modifications, the owner can decide to use low sulphur content fuels, together with slight changes in engines to reduce the levels of nitrogen oxides. But the question posed in this paper is how to support the decision to use high quality oil derivatives, because environment questions, but with a favorable economic balance. That superior cost will be translated in a higher transport chain cost. Additionally regarding coastal navigation, it is possible in the future that some new regulations could penalize elevated rates of CO_2 emissions, not yet considered by MARPOL convention. This paper will analyze the availability of the use of methane as ideal fuel to get compliment of the nowadays and even future, local and international regulations of CO_2 and NO_X, regarding the fuel derivatives and no emissions of sulphur oxides and ashes.**

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I. INTRODUCTION

This paper is going to describe the proposal of an assessment model to validate the economical and operational viability to provide methane gas to ships berthed at port. The proposed model is going to be checked in Castellón port (Spanish Mediterranean coast) which is an example of regional size port, with traffic figures exceeding the 11 millions of metric tons.

The present state of the art regarding the regulation scenario, due to the entrance of the European directive 99/32, is mainly concerned on the limitation of the sulphur quantity in fuels, used for ships berthed at port during more than 2 hours, below to a 0.1% in mass content. At a first glance the most immediate solution is to use gas oil with low sulphur content, but its cost is not negligible above the IFO or MDO prices. [1]

II. SCENARIO

In a highly environment conscious scenario, with an international regulation restricting the emission levels from ships at member part ports, but possibly existing a more restrictive local law. The concern of fleet adaptation to the new requirements is not only technical but also economical and logistics. From one side there are different technical alternatives, affording to comply with the regulations in force. Without major changes on board, the owner can decide to use low sulfur content fuels, and can carry out slight and inexpensive modifications in the main engine, to reduce the levels of nitrogen oxides.

But what is posing this paper also, is the balance between the need to use oil derivates with an everyday better quality, due to environmental questions, and at the same time that the economic balance would be positive. In the long term the environment factor has an elevated cost for the producer (now the owner), and finally that cost will be charged in the following commercial chain step, the costumer. In the other hand and mainly in coastal navigation, maybe in the future it would be possible the establishment of new regulations controlling and penalizing high rates of CO_2 emissions, question not dealt in MARPOL yet, but that is the base on which different protocols for climate change are based. In 2008, the expert group from the International Maritime Organization, modified their previous estimations on the world merchant fleet, fixing them in 1,120 millions of tons of CO_2 per year, produced by the worlds fleet, what means the 4.5% of the planet emissions. In the opinion of this working group, this figure is three times the contribution that was initially estimated, and of course those were not accounted in the objectives to fight against the climate change. The report "Maritime transport and the climate change challenge TD/B/C.I/MEM.1/2 [2], from United Nations, pointed out that other pollutants coming from the transport activity, and

specifically navigation, are increasing quicker than the expected CO_2 growing (estimated in an additional 30% in 2020), like the soot and sulfur oxides, that would increase more than the 30% in the next decade. Both pollutants, contribute to the acid rain and to a wide variety of breath diseases, including the lung cancer. In fact the World Health Organization (2005) has established in 60,000 the number of deaths every year due to the pollution derived from the world's merchant fleet.

Despite this situation, most of the world administrations have sub estimated up to now, the marine traffic contribution to the greenhouse effect. European Union, has minimized this fact confirming that this one, contributes to less than 2% of the total CO_2, emissions, a reason because those never have been contemplated in the national estimations. In this sense we should keep in mind, that recently there are exploring initiatives to correct the previous situation, being one example the recommendations contained in the proposal of report "On the strategic objectives and recommendations for the maritime transport policy in the EU towards 2018" (EU Parliament 2010), complaining that the Copenhagen Summit on Climate Change could not agree conclusions to reduce emissions of maritime navigation, but introducing valid criteria to reach that objective. So we can conclude that the contribution of Maritime transport on the greenhouse gases emission, has been recognized by the worlds' administrations, and this is going to put a superior pressure on the owners to begin to use cleaner fuels and more efficient engines. In the other hand it is possible that EU could include the shipping industry within the CO_2 emissions market. [3]

A. Contribution of Maritime Transport to Greenhouse Effect Gases

CO_2 emissions from ships are directly proportional to the bunker consumption, for all uses, id est propulsion, auxiliary services, heating or others [4]. The consumption estimates and then the emissions of greenhouse effect gases, varies in the time, because the better definition of scenarios and the improvement on the modeling techniques [5] [6]. In the graphic 1, it is showed that the estimations on the greenhouse effect gases coming from maritime sector represent from the 1.6% to 4.1% of the world CO2 emissions coming from bunker burning. IMO estimations for the international maritime transport from 2007 to 2050, are pointing an increase from 2.4% to 3%.

Maritime transport represented in 2005, the 10% of the greenhouse gases emissions of the transport sector, which were headed by the road transport with the 73% of total contribution (IEA 2005).

In absolute figures the greenhouse gases emissions coming from maritime transport are very important, in relative terms show that ships are much more efficient than other transport modes, implying a specific consumption per ton of freight carried much lower than the other modes. CO_2 is created in all the combustion processes and thus is produced in big quantities in the maritime transport, being those directly proportional to fuel consumption. Maybe the best way to reduce CO_2 emissions would be to improve the energetic performance of ships.

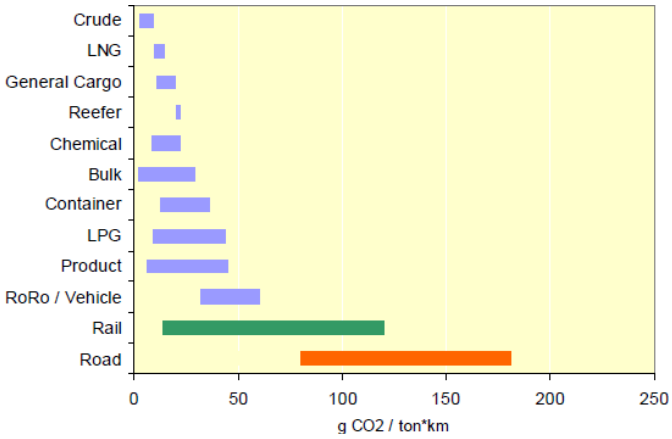

Figure 1. Graphic 1: Range of typical CO_2 efficiencies for various cargo carriers in g CO_2 per Ton and kilometer. Source based on IMO study on greenhouse gases emissions from maritime traffic 2008 (OMI 2008).

III. Guidance for the Development of a Ship Energy Efficiency Management Plan

IMO has established the Shipboard Energy Efficiency Management Plan (SEEMP), a document to improve a ship's energy efficiency through four steps: planning, implementation, monitoring and self-evaluation and improvement. This Plan will become an increasingly valuable tool but now it is just a voluntary application. A performance baseline is necessary to make SEEMP effective and can be used to help learn and improve. The success also depends from the crew using the new technology or deploying new working practices. Crew bonuses based on improvements fuel consumption can pay off. The final element of the energy strategy management using SEEMP is the understanding of how the carbon markets work (The Motorship 2010).

The purpose of the Ship Energy Efficiency Management Plan (SEEMP) is to establish a mechanism for a company and/or a ship to improve the energy efficiency of a ship's operation. SEEMP should be adjusted to the main characteristics and need of individual companies and ships in order to develop the performance of ongoing environmental of its vessel, in the way that any onboard administrative burden will be minimum. (Many companies will already have an environmental management system (EMS) in place under ISO14001). Its application seeks to improve a ship's energy efficiency through four steps, beginning with its planning: This is the most important stage of the SEEMP that includes the current status of the ship energy usage and the future improvement of ship energy efficiency.

- Ship – specific measures: The method to improve ship efficiency depends of the ship type, cargoes, routes and other factors, because not all measures can be applied to all ships or under different operating conditions. In the first place, the specific measures for the ship should be identified as a list to be implemented.

- Company – specific measures: It is recommended that a company also establish an energy management plan for its fleet to reach the most improvement expected. And a good coordination between stakeholders (operators, ports and traffic management service) should exist.
- Human resource development: Another important element to develop this plan is to provide the necessary training to the personnel both on shore and on board.
- Goal setting: This part is voluntary, it's not necessary to announce the results of the plan to the public, and neither there are external inspections. So, the purpose of goal setting is to serve as signal of reference to be conscious and to improve the measures for the energy efficiency.

In order to reduce greenhouse gas emissions from international shipping, the Marine Environment Protection Committee (MEPC) from IMO proposed take some measures involving the design phase of the new ships and helps to improve their fuel efficiency too. The measures had been reviewed in a number of sessions from the MEPC and almost approved in the last one, the 61st session of the MEPC, celebrated on September 2010 in London. In the 59st session (July 2009) of the IMO's Marine Environment Protection Committee (MEPC) a package of interim and voluntary technical and operational measures was agreed as one of the first steps of the implementation of the Energy Efficiency Design Index (EEDI) for the objective to reduce emissions. These measures were used as trial purpose until they were refined in the new session of the MEPC (60st session on March 2010). The measures include interim guidelines on the method of calculation and voluntary verification, of the Energy Efficiency Design Index for new ships:, guidance on the development of a Ship Energy Efficiency Management Plan, for new and existing ships and a guidelines for voluntary use of the Ship Energy Efficiency Operational Indicator for new and existing ships, which enables operators to measure the fuel efficiency of a ship.

The Committee agreed that a vessel's attained EEDI shall be equal or less that the required EEDI. The required EEDI shall be taken account based on EEDI baselines and reduction rates not yet approved.

Additionally an Expert Group will be established on the subject to undertake a feasibility study and impact assessment for the next session, MEPC 61. The 61st session of the MEPC (September 2010) was due to finalize technical aspects of the EEDI and agree the detail of its mandatory application, along with the Ship Energy Efficiency Management Plan (SEEMP) across all new ships but proponents failed to secure approval by consensus. So, the mandatory energy efficiency rules could be adopted for new ships this year (2011) and the measures would come into force in 2013. If made mandatory, it would see ship owners penalized if they do not meet minimum fuel efficiency standards for their vessel type.

IV. Methane Gas Use in Maritime Transport

There has been a quick evolution in the past decade, when we are talking about the methane use on board ships. Before 2000 we could identify ferries using compressed natural gas in Russia, Holland, USA, Canada or Australia. From the year 2000 there are posed some environmental concerns, and begins to appear a generation of freight ships using natural gas as fuel, like the supplier "Viking Energy" and the ship "Stril Pioneer". In 2004 is completed the "Pioneer Knutsen", coastal gas carrier combining diesel and gas, engines. In the early 2007, 5 ferries were built for passenger and car transport, using only liquefied gas engines. Further came into operation the first coast guard boat for Norway using dual fuel engines. The project "BigLNG" is running, participated by "Color Line", "SeaTrans", "Marintek", DNV, "Aker Yards" and "Gas Nor", to develop big ships with ample navigation range using liquefied natural gas.

Different engine manufacturers have developed electrical ship concepts, where the power is generated by LNG. Due to this fact, the consumption is said to be reduced approximately in 4%, because doesn't need previous warming. GHG emissions are expected to be reduced the 25%, and the ones from sulfur, disappear.

V. Methodology of Study

The analysis has begun with the study of different concepts as pollution and health, climate change and social sensitivity or the impact of environment on the company policy. In fact up to some years ago, the concept of pollution was associated almost exclusively to the "air pollution", and its impact was evaluated related to its impact on health. But lastly the idea of climate change has got important, and its origin has been attributed to human activity.

The second step has been the location and identification of regulations related to air pollution and GHG emission, applicable to maritime sector. We can classify regulations from international (MARPOL), European, national and even regional or local; ones. In our case, we are going to analyze the regulations applied to ships in transit to/from Castellon port. From this analysis we have got an abstract with the limits posed by the actual or future, regulations.

The further step, has analyzed the energy efficiency measures on board ships, we are of the opinion that independently from the technical advances the main reason is the price of fuels. The look for the energy efficiency on board ships helps to maintain a reasonable efficiency in the marine business, together with the reduction of pollutant and greenhouse effect, gases.

The fourth step would be the analysis of the environmental advantages provided by the natural gas use, instead of the oil derivates. The minor volume of emissions associated to natural gas, presents it as an ideal fuel to be used at port. Additionally, there will be studied the nowadays situation of gas infrastructures in Spain, its capacity of expansion and distribution in the present and in the future, along the coast. We need to know the technical capacity, to cover future potential demand in the Castellon port. An study of the retributive

system, will be done, in order to know if there is a commercial interest from the distribution companies, to develop this kind of projects. The information will be get from the "Gas Natural" group and the Spanish Ministry of Industry and Energy.

Following the fifth step will be to know the state of the art to know the utilization of natural gas as fuel, as kind of engines, manufacturers and equipment. It will then be possible to know the information from marine engine, providers and manufacturers; making an analysis of the dual fuel technology and the conversion of existing devices to natural gas use. The knowledge of the Castellon coast will be needed, in order to know its climatology, demography and mainly the traffic figures and typology in its port.

The sixth step would be the analysis of the air emissions coming from merchant ships hosted at port of Castellón. The traffic of the port will be inventoried for a significant period, mainly during the year 2009. The information will be obtained from the Port Captain, regarding types of ships and time of berthing; this information has been obtained from MEREP (Merchant ship report). It contains more than 900 registers containing 4 movements each, what means up to 3,600 registers. A database will be developed to identify the ship entrances and leavings. Those registers do not provide information on the ship's and engine, particulars, so that we have not the auxiliary engines characteristics, like power or consumptions. For this purpose has been needed to search in different websites and registries, the ships' particulars. Some of the sources provide full details, but not all of them. In the cases in which no enough information have got, we have used data coming from European project "Ex -tremis", in which the "Maritime Fuel Consumption" database, pose the basic consumptions per ship type, length and nationality, affording to select the type of auxiliary engine. When this last would be no possible, it will be applied the consumption ratio per flag divided by the fleet composition figure, in order to get the unitary value. Finally we will proceed to evaluate the total emissions in the port of Castellón.

The seventh step will provide the hypothetical reduction of emissions coming from the use of natural gas instead of Diesel oil in the Port of Castellón. An Economical analysis will support this step. The following step will provide the model for evaluate the technical viability to design a distribution gas network for ships in the port, that will be also accompanied by an economical viability analysis of this project in the port.

This last step will keep in mind the different stakeholders like the gas distributor, the commercial gas agent and the owner. Then keeping in mind the rules on activity retribution, the minima project investments and returns, minima demand for the viability of the project or the project internal ratio of benefits.

VI. Conclusions

The analysis proposed, has been almost finally tested. It is expected savings of more than 2 MTm of CO_2 per year, by using natural gas instead of Marine Gas Oil. The model pretends to develop a of viability analysis for port conversions in natural gas providers for ships berthed. This last, would be a quick solution to comply with the European directive on sulfur contents in fuels used at port. This project should be supported by a favorable tax and port fees treatment for all ships using this service. The model once completed, would be adapted to different ports, to be applied before the intention to invest in this kind of infrastructures.

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