



Shipping in Changing Climates Conference 2017

Estimation of the Greenhouse effect caused by the Spanish fleet of tugboats

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London, 4th September 2017



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1. INTRODUCTION

- The most important commercial ports are set deep into cities with big population density, so that is needed to know the impact of the ports activity on the health and its global effect
- The citizens have, as one of their main concerns, the environmental issues, specially air emissions and GHG effect
- In this study, it is established the objective of determining the GHG emissions produced by the tugboats fleet in Spain, and its contribution on the carbon footprint of the Spanish maritime transport

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1. INTRODUCTION

We are presenting in this conference the determination and analysis of the effect of the tugboats activity in the carbon footprint of the maritime transport in Spain.



Source: Marine Insight

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2. OBJECTIVES

- The determination of the GHG emissions of tugboats fleet in Spain, and its contribution on the carbon footprint of the Spanish maritime transport
- Analysis and comparison of the tugboat fleet for two years, 2007 and 2017
- Structuring the tugboat fleet for the years 2007 and 2017
- Analysis of the GHG concentrations (and its inequality) by each Spanish regions
- Define the profile of the most polluting tugboat by location, deadweight, power installed, age and length

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3. METHODOLOGY

- The estimation of the GHG caused by the tugboats fleet is done from the fuel consumption for each individual tugboat by applying the bottom-up methodology
- The GHG emissions are been calculated applying the emissions factors defined in the 3rd IMO GHG study, 2014, for the below pollutants:

CO₂

CH₄

N₂O

Applying the following equation: $E_i = C_{T,j} \times EF_i$

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3. METHODOLOGY

- Carbon Footprint

The carbon footprint is defined as “the totality of all GHG emitted by direct or indirect effect of one individual, organization, event or product. The carbon footprint is measured in mass of CO₂ equivalent”.

In this study is considered the emissions of CO₂, N₂O and CH₄, expressing all of them in CO₂ equivalent as it is shown in the following equation:

$$CF = \sum CO_{2eq}$$

Global Warming Potential (GWP)	
Component	GWP (tons CO ₂ equivalent)
CO ₂	1
CH ₄	25
N ₂ O	298

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3. METHODOLOGY

- ***GINI Indexes*** for the evaluation of the GHG concentration (inequalities).

These indexes, which synthesize the global concentration in a population, provide very useful information when quantifying the level of concentration of the variable that is examined in each case → Distribution of the GHG emissions

The ***GINI coefficient*** is based on the ***Lorenz curve***, which is a cumulative frequency function that compares the empirical distribution of a variable with the uniform (equality) distribution. This uniform distribution is represented by the diagonal $y = x$. The greater the area between the Lorenz curve and this diagonal, the greater the inequality.

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3. METHODOLOGY

- **RATES OF CO₂ EQUIVALENT FOR THE TUGBOATS FLEET**

Due to the *GINI indexes* only explain the inequality in the general context in an aggregate way, as a complement to a more disaggregated analysis, the rates of CO₂ equivalent are formalized -by regions- for the same variables.

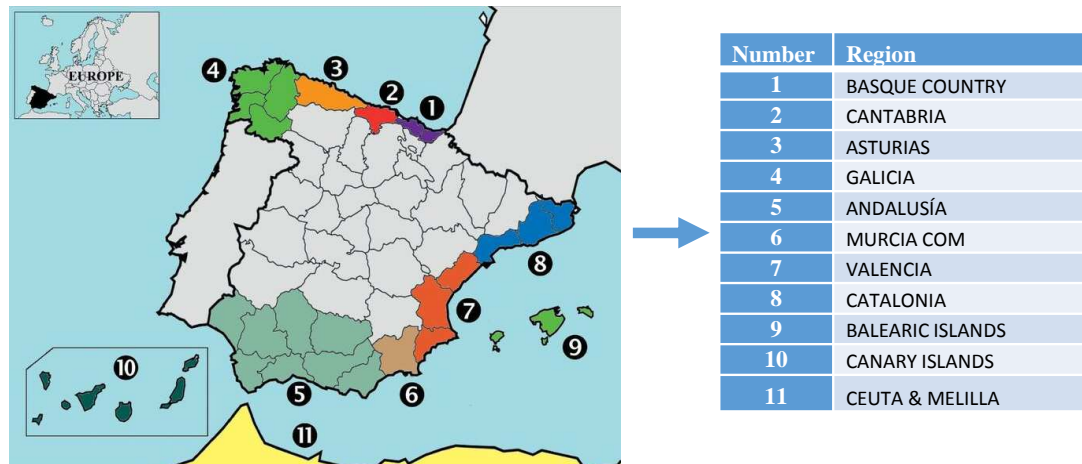
The expression determining the average rate of CO₂ equivalent of a population variable *X* of the fleet *i* of group *G* in a period *t* is given by the following relation:

$$AR / X_i(t) = [GX_i(t) / X_i(t)]$$

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4. RESULTS

- In Spain, the fleet of port tugboats is distributed on base-ports throughout 9 coastal Autonomous Communities (Basque Country, Cantabria, Asturias, Galicia, Andalusia, Community of Murcia, Valencia, Catalonia, Balearic Islands, Canary Islands) and two Autonomous cities (Ceuta and Melilla), as indicated below:



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4. RESULTS

Table 2: Evolution of the tugboats fleet structure

Region	No. Tugs		DWT (tons)		GT (Tons)		Power (KW)	
	2007	2017	2007	2017	2007	2017	2007	2017
BASQUE COUNTRY	15	19	1819	5169	2863	8134	24689	56641
CANTABRIA	4	7	649	1828	1623	2925	17740	31178
ASTURIAS	14	14	3076	3161	4805	4889	33838	35966
GALICIA	27	32	7866	9707	10223	13685	69602	94469
ANDALUSÍA	47	47	5952	7409	10670	14066	90962	112784
MURCIA COM	7	7	4054	4054	5378	5378	33943	33943
VALENCIA	29	32	4173	6182	7855	9910	74190	91831
CATALONIA	12	17	1747	3016	3542	6140	35932	60849
BALEARIC ISLANDS	4	5	651	1201	924	1831	7966	11710
CANARY ISLANDS	26	24	4429	4231	7361	6747	60412	62606
CEUTA & MELILLA	5	5	950	950	1065	1065	7673	7673

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4. RESULTS

Table 3: Concentration Indexes of GHG (GII) for the tugboats fleet, by regions

Year	GII _{NV} ^a	GII _{DWT} ^b	GII _{KW} ^c
2007	0.377	0.555	0.366
2017	0.423	0.626	0.437

Where

a = Concentration indexes of GHG of the tugboat fleet in Spain by NV.

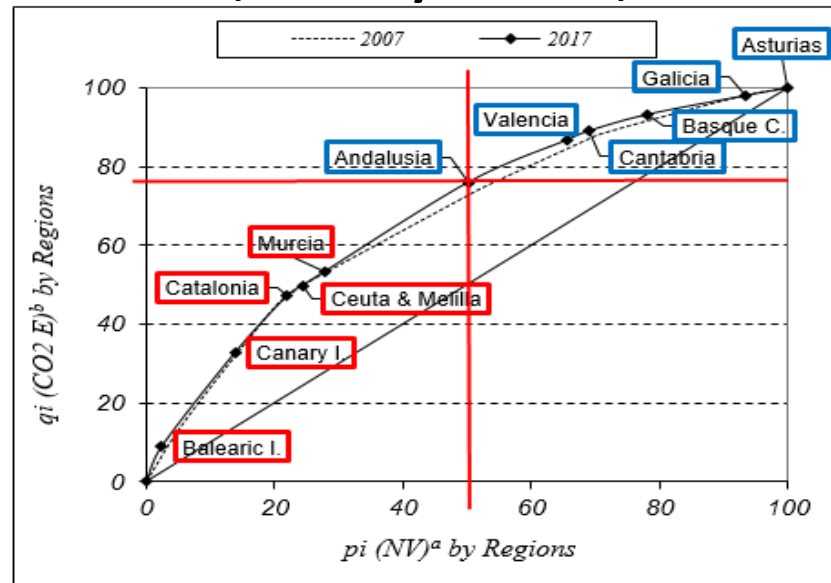
b = GHG levels (CO₂ E) of the Spanish tugboat fleet by DWT

c = GHG levels (CO₂ E) of the Spanish tugboat fleet by PI

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4. RESULTS

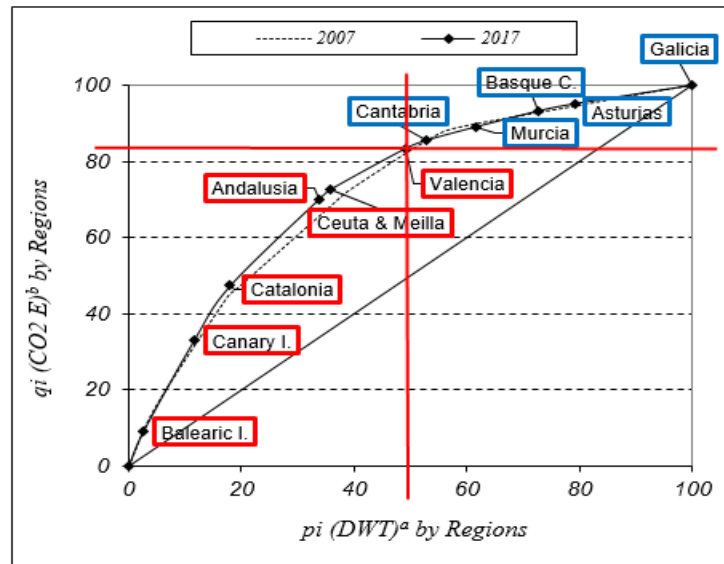
In the last year under analysis (01/01/2017), around 50% of the tugboats fleet emitted almost 77% of the total CO₂ equivalent produced by the fleet, distributed in five regions: Balearic Islands, Canary Islands, Catalonia, Ceuta & Melilla and Murcia



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4. RESULTS

Also, looking at the deadweight of the tugboat fleet, 50% of the total deadweight of the fleet is emitting 83% of the CO₂ equivalent, distributed in six regions: Balearic Islands, Canary Islands, Catalonia, Ceuta & Melilla, Andalusia and Valencia

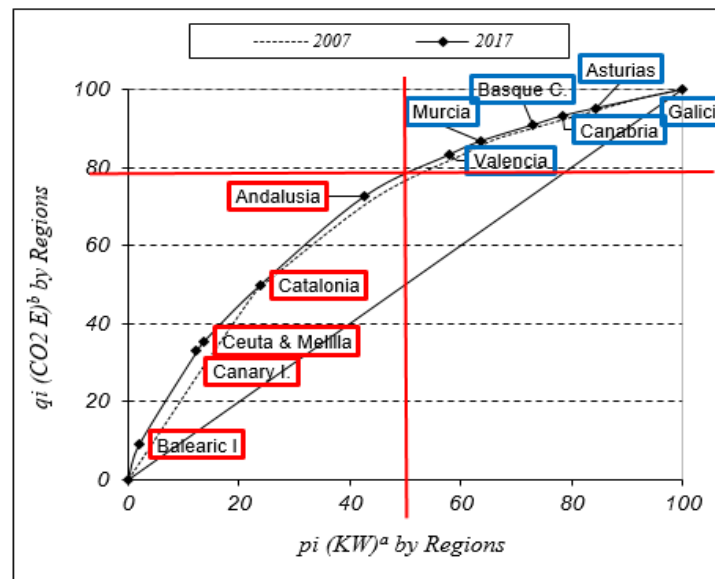


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In the same year analysed, 50% of the installed power concentrates almost 80% of the equivalent CO₂ emissions. The regions that are emitting these percentages are Balearic Islands, Canary Islands, Ceuta & Melilla, Catalonia and Andalusia



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4. RESULTS

Table 4: Rates of CO₂ equivalent of the tugboats fleet and the variations, by regions

Coastal Spanish Regions	TCO ₂ E / NV ^a			TCO ₂ E / DWT ^b			TCO ₂ E / kW ^c		
	2007	2017	Variation	2007	2017	Variation	2007	2017	Variation
<i>Basque Country</i>	124	124	0.77	1.0	0.5	-55.08	0.075	0.042	-44.37
<i>Cantabria</i>	192	184	-4.01	1.2	0.7	-40.36	0.043	0.041	-4.42
<i>Asturias</i>	80	80	-0.35	0.4	0.4	-3.03	0.033	0.031	-6.25
<i>Galicia</i>	115	86	-25.56	0.4	0.3	-28.51	0.045	0.029	-35.00
<i>Andalusía</i>	238	275	15.38	1.9	1.7	-7.31	0.123	0.115	-6.94
<i>Murcia</i>	227	281	23.72	0.4	0.5	23.72	0.047	0.058	23.72
<i>Valencia</i>	201	189	-5.64	1.4	1.0	-29.72	0.078	0.066	-15.88
<i>Catalonia</i>	682	482	-29.33	4.7	2.7	-42.01	0.228	0.135	-40.88
<i>Balearic I</i>	308	1.013	228.29	1.9	4.2	122.44	0.155	0.432	179.16
<i>Canary I</i>	556	566	1.88	3.3	3.2	-1.56	0.239	0.217	-9.25

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4. RESULTS

Table 5: Total GHG and CO₂ equivalent (tons) of the tugboat Fleet, by regions on 2007 and 2017

Coastal Spanish Regions	2007				2017			
	CO ₂	CH ₄	N ₂ O	CO ₂ E	CO ₂	CH ₄	N ₂ O	CO ₂ E
<i>Basque Country</i>	1.827	0.034	0,085	1853	2332	0.044	0.109	2365
<i>Cantabria</i>	756	0.014	0.035	767	1271	0.024	0.059	1289
<i>Asturias</i>	1107	0.021	0.052	1123	1104	0.021	0.052	1119
<i>Galicia</i>	3058	0.057	0.143	3102	2698	0.050	0.126	2737
<i>Andalusía</i>	11038	0.207	0.516	11197	12736	0.238	0.596	12919
<i>Murcia</i>	1567	0.029	0.073	1590	1939	0.036	0.091	1967
<i>Valencia</i>	5739	0.107	0.268	5821	5975	0.112	0.280	6061
<i>Catalonia</i>	8068	0.151	0.377	8184	8077	0.151	0.378	8194
<i>Balearic I</i>	1216	0.023	0.057	1234	4991	0.093	0.234	5063
<i>Canary I</i>	14245	0.267	0.667	14451	13397	0.251	0.627	13590
Total tugboats fleet	50366	0.943	2.356	51091	55952	1.047	2.618	56758

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4. RESULTS

Table 6: Carbon footprint of the maritime transport in Spain for 2014. Carbon footprint originated by the tugboats fleet in 2017, and percentage of the total carbon footprint caused by the tugboat fleet.

Country	Carbon footprint of maritime transport (kTon CO ₂ E / year)	Carbon footprint of tugboat fleet (kTon CO ₂ E / year)	Percentage of carbon footprint caused by the tugboats
Spain	1930	56.758	2.94 %

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5. CONCLUSIONS

- ✓ The methodology used for determination of the GINI indexes is shown as an efficient tool to determine the concentration and inequality by regions of GHG emissions of the tugboat fleet in Spain. This methodology may be applied in other population groups.
- ✓ The concentration of GHG originated by the tugboats fleet shows an increase of **12.2%** in the period under review (2007-2017). The tugboats that concentrate the most emission of greenhouse gases are in the regions of Balearic Islands, Canary Islands, Catalonia, Andalusia and Ceuta & Melilla.
- ✓ At the beginning of 2017, the Spanish tugboat fleet accounted for **2.94%** of the carbon footprint originated by the maritime transport sector of the country.
- ✓ The profile of the most polluting tugboat of the Spanish fleet at the beginning of 2017 is defined as a tugboat operating on the Mediterranean coast, with an age between 10 and 15 years, over 30 meters in length, with a deadweight between 100 and 300 tons and with more of 4,000 kW of power installed.



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