EU shipping's climate record

Maritime CO2 emissions and real-world ship efficiency performance

TRANSPORT & ENVIRONMENT

Transport & Environment

Published: December 2019

In house analysis by Transport & Environment

The data analysis behind the report has been reviewed by the International Council on Clean Transportation (ICCT) for which T&E is grateful. All mistakes are our own.

Coordination: Faig Abbasov

Data analysis: Thomas Earl and Filipe Afonso

Expert group: Faig Abbasov, Thomas Earl, Jo Dardenne, Filipe Afonso, Lucy Gilliam, Carlos Calvo Ambel and Juliette Egal

For more information

Faig Abbasov

Shipping Programme Manager

Transport & Environment

faig.abbasov@transportenvironment.org

Tel: +32(0)483 7179 28

Square de Meeûs, 18, 2nd floor | B-1050 | Brussels | Belgium www.transportenvironment.org | @transenv | fb: Transport & Environment

Executive Summary

The monitoring, reporting and verification (MRV) regulation of EU maritime emissions requires most ships to report their CO_2 emissions associated with journeys to and from the EU. The reported data is very granular and requires further analysis. The purpose of this study is to translate raw emissions and ship performance data from the EU shipping MRV into policy relevant and relatable to general public knowledge. In doing so, the aim is to raise awareness on EU maritime emissions and provide concrete recommendations to policy-makers.

Guided by these goals, a key finding of this study is that container shipping operator, Mediterranean Shipping Company (MSC), joined coal power plants in the EU's top 10 emitters list in 2018. MSC was responsible for about 11 Mt of CO_2 from operations falling under the scope of the EU MRV. If shipping were part of the EU ETS, this would make MSC the EU's 8th most emitting operator.

Secondly, this study concluded that there is a large performance (i.e. gCO_2 emitted per tonne-nautical mile) gap between ship design standards and real-world maritime operations. Due to this performance gap, half the EU cargo shipping emitted about 22 Mt more CO_2 than what it would have emitted if ships operated according to their design standard. If one assumes the same trend would be observed in the remaining part of the fleet, one-third of EU shipping emissions could be attributed to the performance gap. This highlights the inadequacy of the ship design standard as a regulatory tool to decarbonise the sector.

Thirdly, the report revealed that CO_2 emitted by shipping attributed by this study to the Netherlands, Belgium, Norway, Latvia and Estonia in 2018 was larger than or comparable to CO_2 emitted by the total national passenger car fleet in those countries. In France, Germany, UK, Spain, Sweden, and Finland, shipping emissions in 2018 were larger than the emissions from all the passenger cars registered in 10 or more of the largest cities in each country. The analysis shows that approximately 20% of the EU maritime CO_2 was emitted by ships transporting fossil fuels, namely, coal, crude oil, and LNG. In France, Norway, and Latvia, this figure is above a third of the total national maritime emissions attributed by this study to those countries.

Lastly, the study recommends including EU shipping in the EU Emissions Trading Scheme (ETS) via the establishment of a European Maritime Climate Fund to ensure the sector pays for its carbon pollution. In addition, the report recommends mandating operational EU CO_2 standards to shipping (covered under the MRV scope) in order to cut emissions and drive the uptake of energy efficiency technologies and zero-carbon fuels/energy.

Table of Contents

1. Policy and regulatory context

European shipping is a large source of greenhouse gas (GHG) emissions and air pollution. The sector emitted about 139 million tonnes of CO_2 in 2018[1] and recent analysis has shown that its contribution to air pollution can be larger than those of all passenger vehicles in Europe.[2]

By signing the Paris Agreement, EU committed for "economy wide" emissions reduction efforts.[3] However, shipping is currently the only sector not yet contributing to the EU's emissions reduction targets and efforts. As such international shipping stands in the way of the EU fulfilling its Paris commitment. As a result, sectoral emissions have grown by about 26 million tonnes of CO_2 or 19% since 1990.[4]

1.1. Maritime tax subsidies

The sector is benefiting under EU law from €24 billion per year fossil fuel tax subsidies for international journeys[5], as well as exemptions from ticket taxes (passenger ships), VAT and corporate taxes. The latter has been replaced by a mediocre "tonnage tax" system, which is applied to the fleet's cargo carrying capacity as opposed to regular corporate income or profits. Tonnage tax is considered a favourable tax treatment to shipowners, as under this system shipping companies pay much lower than regular corporate actors. Some call this "zero taxation" for shipping.[6]

In addition to fuel tax subsidies for international journeys, a recent report by the International Transport Forum (ITF) found that "*at least EUR 3 billion per year is spent on just three maritime subsidies in OECD countries: tonnage taxes, tax exemptions for fuels for domestic shipping, and fiscal measures to reduce wage costs of seafarers*".[7] The report also concluded that these maritime subsidies have failed to deliver their expected aims, inter alia, increasing local flags, seafarer employment and short-sea shipping. Quite the opposite, the subsidies have boosted the shipbuilding business in Asia instead of Europe, which could have indirectly contributed to jobs creation. In contrast, Europe's market share in global shipbuilding hovers around 1.6%.[8]

1.2. (Lack of) Climate regulation

European governments have in the past prioritised the efforts through the International Maritime Organisation (IMO) – UN's maritime agency, to find a global solution for shipping GHG. First discussions at

---

[1] EU THETIS MRV, 2019. Accessed October 2019, file version 100. Accessible: https://mrv.emsa.europa.eu/#public/emission-report

[2] T&E, *One Corporation to Pollute Them All: Luxury Cruise Air Emissions in Europe*, 2019.

[3] Paris Agreement, Article 4.4, 2015.

[4] Member State reporting of greenhouse gas inventories to UNFCCC. Available: https://unfccc.int/process-and-meetings/transparency-and-reporting/reporting-and-review-under-the-convention/greenhouse-gas-inventories-annex-i-parties/national-inventory-submissions-2019. This increase is based on fuel sales, as MRV type data is not available in 1990, and includes all ship types not covered in the MRV.

[5] T&E, *EU shipping's €24 bn a year fossil tax holidays: Maritime ETS is urgent to cut shipping's fuel subsidies*, 2019.

[6] Knudsen, K. (1997), "The economics of zero taxation of the world shipping industry", Maritime *Policy and Management*, Vol. 24:1, pp. 45-54.

[7] International Transport Forum, *Maritime Subsidies: Do They Provide Value for Money?*, 2019, p.6.

[8] BRS Group, *Shipping and Shipbuilding Markets,* Annual Review 2019, p.7.

the IMO started in 1997 when the Kyoto Protocol asked developed countries to work through the IMO to find a solution to shipping's climate impact. Despite this and multiple deadlines for action by the EU, the IMO has failed to make progress to implement mandatory deep GHG reduction measures.

After 21 years of procrastination, the IMO eventually agreed in 2018 a GHG strategy - a non-binding resolution accepting the need for eventual decarbonisation of the sector. However, the ensuing efforts at the IMO proved insurmountable.

Since the adoption of the 2018 GHG Strategy, the IMO held three rounds of international negotiations. Unfortunately, they were limited to discussions on the process, procedure, action plans and resulted in nothing more than superficial declarations without agreement on actual emissions reduction measures capable of delivering deep emissions reductions and deployment of zero-carbon green fuels.

Frustrated with the dysfunctional IMO process the European Parliament and civil society increased calls for EU to regulate international shipping. Consequently, the President-elect of the European Commission Ursula von der Leyen made extending the EU Emissions Trading Scheme to maritime transport as one of the top political priorities of her upcoming tenure.[9] A maritime ETS also featured high during the confirmation by the European Parliament of the first executive vice-president nominee Frans Timmermans in charge of climate action.

1.3. EU Shipping MRV regulation

The only EU GHG regulation currently applicable to EU shipping is the EU Monitoring, Reporting and Verification Regulation (2015/757), or the MRV, adopted in 2015. The regulation requires all ships above 5 000 gross tonnage (GT) to report their annual fuel consumption and associated CO_2 emitted during the voyages between the European Economic Area (EEA) ports, the last non-EEA ports and the next EEA ports and the last EEA ports and the next non-EEA ports. The first year of compliance was set for 2018 with the first EEA-wide emissions reports released on the 30 July 2019.

Under this regulation, ships are required to monitor and report per ship, inter alia, the following parameters: total annual CO_2; total annual CO_2 separately for outbound and inbound journeys; total annual CO_2 emitted inside the EEA ports; average CO_2 emissions per transport work, defined as gCO_2/tonne-nautical mile (also known as the EEOI); average CO_2 emissions per distance, defined as gCO_2/nautical-mile.

After the adoption of the EU MRV, the IMO has since adopted its own system, called Data Collection System (DCS). Under the DCS ships are required to monitor their emissions starting from the year 2019. However, unlike the EU MRV, the IMO DCS doesn't include transport work based on actual cargo/passenger carried, nor is it third-party verified. Also, IMO DCS is not transparent, in other words, the reported data will never be made public. Following the adoption of the IMO DCS, the European Commission has since proposed to

---

[9] Ursula von de Leyen (2019), A Union that strives for more: My agenda for Europe, Political guidelines for the next European Commission 2019-2024.

revise the EU MRV in order to harmonise some of its elements with the DCS. During the preparation of this report, the revision of the EU MRV had not yet been finalised.

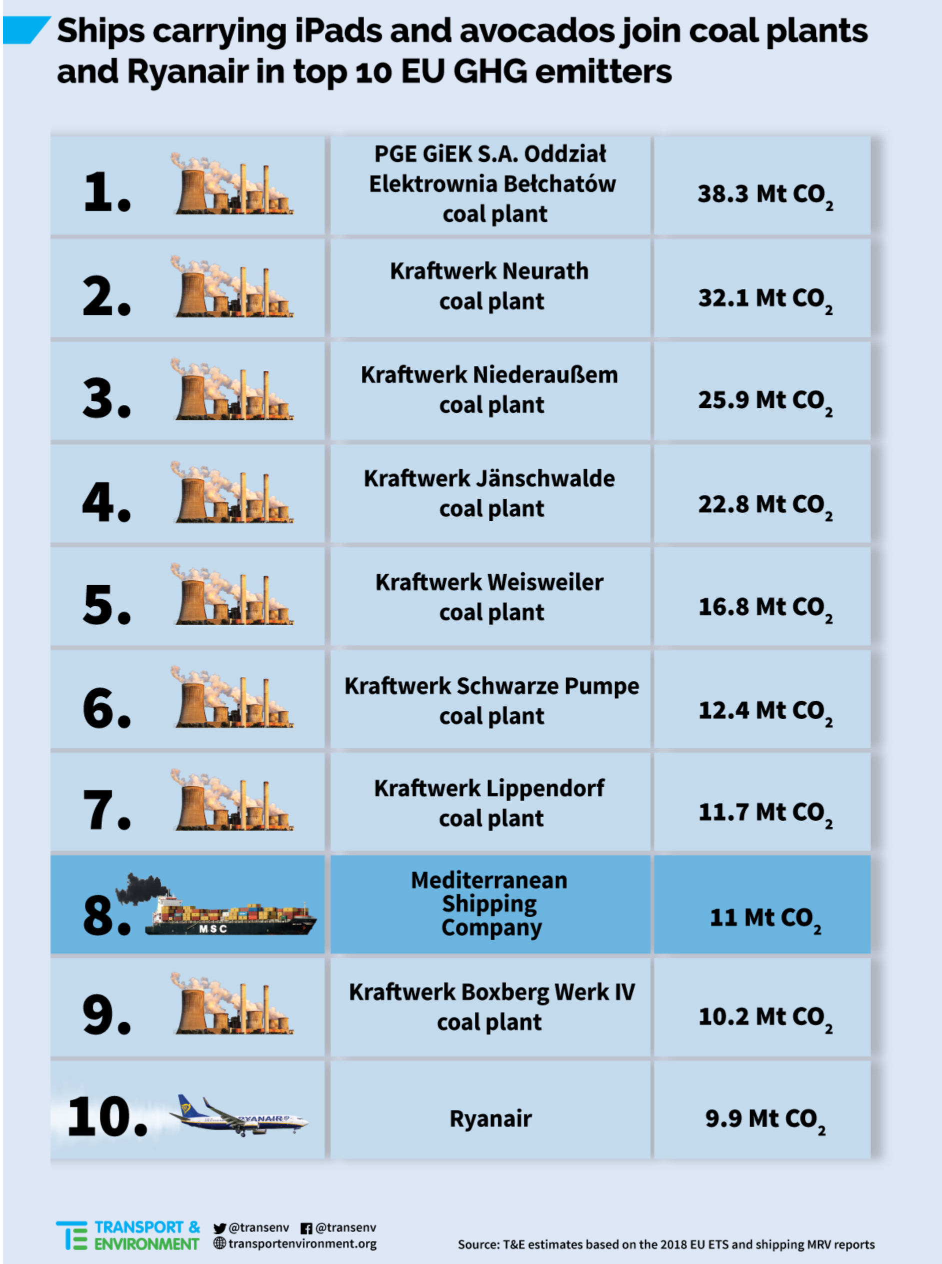
1.4. The purpose of this report

The MRV is a rich source of data allowing independent analysis of the shipping sector to monitor the progress of individual ships. This report presents the findings of our in-house analysis of the MRV data to show the ships and the companies that are performing well or not, to show the magnitude of shipping emissions that is not often in the consciousness of policy makers and citizens, and to provide concrete recommendations to enable effective short terms improvements along with steering the emissions trajectory towards a decarbonised future. To perform this analysis, we used complementary third-party databases too, including Clarkson's Fleet Register and Alphaliner containership database.

2. Company level findings

2.1. Ranking of TOP 10 emitters and container liners in Europe

Based on the data submitted by shipping companies through the MRV regulation, T&E has updated its ranking[10] of the most polluting operating companies that would fall under the EU ETS. The analysis revealed that the **Mediterranean Shipping Company (MSC)** joined coal power plants and Ryanair in the list of top 10 most CO_2 emitting companies in Europe. This list is based on the emissions of installations/operators that are currently covered or would have been covered by the EU Emissions Trading Scheme (ETS).



Ships carrying iPads and avocados join coal plants and Ryanair in top 10 EU GHG emitters

1.	PGE GiEK S.A. Oddział Elektrownia Bełchatów coal plant	38.3 Mt CO_2
2.	Kraftwerk Neurath coal plant	32.1 Mt CO_2
3.	Kraftwerk Niederaußem coal plant	25.9 Mt CO_2
4.	Kraftwerk Jänschwalde coal plant	22.8 Mt CO_2
5.	Kraftwerk Weisweiler coal plant	16.8 Mt CO_2
6.	Kraftwerk Schwarze Pumpe coal plant	12.4 Mt CO_2
7.	Kraftwerk Lippendorf coal plant	11.7 Mt CO_2
8.	Mediterranean Shipping Company	11 Mt CO_2
9.	Kraftwerk Boxberg Werk IV coal plant	10.2 Mt CO_2
10.	Ryanair	9.9 Mt CO_2

Source: T&E estimates based on the 2018 EU ETS and shipping MRV reports

Figure 1: Ranking of the top 10 CO_2 emitters in Europe in 2018

---

[10] https://www.transportenvironment.org/press/ryanair-joins-club-europe%E2%80%99s-top-10-carbon-polluters

MSC, the world's second largest container shipping company, released over **11 million tonnes of CO_2** in the atmosphere in 2018 during the journeys falling under the scope of the EU MRV, which puts it at the 8th position on the ranking of the most polluting in Europe, next to some of the most CO_2 intensive coal plants (Figure 1).

European companies dominate the world container fleet[11], which is also reflected in their relative share of the EU maritime emissions. This study found that the top 4 of the largest emitters among the container fleet are European, namely, MSC, Maersk and CMA CGM group. These three companies are cumulatively responsible for more than half of Europe's container ship emissions (Table 1).

First developed in the early 1950s, container ships currently transport most consumer goods, ranging from consumer electronics, clothes and furniture to fresh fruit and pharmaceutical products. Container ships usually operate on set routes under fixed schedules and are therefore known as liner vessels. According to United Nations Conference on Trade and Development (UNCTAD), transportation of containerised goods has more than tripled since 2000 and the trend is only growing.[12]

Table 1: Ranking of Top 10 container shipping CO2 emitters

Ranking	Container ship companies	# of ships	CO_2 (Mt)	% container CO_2
1	Mediterranean Shipping Company	362	11.04	25.0%
2	APM-Maersk	335	8.22	18.6%
3	CMA CGM Group	231	5.67	12.8%
4	Hapag-Lloyd	135	4.32	9.8%
5	COSCO Group	113	3.71	8.4%
6	ONE (Ocean Network Express)	68	2.32	5.3%
7	Evergreen Line	50	1.48	3.4%
8	Yang Ming Marine Transport Corp.	29	0.80	1.8%
9	UniFeeder	32	0.40	0.9%
10	X-Press Feeders Group	28	0.34	0.8%

Analysis of the EU MRV data also helps shed light on the breakdown of different cargo/passenger carriers in the total EU shipping emissions. As Table 2 indicates, ships transporting unitised consumer goods to/from

---

[11] Alphaliner TOP 100, accessible: https://alphaliner.axsmarine.com/PublicTop100/
[12] UNCTAD, Review of Maritime Transport in 2018, p. 8.

the EU emitted in 2018 around 59 Mt CO_2, representing 42% of the total CO_2 emissions of the sector. These are comparable to total emissions of all Italy's 38 million passenger cars in a year.[13] Emissions from the bulk sector, additionally, are comparable to cumulative emissions public heating and electricity sectors of Denmark, Ireland, Sweden, Austria, Norway, Croatia, Cyprus, Slovakia and Slovenia combined (Table 2).

Table 2: Breakdown of EU shipping emissions and other comparable sectors in the EU

CO_2 from shipping (Mt)		CO_2 from comparable sectors (Mt)[14]	
Ships carrying unitised consumer goods	59	62	Italy's total car emission (2017)
		65	Benelux's total industrial emissions (2017)
Passenger shipping (cruise/ferry)	20	18	Netherland's total car emissions (2017)
Non-unitised bulk cargo	53	53	Total cumulative emissions from the public heating and electricity sectors of Denmark, Ireland, Sweden, Austria, Norway, Croatia, Cyprus, Slovakia and Slovenia (2017)
Other ship types	7		
Total	**139**		

Under the T&E breakdown of emissions reported under the MRV, the transport of unitised consumer goods includes a range of different ships that carry all kinds of consumer goods. It includes:

- container ships, container/Ro-Ro and general cargo ships (which can transport any consumer product from phones to TVs, to clothing, to furniture, to packaged processed food)
- refrigerated cargo containers (for fresh and frozen food and goods)
- vehicle carriers (transporting passenger cars we buy)
- roll-on/roll-off cargo carriers (transporting wheeled cargo, such as cars, trucks, semi-trailer trucks)

2.2. Ranking of container ship operators based on operational efficiency

Ship CO_2 intensity is an important factor having an impact both on the environment, as well as the economics of the maritime operations. Operational CO_2 intensity of a ship, dubbed energy efficiency operational index (EEOI), is a function of the amount of CO_2 emitted per transport work. Transport work is defined as the total amount cargo or passengers carried multiplied by the total distance sailed. Given that different ships carry different types of cargo, the units of transport work also change, i.e. *tonne-nautical-*

---

[13] EU GHG emissions inventory reported to UNFCCC, 2017.
[14] EU GHG emissions inventory reported to UNFCCC, 2017.

miles, m^3-nautical-miles, or passenger-nautical-miles. Table 3 below classifies various metrics for transport work commonly used by the industry and the EU MRV regulation.

Table 3: CO_2 intensity metrics for different ship types under the EU MRV Regulation

Ship types	CO_2 intensity metrics	Notes
Passenger, Ro-Pax	gCO_2/Pax-nm	Based on the number of passengers carried. Ro-Pax vessels also report transport work for freight by mass.
Oil tankers, chemical tankers, bulk carriers, refrigerated cargo ships, vehicle carriers, gas carriers, combination carriers, container ships, Ro-Ro, Ro-Pax	gCO_2/tonne-nm	Based on the mass of the actual cargo carried
LNG carriers, container/ro-ro cargo ships	gCO_2/m^3-nm	Based on the volume of the actual cargo carried
General cargo ships, other ship types	gCO_2/DWT-t-nm	Based on ship deadweight for laden (i.e. loaded) voyages and as zero for ballast voyages

It is also important to stress that, since almost the entire global fleet sails on fossil energy, the combustion of which releases GHG, CO_2 intensity of a ship is also an indirect indicator of its energy efficiency. Energy efficiency is defined as grams of fuel burned per transport work (differentiated per ship type as per Table 3). As such, the lower the carbon intensity the more efficient a ship is, hence, the lower is the fuel consumption to transport goods and passengers. Therefore, analysis of CO_2 intensity of ships is a good indication both of their *relative* impact on the climate but also fuel costs of associated by maritime freight.

EEOI should be contrasted with energy efficiency design index (EEDI) or estimated index values (EIV), which are theoretical carbon intensity estimates by ship designers and builders. The EU MRV data is granular enough to comparatively analyse design and operational efficiency indicators for each ship type.

Table 4 below provides the ranking of the top 10 emitting container companies in terms of their design and operational efficiency. At face value, the results indicate that, apart from COSCO Group and ONE (Ocean Network Express), ships operated by all other major liner companies performed on average worse in real world conditions than what their design labels would promise. This means that operational efficiency (i.e. low carbon intensity) promised by the design certification of these ships was not realised in the real world. Identification of the precise factors leading to this performance gap is beyond the scope of this analysis.

Table 4: On average container ships have worse real-world performance compared to their design labels (CO_2 weighted averages per company).

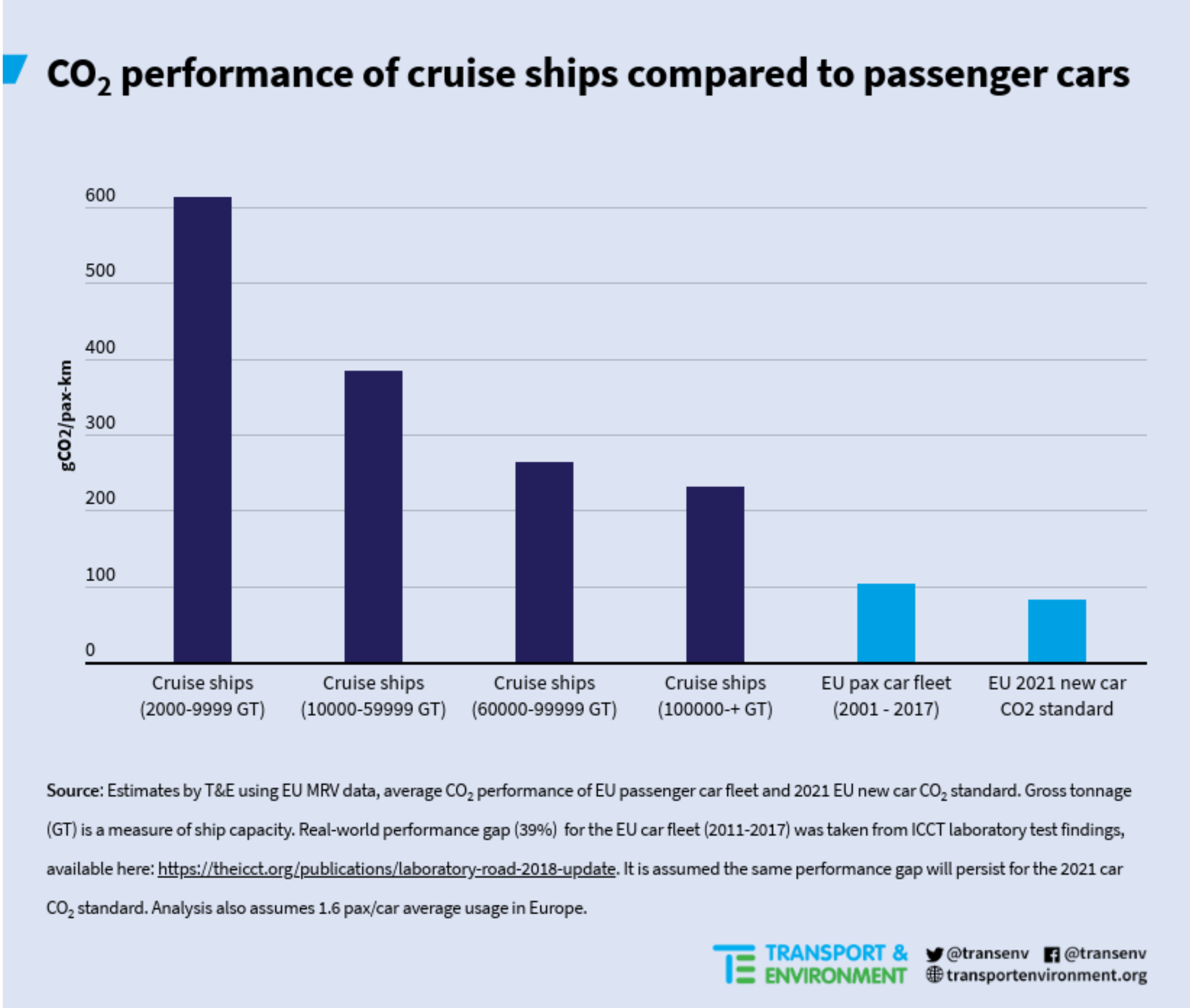
Theoretical design efficiency				Real-world operational efficiency			
Ranking*	**Companies**	**# ships with EIV or EEDI****	**EIV or EEDI (gCO_2/dwt_t-nm)[†]**	**Ranking***	**Companies**	**# ships with EEOI****	**EEOI (gCO_2/cargo_t-nm)**
1	COSCO Group	82	13.74	1	COSCO Group	85	13.24
2	Yang Ming	3	16.02	2	ONE (Ocean Network Express)	58	14.59
3	MSC	169	16.31	3	MSC	347	19.92
4	CMA CGM Group	175	16.33	4	CMA CGM Group	205	20.40
5	Evergreen Line	33	16.49	5	Evergreen Line	47	20.70
6	APM-Maersk	249	17.03	6	Hapag-Lloyd	123	21.13
7	ONE (Ocean Network Express)	47	17.96	7	Yang Ming	26	21.35
8	Hapag-Lloyd	65	18.29	8	APM-Maersk	261	22.07
9	UniFeeder	16	29.24	9	UniFeeder	30	39.02
10	X-Press Feeders Group	14	29.36	10	X-Press Feeders Group	21	43.05

** The higher position an operator holds in the ranking, the more efficient their ships/operations were.*
*** Some ships did not report their EIV OR EEDI and/or EEOI. This explains the discrepancy in the number of vessels for the design and operational efficiency scores.*
[†] *Estimations of EIV OR EEDI for containerships assume 70% load-factor under the relevant IMO guidelines.*

2.3. Real world operational performance of cruise ships

Unlike cargo ships, passenger vessels are a public facing segment of the industry and have in the past been subject to public criticism for their excessive emissions. The sector usually responds to such criticism by pointing out their superior energy efficiency per passenger km. The availability of granular MRV data allows to perform a comparison between passenger vessels and road vehicles in Europe. This report analysed only the cruise ships, classified as “passenger ships” in the MRV database. Interpretation of Ro-Pax ships is complicated by the choice of emission allocation method (between freight and passengers) and what appears to be unclear reporting for a large portion of ships. See for Methodology in Annex I for further discussion.

To carry out this analysis, we used the real-world performance of cruise ships, categorised per size segment and the real-world performance of the current EU fleet, as well as the upcoming EU passenger car CO_2 standard. Figure 2 below demonstrates that, cruise ships in Europe emitted in 2018 up to 5 times more CO_2 per passenger km compared to the average passenger car fleet in Europe. This gap increases to 6 when compared to the EU new car CO_2 standard to be phased in 2021.



Source: Estimates by T&E using EU MRV data, average CO_2 performance of EU passenger car fleet and 2021 EU new car CO_2 standard. Gross tonnage (GT) is a measure of ship capacity. Real-world performance gap (39%) for the EU car fleet (2011-2017) was taken from ICCT laboratory test findings, available here: https://theicct.org/publications/laboratory-road-2018-update. It is assumed the same performance gap will persist for the 2021 car CO_2 standard. Analysis also assumes 1.6 pax/car average usage in Europe.

Figure 2: CO2 performance of cruise ships compared to passenger cars

The findings are not rosy for the luxury cruise operators, such as Carnival Corporation and Royal Caribbean Cruises (RCC), the world's first and second largest cruise operators. Carnival's 2018 environmental sustainability report claims on average 251 grams of CO_2 per available lower berth-km (ALB-km).[15] The conversion of ALB-km to passenger-km is not always straightforward. Above-mentioned Carnival report explains that ALB is a measure of "*guest beds available on a cruise ship, assuming two people occupy each cabin*".[16] If one assumes 1 ALB-km equals 2 passenger-km[17] when ships are occupied to their maximum theoretical capacity, then this would translate to 125 grams of CO_2 per pax-km for Carnival ships. Royal

---

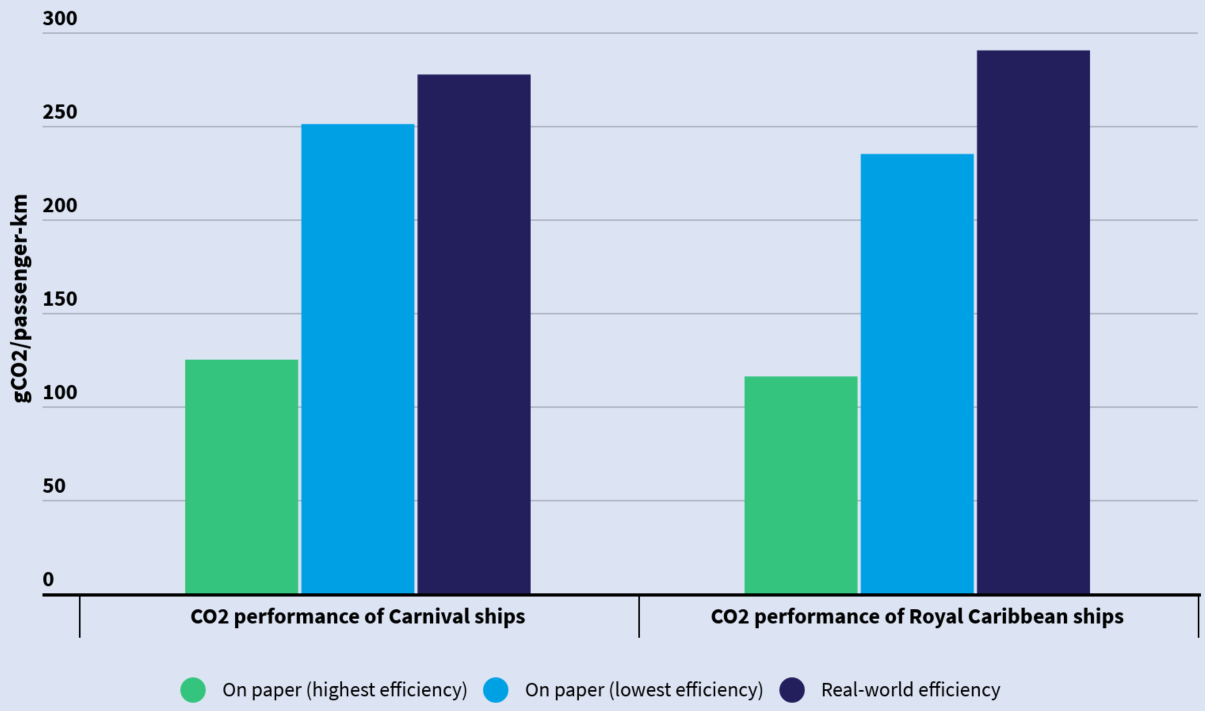
[15] Carnival 2018 sustainability Report, p. 102. Available at: https://carnivalsustainability.com/download-files/2018-carnival-sustainability-full.pdf

[16] Carnival 2018 sustainability Report, p. 141.

[17] Western Norway Research Institution explains that ALB-km is equivalent to two passengers per km. Simonsen, M. (2014) "Cruise Ship Tourism - A LCA Analysis", Western Norway Research Institution, p.5. Available at: http://transport.vestforsk.no/Dokumentasjon/pdf/Skip/Cruise.pdf

Caribbean cruises, similarly, claimed 232 grams of CO_2 per ALB-km, or 116 grams of CO_2 per pax-km in their 2017 environmental sustainability report.[18]

In real-world cruise ships perform worse than on paper



Source: Estimates by T&E based on the EU shipping MRV and the environmental sustainability reports of Carnival and Royal Caribbean Cruises: available at http://sustainability.rclcorporate.com/download/report/ and https://carnivalsustainability.com/download-files/2018-carnival-sustainability-full.pdf. Real-world CO_2 intensity is a weighted average of the selected cruise ships per company based on each ship's absolute CO_2 emissions as reported under the EU MRV. Cruise companies report their efficiency as a function of available low berth km (gCO_2/ALB-km), assuming two passengers occupy each cabin. To translate ALB-km to Pax-km, green bars assume 1 ALB = 2 pax, while light blue bars assume 1 ALB = 1 pax.

TRANSPORT & ENVIRONMENT @transenv @transenv transportenvironment.org

Figure 3: Real-world and on-paper performance gap of luxury cruise ships

This report found that the real-world performance of cruise vessels owned by Carnival and Royal Caribbean Cruises and operated in Europe in 2018, were far inferior to those claimed by the industry.[19] On the basis of the weighted average for each ship's relative share of total CO_2 emissions, this report found that the real-world efficiency performance of Carnival and RCC was 277 gCO_2/pax-km and 290 gCO_2/pax-km, respectively. This equals to more than two-fold real-world performance gap for these two luxury cruise operators when one assumes that 1 ALB equals to 2 passengers (Figure 3).

---

[18] http://sustainability.rclcorporate.com/download/report/

[19] We assume that the efficiency of ships operated by Carnival and RCC in Europe are representative of the efficiency of the fleet operated by those respective companies globally.

2.4. Impact of design performance gap on real world CO_2 emissions

Traditionally, a ship's design efficiency was a theoretical indicator of its economic performance, hence an important factor in the *commercial transaction* between the shipbuilder and shipowner. In the context of climate change, design efficiency can also be construed as an "*implicit promise*" given to society about the *maximum* damage that a given (fossil) ship could cause to the environment for a given amount of transport work. This promise underpins relevant policy designs by governments. Therefore, the success or failure of those policies to deliver the promised emissions reductions should inform future policy choices.

This report found that in the majority of the cases theoretical design efficiency of ships were not upheld in real-life operational conditions. With the aim to demonstrate the impact of the aforementioned non-performance, this report quantified the extra CO_2 emitted by each ship due to the gap between the theoretical design and operational real-world efficiency.

Table 5, Table 6 and ANNEX III: below present the analysis of ships cumulatively responsible for about half the EU maritime emissions. The results show that, about 22 million tonnes of CO_2, representing about one-third of the analysed maritime emissions by cargo ships, can be attributed to the gap between the EIV OR EEDI and EEOI, the two metrics respectively measuring theoretical design and operational real-world efficiency of ships. If one assumes that the same trend would be observed in the remaining part of the fleet, then one could conclude that one-third of the total EU maritime emissions are due to the performance gap between design and real-world operational ship efficiency.

Table 5: Extra CO_2 emitted by cargo ships due to the gap between design standard and the real-world operational performance

MRV ship type	size metric	# of analysed ships and share of total ships they represent in each category (%)	CO_2 (Mt) and share of total (%)*	EIV or EEDI**	EEOI**	Real-world emissions gap (Mt CO_2)
Ro-ro ship	DWT	128 (51.0%)	3.34 (55.2%)	19.06	113.3	2.56
General cargo ship	DWT	503 (50.0%)	2.50 (41.5%)	13.54	29.8	1.17
Vehicle carrier	Vehicle	211 (51.5%)	2.17 (42.4%)	19.97	80.2	1.56
Container ship	TEU	831 (51.0%)	22.39 (50.6%)	17.38	21.5	1.34
Other ship types	GT	29 (47.5%)	0.18 (17.3%)	15.56	110.7	0.03
Gas carrier	DWT	163 (56.6%)	1.33 (54.3%)	13.62	68.6	1.00
Bulk carrier	DWT	1927 (64.7%)	10.63 (59.1%)	4.71	8.4	4.29
Chemical tanker	DWT	713 (65.2%)	5.02 (54.4%)	9.21	21.1	2.61
Refrigerated cargo carrier	DWT	95 (70.4%)	1.21 (68.2%)	23.42	125.1	0.83
Oil tanker	DWT	1144 (71.4%)	12.29 (68.1%)	4.62	10.2	5.89
Combination carrier	DWT	2 (40.0%)	0.02 (22.9%)	8.09	19.2	0.01
LNG carrier	CBM	104 (54.2%)	2.71 (49.5%)	17.08	27.5	0.60
Total	--	5,853 (60.6%)	**72.82 (52.2%)**	--	--	**21.89**

** This table excludes emissions from cruise, Ro-Pax and container-RoRo ships as their design and operational efficiency metrics are incomparable. Also, the analysis is limited to individual ships that have report their EIV OR EEDI, EEOI and port emissions. CO_2 column too is limited ships that have reported the three indicates mentioned-above.*
*** EIV OR EEDI and EEOI of different ship types take into account the size metrics identified in Table 3 above. The only difference is LNG carriers, where we have converted the EEOI from gCO_2/CMB-nm to gCO_2/tonne-nm using the gravimetric density of LNG.*

Table 6: Extra CO_2 emitted by container ship companies due to the gap between design standard and the real-world operational performance

Companies	CO_2 (Mt) and share of total emissions per company (%)	EIV or EEDI (gCO_2/dwt_t-nm)	EEOI (gCO_2/cargo_t-nm)	Real-world emissions gap (Mt CO_2) (Mt)*	# ships analysed
MSC	5.22 (47.3%)	16.31	19.92	0.64	161
APM-Maersk	4.95 (60.2%)	17.03	22.07	0.46	196
CMA CGM Group	4.24 (74.8%)	16.33	20.40	0.19	156
Hapag-Lloyd	1.92 (44.5%)	18.29	21.13	0.06	63
COSCO Group	2.10 (56.7%)	13.74	13.24	-0.26	64
ONE (Ocean Network Express)	1.43 (61.5%)	17.96	14.59	-0.36	42
Evergreen Line	0.44 (30.0%)	16.49	20.70	-0.01	30
Yang Ming	0.06 (8.0%)	16.02	21.35	0.02	3
UniFeeder	0.21 (51.6%)	29.24	39.02	0.04	14
X-Press Feeders Group	0.19 (56.4%)	29.36	43.05	0.05	11
Remaining carriers	2.80 (47.3%)	17.47	21.62	0.55	370
Total	**23.57 (53.3%)**	**15.78**	**19.08**	**1.38**	**1110**

** positive values mean ships emitted more CO_2 than what their design efficiency would predict. Negative values mean the opposite.*

From the policy-making viewpoint, the implications of these findings are two-fold. Firstly, given that operational conditions of a ship change due to fluctuations in the market conditions, including cargo load and operating speed, but also weather and sea conditions, design standards fail to correctly predict ships' performance in the real-world. Secondly, due to this mismatch between theoretical and real-world performance, climate policy for shipping solely relying on design technical standards will likely fall short of achieving emissions reductions objectives.

2.5. Share of different on-board emissions sources in total shipping CO_2

Ships burn fuel for three main reasons: propulsion via the main engines (ME), electricity production via the auxiliary engines (AE), and steam generation via auxiliary boilers (AB) to produce for on-board operations.[20]

---

[20] Ships with diesel-electric propulsion use on-board diesel generators to produce electricity both for electric propulsion motors and auxiliary power demand, such as hotel loads in cruise ships.

This means that even when ships are immobile, docked at berth or anchorage, fuel is still used by the AEs and ABs that emit CO_2 and other air polluting substances.

Under the EU MRV Regulation, ships are required to report separately their emissions at berth in EEA ports. This covers emissions by AE and AB as explained above. However, AE and AB emissions at sea are not reported separately. Using the ratio of fuel consumption between ME and AE estimated by the 3rd IMO GHG study[21] (see Methodology for details), this report has concluded that AE are responsible for about 30% of the EU shipping emissions (Table 7). Ship emissions while at berth is 6% of the total. These findings have relevance both for the gradual use of the carbon-free renewable fuels/energy by ships, but also for the choice of European regulatory measures to ensure the uptake (see Section 4).

Table 7: Contribution of auxiliary engines and port emissions to the total EU shipping CO_2

MRV ship type	# of ships (% of total number of ships of each type)	Total CO_2 (Mt) and share of ships covered (%)	CO_2 from AE in port (Mt)	Estimate CO_2 from AE at sea (Mt)	Estimated share of AE in total CO_2 (%)
Passenger (cruise) ship	133 (89.9%)	5.6 (88.1%)	0.59	2.35	42%
Ro-pax ship (passenger ferries)	328 (93.7%)	13.0 (93.6%)	0.91	2.46	19%
Ro-ro ship	250 (96.2%)	5.9 (97.1%)	0.27	2.05	35%
General cargo ship	1004 (91.4%)	5.5 (91.5%)	0.25	1.33	24%
Vehicle carrier	410 (91.5%)	4.6 (89.8%)	0.21	1.00	22%
Container ship	1626 (92.8%)	41.6 (94.1%)	1.48	8.16	20%
Other ship types	61 (52.6%)	0.6 (55.4%)	0.03	0.29	50%
Gas carrier	288 (94.1%)	2.3 (95.6%)	0.15	1.45	62%
Bulk carrier	2977 (80.4%)	14.8 (82.1%)	0.56	2.14	15%
Chemical tanker	1094 (82.9%)	7.6 (82.6%)	0.72	1.47	19%
Refrigerated cargo carrier	135 (93.1%)	1.7 (96.1%)	0.05	0.69	40%
Container/ro-ro cargo ship	72 (93.5%)	1.5 (91.4%)	0.15	0.72	23%
Oil tanker	1603 (88.0%)	16.2 (89.9%)	1.61	4.48	28%
Combination carrier	5 (71.4%)	0.1 (88.9%)	0.00	0.02	26%
LNG carrier	192 (96.5%)	5.1 (94.0%)	0.14	0.86	17%
Total	10178 (86.6%)	126.2 (90.5%)	**7.13**	**29.47**	**29%**

---

[21] http://www.imo.org/en/OurWork/Environment/PollutionPrevention/AirPollution/Documents/Third%20Greenhouse%20Gas%20Study/GHG3%20Executive%20Summary%20and%20Report.pdf

3. Country level findings

3.1. Ranking of allocated shipping emissions per European country

The EU MRV regulation requires ships to monitor and report their EU-related CO_2 emissions in an aggregated manner. Therefore, the MRV THETIS database includes combined EEA emissions only without country or port breakdown. From a policy-making viewpoint, this means that potential future EU measures on shipping will need to regulate ship GHG as a whole without sharing the efforts among different member states.

However, the availability of trade data on EUROSTAT allows us to allocate MRV emissions to individual countries as a function of maritime cargo volumes (by mass) and passenger numbers handled in each country's ports. Based on this methodology (details in Annex I), this report assigned/allocated MRV ship CO_2 to each country (Figure 4). Emissions reported to the UNFCCC (dark blue bars in Figure 4) are based on marine fuel sales in each European country. This does not reflect activity-based emissions associated to each country. Conversely, estimated MRV CO_2 (light blue bars) has been calculated and allocated by T&E using the EU MRV CO_2 and maritime trade volumes per cargo type published by Eurostat and reflects emissions related to voyages to national sea ports.

The results indicate that one-third of EU member states account for more than two-thirds of the EU ship GHG emissions. This can be explained by the fact that the biggest European sea ports are located in the largest EU economies. It must be stressed that, cargo volumes handled by these ports are not destined to host countries alone and are usually transported, in part by rail and trucks, to the rest of the EU, too. However, the existence of large maritime ports also contributes to the development of national industrial production, and transport, storage and communications sectors. As a result, it is often the case that the big EU sea ports tend to also be large industrial production sites.

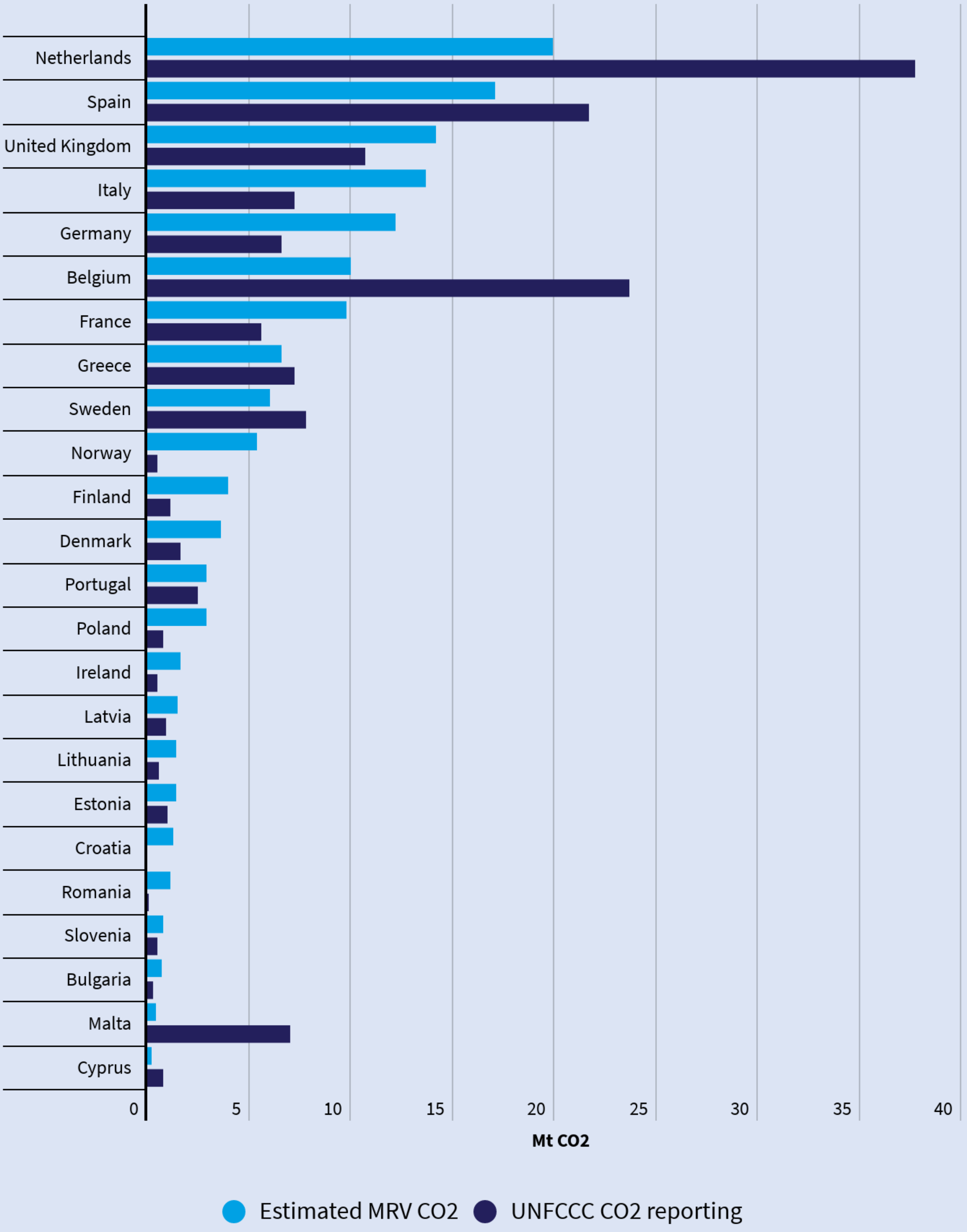
For example, according to recent estimates the Port of Rotterdam alone contributes about €45.6 billion a year to the Dutch economy.[22] Belgian ports, too, contribute significantly, about €20 billion per year to the Belgian economy.[23] The economic opportunity that large ports generate also creates ethical responsibility to tackle (shipping) emissions linked to those ports. Therefore, EU countries with the largest ports could be expected to bear the political burden of driving ambitious European measures to help decarbonise the maritime sector.

---

[22] https://www.portofrotterdam.com/en/news-and-press-releases/the-rotterdam-effect-economic-significance-of-the-port-is-twice-as-high-as

[23] https://www.nbb.be/en/articles/economic-importance-belgian-ports-flemish-maritime-ports-liege-port-complex-and-port-5

European shipping emissions per country (2018)



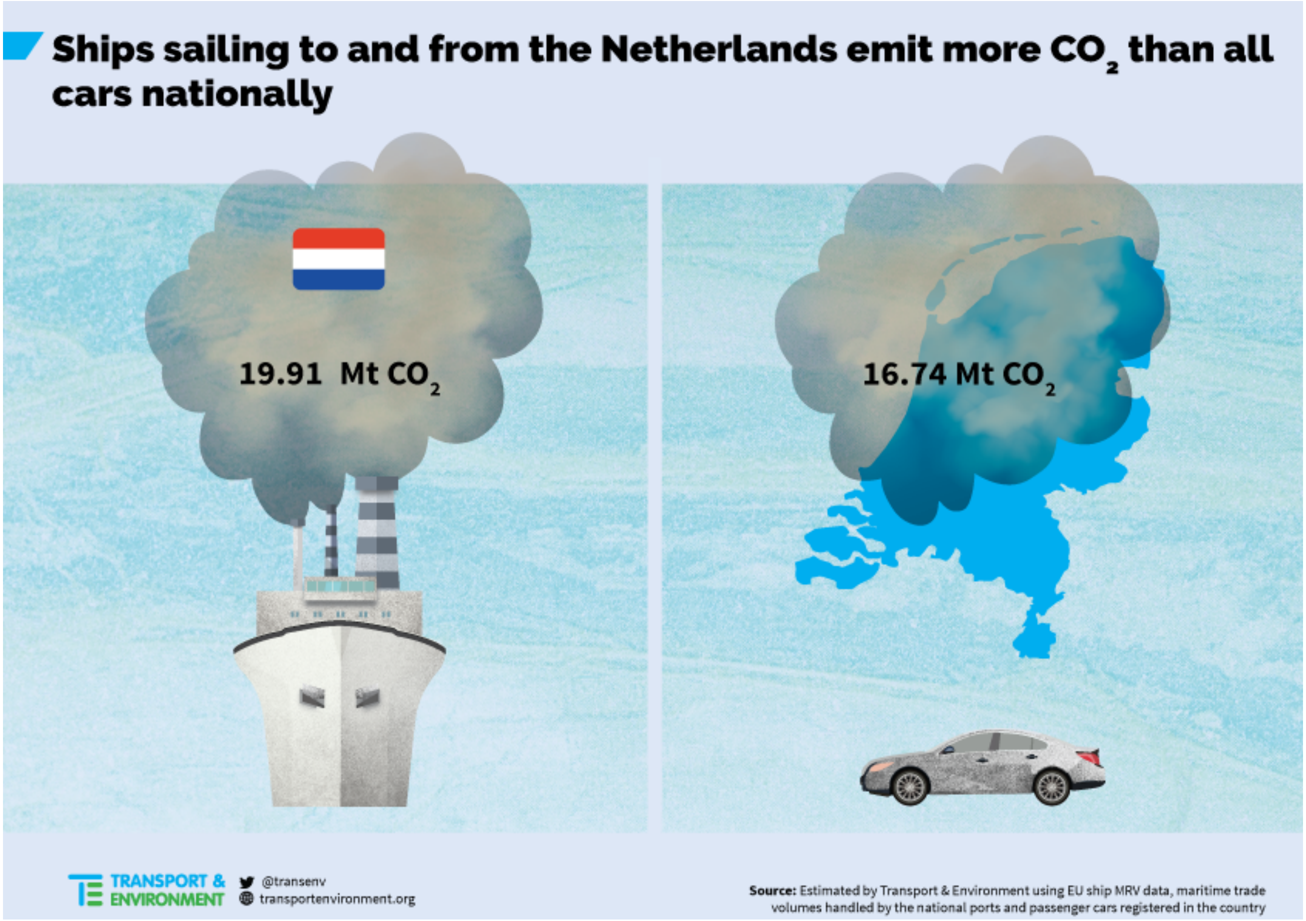
Source: Emissions reported to the UNFCCC (dark blue bars) are based on marine fuel sales in each European country. This does not reflect activity-based emissions associated to each country. Conversely, estimated MRV CO_2 (light blue bars) has been calculated by T&E using the EU MRV CO_2 and maritime trade volumes per cargo type published by Eurostat and reflects emissions related to voyages to national sea ports.

TRANSPORT & ENVIRONMENT @transenv @transenv transportenvironment.org

Figure 4: MRV CO2 emissions allocated to European countries

3.2. EU shipping's climate impact relative to passenger car CO_2 emissions

The amount of the ship CO_2 assigned to each European country can be compared to the EU car fleet. As Table 8 demonstrates, allocated ship CO_2 is larger than or comparable to the CO_2 emitted by the **total national car fleet** in the Netherlands, Belgium, Norway, Latvia and Estonia. In addition, in France, Germany, UK, Spain, Sweden and Finland shipping emissions in 2018 were larger than the emissions from all the passenger cars registered in **10 or more largest cities** in each country respectively (see Annex II for further information).



Source: Estimated by Transport & Environment using EU ship MRV data, maritime trade volumes handled by the national ports and passenger cars registered in the country

Figure 5: Comparison of maritime emissions related to the Netherlands and total national car CO_2

These findings have huge political implications in EU countries. On the one hand, not regulating shipping emissions is akin to exempting large sources of CO_2 in major European cities and countries. In absolute terms, EU shipping emissions would equal to CO_2 from a quarter (68 million) of the Europe's total passenger car fleet (see Methodology and ANNEX II: Comparison of ship and car emissions for details for car CO_2 calculations). Secondly, given the magnitude of EU emissions, inaction on shipping risks undoing already inadequate decarbonisation gains achieved in other sectors.[24] Therefore, without tackling shipping emissions, Europe's commitment to the Paris Agreement will remain incomplete and unfulfilled.

Table 8: CO2 from ships vs. emission from the national car fleet (see Annex II for details and sources)

Rank	Country	Ship CO_2 (Mt)	Comparison	CO_2 from passenger cars (Mt)	
1	Netherlands	19.9	larger	16.7	Total national car fleet
2	Spain	17.1	larger	12.2	Cars from Top 30 cities (municipalities)
3	UK	14.2	larger	13.9	Cars from Top 17 cities (incl. Greater London area)
4	Italy	13.7	larger	13.5	Cars from 4 large provinces (Rome, Milan, Turin, Bologna)
5	Germany	12.3	larger	9.4	Cars from Top 10 cities (incl. state of Berlin and Hamburg)
6	Belgium	10.0	comparable	11.7	Total national car fleet
7	France	9.8	larger	9.6	Cars from Top 10 cities and 1 large region (Grand Est)
8	Greece	6.6	Equal to 2/3	10.7	Total national car fleet
9	Sweden	6.0	larger	4.3	Cars from Top 30 cities (communes)
10	Norway	5.4	comparable	5.4	Total national car fleet
11	Finland	3.9	larger	2.3	Cars from Top 10 cities
12	Denmark	3.6	Equal to 2/3	5.0	Total national car fleet
13	Portugal	2.9	larger	2.8	Cars from Top 8 cities
14	Poland	2.9	larger	2.7	Capital region (Warsaw)
15	Ireland	1.6	comparable	1.7	Cars from three large cities (Dublin, Cork, Limerick)
16	Latvia	1.5	larger	1.4	Total national car fleet
17	Lithuania	1.4	Equal to 1/2	2.6	Total national car fleet
18	Estonia	1.4	larger	1.4	Total national car fleet
19	Croatia	1.3	Equal to 1/3	3.2	Total national car fleet

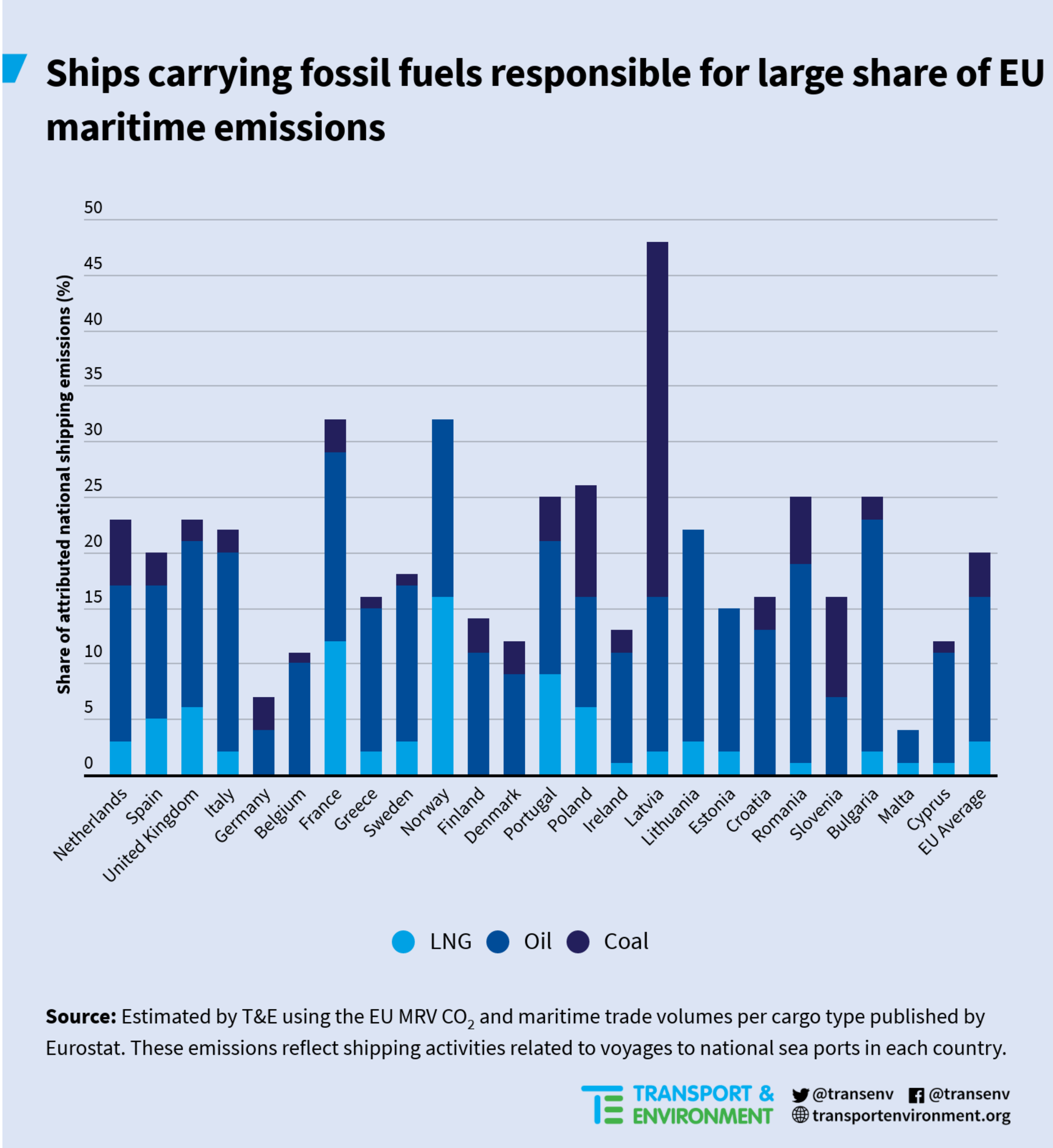
3.3. Share of fossil trade in maritime emissions

The availability of the granular trade data in Eurostat also allowed us to estimate the share of CO_2 emitted by ships carrying fossil fuels, namely, coal, crude oil (and fossil derivatives) and LNG (see Methodology for details). As Figure 6 indicates, the transport of fossil fuels by ships contribute to a sizeable share of maritime emissions. In France and Norway this figure stands at 1/3 of allocated national ship CO_2. On average, 20% of the EU's maritime emissions are due to the crude tankers, coal and LNG carriers, i.e. the transportation of fossil fuels.

Given that these ships are currently exempt from fuel taxation and/or carbon pricing, one could view this as an additional layer of indirect subsidies given by the Europe to the fossil fuel industry. This contributes to prolonging Europe's dependence of fossil fuels, consequently slowing down the transition to decarbonised economy.

---

[24] CE Delft, The share of aviation and maritime transport in the EU's transport related fossil fuel demand, 2016. Available at: https://www.transportenvironment.org/publications/share-aviation-and-maritime-transport-eu%E2%80%99s-transport-related-fossil-fuel-demand



Source: Estimated by T&E using the EU MRV CO_2 and maritime trade volumes per cargo type published by Eurostat. These emissions reflect shipping activities related to voyages to national sea ports in each country.

Figure 6: Share of fossil fuel transport in maritime CO_2 emissions

4. How can EU measures help the sector decarbonise?

4.1. Technical options

Technical options for zero and low emission shipping exist and fall into 2 broad categories: zero carbon fuels that would substitute current fossil marine fuels, and the technologies which improve efficiency of ships. Both require policy interventions, i.e. regulatory measures to support their deployment in the market.

In terms of fuels, the most sustainable options are battery-electric and hydrogen (pure or in denser forms such as ammonia) technologies from sustainable renewable sources to decarbonise shipping. Although battery-electric propulsion appears to be the most efficient use of primary energy, a technology mix - battery, hydrogen, ammonia - is a more likely pathway for the different segments of EU shipping - domestic, intra-EU and extra-EU. Varying combinations of battery-electric and carbon-free fuels are likely to be pursued depending on the available renewable energy and specificities of individual shipping segments.[25]

4.2. Regulatory measures

Broadly speaking, policy measures to regulate shipping sector fall under two categories:

1. *Command and control measures*: include, but are not limited to, operational CO_2 standards, as well as zero-emission shipping mandates.
2. *Economic measures*: include, but are not limited to, Emissions Trading Scheme, CO_2 levies and fuel taxes.

The following sections will discuss these categories in further detail, while the last section will provide policy recommendations for Europe.

4.2.1. Command & control measures | EU Operational CO_2 standard & ZEV mandates

Operational CO_2 standards

Command and control mechanisms that were traditionally applied to the means of transport were limited to vehicle design standards and fuel blending mandates. While the former requires vehicle manufacturers to improve the carbon intensity of the new vehicles sold in the market, the latter places an obligation on the fuel suppliers to reduce the carbon intensity of the fuel provided to the consumers. EU car CO_2 standards and biofuel blending mandates for road petrol and diesel under the EU Renewable Energy Directive (RED II) are the prime examples of these measures. While fuel blending mandates proved to be a counterproductive effort, leading to vast uptake of unsustainable biofuels[26], EU car CO_2 standards appear to be a robust tool to drive in electrification of the European car fleet.[27]

In the case of shipping, both fuel blending and ship design CO_2 standards (EEDI) appear to be inadequate tools to drive decarbonisation. On the one hand, this report found that ships performed considerably differently in the real-wold and that half of the EU shipping CO_2 can be attributed to this gap between theoretical design standard and the real-world performance (see section 2). On the other hand, fuel

---

[25] For details, see T&E (2018), *Roadmap to decarbonising European shipping*, https://www.transportenvironment.org/publications/roadmap-decarbonising-european-shipping

[26] BBC, Biofuels: 'Irrational' and 'worse than fossil fuels', 2013. Accessible at: https://www.bbc.co.uk/news/science-environment-22127123

[27] T&E, Mission Possible: How carmakers can reach their 2021 CO2 targets and avoid fines, 2019. Available at: https://www.transportenvironment.org/publications/mission-possible-how-carmakers-can-reach-their-2021-co2-targets-and-avoid-fines

blending is expected to lead to the same disastrous results as in the road sector and is deemed inappropriate regulatory also from the enforcement viewpoint.[28]

In this context, there are additional regulatory tools available, namely, operational CO_2 standards (EEOI) and operational ZEV mandates, that are almost unique to shipping. If designed well, these measures can help reduce the sectors carbon emissions and incentivise the deployment zero-carbon energy and fuels.

Operational CO_2 standards refer to the regulator setting a carbon intensity objective (X gCO_2/tonne-nm or X gCO_2/passenger-nm) for the fleet, shipping operator and/or ship to achieve in the near future and leave it to the shipowner/operator to choose the means of achieving the set goal. To comply with such an objective, ships can in the near-term reduce their operational speed, increase their load-factor, install energy saving devices, including wind-assist technologies and implement other operational optimisations. In the mid-term with stringent enough CO_2 objective, a switch to zero-carbon fuels/energy source to propel the ship and produce auxiliary power would be necessary. This would force existing ships to retrofit to run on carbon-free fuels and incentivise news ship designs that are optimised for new propulsion methods.

As such, there are three main practical differences between operational (EEOI) and design CO_2 standards (EEDI):

1. Firstly, under the EEDI design standard, the legal obligation of the shipowner is to purchase and/or operate a ship that is certified by the manufacturer to theoretically achieve certain improvements. Such a system does not place any legal requirement on the shipowner to actually achieve those promised improvements in real world. Conversely, under the operational CO_2 standard the legal obligation of a shipowner/operator would be to prove to have achieved required improvements in real-world operations.
2. Secondly, EEDI design standard applies to new ships only. With an average ship lifetime of 25-30 years, it would take EEDI significantly longer time horizon to renew the global fleet and drive in new technologies and fuels to decarbonise the sector. In contrast, EEOI operational CO_2 standard would apply to all ships, existing and new fleet alike, and ensure level playing field in reducing emissions and the adoption of new technologies.
3. Lastly, despite global operations, the majority of new ships are built and sold in East Asia.[29] For this reason, a European regulation setting design CO_2 standard for new ships, built and/or sold in Europe, would likely exempt 98% of ships sailing around the world and have no real impact on emissions reductions. Conversely, operational CO_2 standards would not face such a constraint as it would apply to all ships, new and old alike, regardless of the place construction, flag and nationality of the ship owner or operator.

Therefore, operational CO_2 standard is a more equitable, practical and effective regulatory tool to drive in new technologies/fuels and reduce emissions. Figure 7 below presents preliminary results of the impact of

---

[28] see T&E (2018), *Roadmap to decarbonising European shipping*, https://www.transportenvironment.org/publications/roadmap-decarbonising-european-shipping

[29] BRS Group, *Shipping and Shipbuilding Markets,* Annual Review 2019, p.7.

an operational CO_2 standard on EU shipping emissions. Analysis uses 2018 transport work per ship, defined for this purpose as tonne/CMB/passenger nautical miles, as a baseline and assumes a -40% linear operational carbon intensity (gCO_2/cargo-tonne-nm) improvement mandate for the year 2030. Analysis assumes annual transport work for oil tankers, container ships, bulk carriers to grow by -3.5%, 2.5% and 4.0% respectively.[30] Transport work for all other ship types is assumed to remain constant. The results demonstrate effective absolute emissions reductions in the region of 40% by 2030 compared to business as usual (BAU) levels in 2030 or 30% emissions reductions by 2030 compared to 2018.

With such a mandate in place, ships would have several technical and operational options for compliance. The most straightforward and easiest option would be for ships to slow down (slow steaming) to reduce fuel consumption, hence the emissions. The impact of slow steaming is a well-understood and researched subject. CE Delft analysis from 2017 concluded that 30% speed reduction would deliver a cumulative 33% emissions reduction for bulk carriers, tankers and containerships alone.[31]

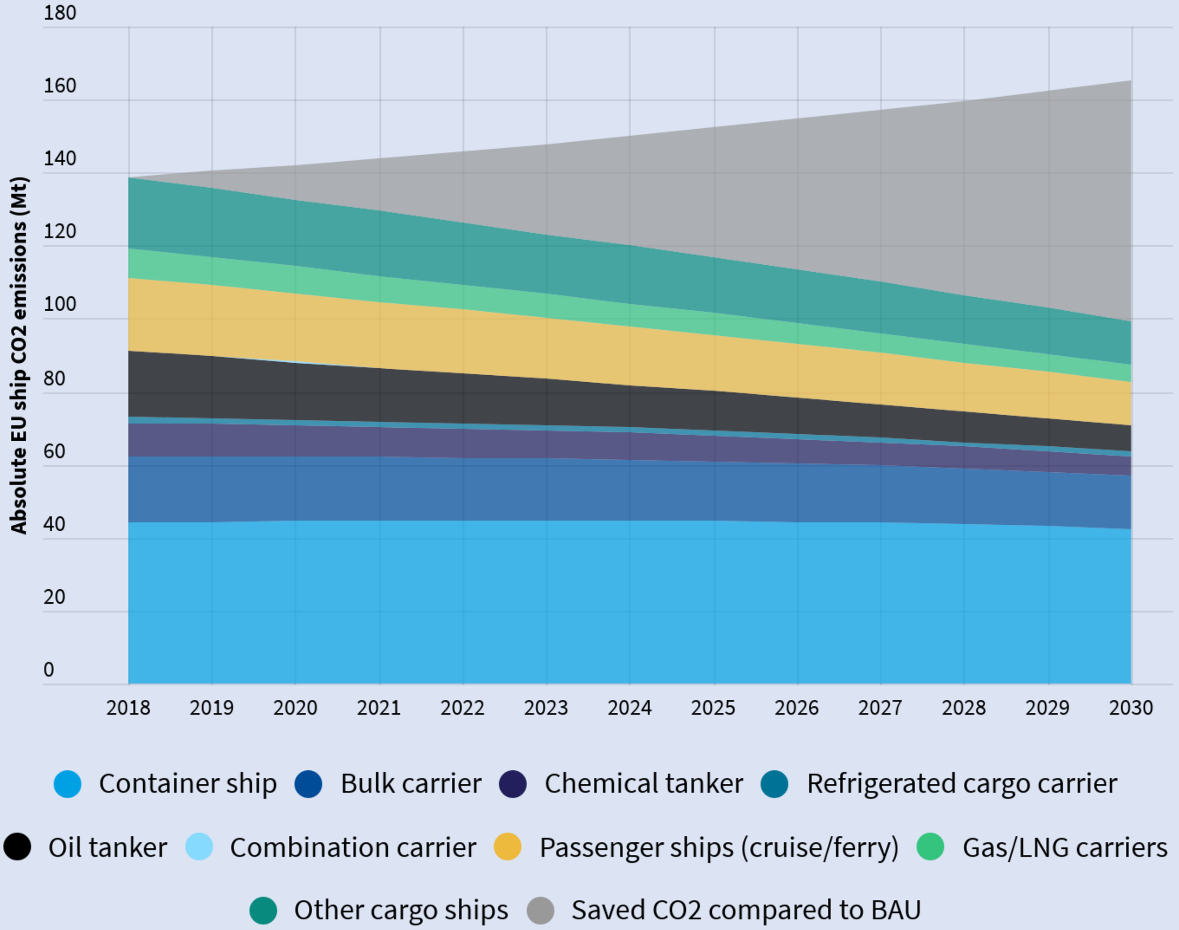
In addition to or in lieu of slow steaming, ships would have alternative methods to comply with such a mandate. Using shore-side electricity (SSE) when at berth, installing wind-assist and other energy saving technologies, as well as fully or partially switching to zero-carbon fuels when at sea are among the possible technical options available to shipowners' and operators'. Section 2.5 above estimated that about 30% of EU ship emissions are due to fuel consumption by auxiliary engines, both in port and at sea (Table 7). Ships could eliminate those emissions by connecting to SSE when in port and using hydrogen and/or ammonia by auxiliary engines/boilers when at sea.

The analysis of the precise contribution of different emissions reduction methods to the -40% 2030 operational CO_2 standard is beyond the scope of this study. However, one could expect that in the short-term ships could use slow steaming to reduce their carbon intensity. In the mid-term, all else being equal, a combination of moderate (10-15%) speed reduction and switch to zero carbon fuels/energy for auxiliary engines/boilers would deliver and over-achieve a -40% 2030 operational CO_2 standard.

---

[30] Growth factors in transport work was taken from the UMAS (2018), LNG as a marine fuel in the EU, p.11, accessible at: https://www.transportenvironment.org/sites/te/files/2018_06_LNG_marine_fuel_EU_UMAS_study.pdf

[31] CE Delft (2017), Regulating speed: a short-term measure to reduce maritime GHG emissions; see also, UMAS and CE Delft (2019) Study on methods and considerations for the determination of greenhouse gas emission reduction targets for international shipping Final Report: Short-term Measures.



Operational CO_2 standard could reduce EU ship GHG by 40% compared to business as usual in 2030

Source: Estimates by T&E based on the EU MRV data. Analysis uses 2018 transport work per ship, defined for this purpose as cargo-tonne nautical miles, as a baseline and assumes -40% linear operational carbon intensity (gCO2/tonne-nm or gCO2/pax-nm) improvement mandate for the year 2030. Analysis assumes annual transport work for oil tankers, container ships, bulk carriers grow by -3.5%, 2.5% and 4.0% respectively. Transport work for all other ship types is assumed to remain constant.

TRANSPORT & ENVIRONMENT @transenv @transenv transportenvironment.org

Figure 7: The impact of operational CO2 standards on EU shipping emissions towards 2030

Operational ZEV mandates

Operational CO_2 standards can also provide a legal framework for more demanding policy tools, such as operational zero emission vessel (ZEV) mandates, to ensure deep emissions cuts and larger uptake of zero-carbon fuels. Applied to new and old ships alike, operational ZEV mandates would require vessels to emit no GHG in real life operations. These mandates can be applied globally, but also regionally, e.g. to journeys covered by the scope of the MRV regulation. Such mandates could also be implemented in geographically limited areas, dubbed zero-emission control areas (ZECAs), for example, in the North Sea and Baltic Sea. Differentiations could also be made for different ship types; e.g. initially operational ZEV mandates could apply to luxury cruise ships and passenger ferries, which usually sail close to the shore and have predictable itineraries. This would help to accelerate the deployment of new fuels/technologies on ships, but also refuelling/recharging infrastructure in ports. Gradually, operational ZEV mandates could be extended to other ship types. In addition to direct emissions reductions, ZECAs would:

1. Create demand for zero-carbon fuels/energy and aggressively force technology uptake.
2. Would send an investment signal for fuel/technology providers and help mobilise financial resources.
3. Would help moderate operational (voyage) cost increase for the shipowners, because ships would be required to switch to (expensive) carbon-free fuels only when sailing within ZECA. This means that they would be allowed to use current marine diesel for the rest of the journey. Some shipowners are already testing duel-fuel hydrogen/diesel propulsion methods, which could underpin such a transitional set-up.[32]
4. ZECAs would also eliminate or dramatically reduce ship-sourced air pollution, hence improve coastal air quality.

The impact of ZECAs on emissions reduction will depend on the policy design, including the scope and implementation timelines. Estimation of such an impact is beyond the scope of the current report.

4.2.2. Economic measures – CO_2 levy under EU Maritime Climate Fund

Economic measures, such as carbon pricing, have long been viewed as a cornerstone of any climate policy. In Europe, two types of economic measures could be distinguished which impose direct and indirect carbon pricing on fossil fuels. Fossil fuel taxation is a prime example for the latter; however, taxing marine fuel is prohibited under the EU Energy Tax Directive.[33]

For direct carbon pricing, EU Emissions Trading Scheme (ETS) has been Europe's flagship measure for the past two decades. Based on cap & trade principle, ETS aims to lower emissions at the lowest cost and give flexibility to the economic actors to find the most cost-effect method to reduce their emissions. Despite this straightforward and theoretically effective rationale, EU ETS has long suffered from chronical low carbon price and has failed to bring about much-expected technological innovation. This does not mean that ETS has had no societal or policy relevance. It has generated substantial revenues for the governments to fund the deployment of sustainable technologies, including renewable electricity production facilities via the

---

[32] http://www.hydroville.be/en/
[33] T&E (2019), EU Shipping's €24billion/year fossil tax holidays.

feed-in tariffs. This has worked well hand-in-hand with the renewables mandate that the EU has set for the year 2020.

Politically too ETS has been a useful mechanism as it is underpinned by the ordinary-legislative procedure, a co-decision process, whereby decisions at the EU level are taken by a qualified majority as opposed to unanimity. This has helped to avoid any single country blocking the policy decisions.

Given the upcoming EU Commission for the period 2019-2024 has made extending the EU ETS to cover maritime transport, past experience with the scheme allows to design system in a way to maximise its practical relevance for decarbonising the sector, while reducing compliance costs. In general, ETS requires covered "installations" to purchase and surrender emissions allowances as a means for compliance. As per default, these rules would apply to ships covered by the scope of the EU MRV regulation, too.

An alternative method to achieve similar results, i.e. apply carbon pricing to European shipping, would be the establishment of a European Maritime Climate Fund (MCF) under the ETS. Under this system, ships would be required to pay directly to the fund CO_2 levy proportionate to their MRV emissions. Price per tonne of CO_2 could be set as an average CO_2 price in the EU ETS in the preceding year/s giving shipowners/operators predictability to factor in these costs into their future operations.

The revenues of the MCF could be channelled to reinvestment in the maritime sector, including deployment of energy saving and zero-emission technologies, port bunkering/charging infrastructure, as well as *feed-in tariffs* for zero-emission vessels under the *contracts for difference*. The latter would allow the shipping companies to cover the extra costs associated with using zero-carbon fuels/energy, such as liquid hydrogen and ammonia, while reducing financial and technological risks being the first-mover.

A recent report by T&E concluded that, requiring ships to pay for their emissions under the ETS (with current €26/tonne-CO_2 prices) would generate over €3.6 billion/year in revenues. Given the low pass-through freight costs of shipping, as well as high emissions abatement costs specific to the maritime sector, a *multiplier* (e.g. 2x) could be applied to maritime CO_2 under the ETS to double the revenues, bringing them up to €7.2 billion. CO_2 multipliers can help fill the *"fuel subsidy gap"* for the maritime sector by increasing the level of carbon pricing while maintaining the scope of emissions covered.[34] The access to capital for the development of energy-saving technologies, especially for building and testing of full-scale models and demonstration projects has been identified as the most important key barrier to the development and uptake of wind propulsion technologies. MCF could help bridge that gap by providing necessary funding, as well as risk management for the sector.

The price impact of the ETS/MCF on consumer goods would be insignificant, measured in a few euro cents. According to T&E estimates, if ships calling at EU ports were required to pay even a €50 per tonne of CO_2 price under the EU ETS and if these costs were fully passed on to final consumers proportionate to each

---

[34] 34 T&E (2019), EU Shipping's €24billion/year fossil tax holidays.

products' share of CO_2 emitted during the voyage, the price increase on these consumer goods would be insignificant. For example, a kg of banana from Ecuador or an iPad from China would respectively cost Belgium consumers for about 0.55% and 0.0005% more (all else being equal). [35]

5. Conclusions and Policy recommendations

This report found that shipping constitutes a substantial source of GHG emissions in the EU. CO_2 emitted by the world's second largest container ship operators is comparable to the largest coal power plants in the EU, while attributed national shipping emissions are in some cases larger than the total national passenger car fleet in several European countries.

Taking these into account, this report makes the following recommendations to the EU policy-makers:

- Enact CO_2 levy on EU shipping by extending EU ETS to cover international and domestic EU maritime GHG and establishing a European Maritime Climate Fund to reinvest in the sector. The revenues of the Fund could be used to finance the uptake of energy saving technologies on ships, bunkering/charging infrastructure for zero-carbon fuels/energy in European ports and subsidising the uptake of zero-carbon fuels by ships via contracts for difference.
- Mandate operational CO_2 standards for international and domestic EU shipping under the MRV scope. These standards should make use of relevant operational metrics reported under the EU MRV, preferably, EEOI and should be set at high levels in order to drive in new fuels to the maritime sector.
- Include emissions reported under the EU MRV regulation in the revised EU's 2030 reduction objective, as well as upcoming EU 2050 decarbonisation target.

The report also identified avenue for further research. This includes a techno-economic analysis on the use of different GHG reduction methods (incl. speed reduction, and uptake of energy saving technologies and zero-carbon fuels/energy, including retrofitting the existing fleet) to comply with possible EU operational ship CO_2 standards for the year 2030.

---

[35] https://www.transportenvironment.org/sites/te/files/publications/2019_09_EU_Shipping_24bn_fossil_tax_holiday.pdf

Annex I: Methodology

General notes on data analysis

This report analyses the 100th version of the THETIS-MRV database, released on 13 November 2019. In early versions of the database, there were clear outliers in the data, particularly in the total CO_2 emissions. These appear to have been mostly resolved. For other key metrics used in this study, for example the EIV OR EEDI, EEOI, and the CO_2 emissions at ports, these metrics were considered by ship type, and only the 99th percentile (or, where there were insufficient number of ships, the 95th percentile or even the 90th percentile) data was analysed to remove outliers. Some of the observed outliers were several orders of magnitude greater than the rest of the data.

We compiled additional information on the individual ships by cross matching the IMO numbers from the MRV database to the Clarkson's World Fleet Database.[36] This enabled us to add metrics such as maximum design speed, DWT, build year, GT, TEU, CBM, vehicle and passenger capacity. Coverage for most metrics was 87%.

From the Alphaliner[37] database, we allocated container ships reported under the MRV regulation to the container shipping operators based on whether they owned and/or operated those ships in 2018. More specifically, we allocated a ship to an operating company if that ship was operated by the company on both 1 March 2018 and 1 October 2018. This assumes that there was a long enough charter contract between the operator and shipowner between these two dates to bring the ship under the control of the operator in question for 2018. Hence, those ships' emissions should fall under the responsibility of the operating company in question. In total, 87% of containerships were assigned to a company based on this data. The remaining 13% of ships were not operated/owned by the same operator both in March and October 2018.

All average metrics provided are CO_2 weighted averages. When based on ship size, CO_2 weighted metrics were only calculated for the ships where there was the relevant size metric available. The ship size categories (bins) and binning metric (e.g. size by DWT, GT, TEU, etc) was based on the 3rd IMO GHG study. The ship types used in the 3rd IMO GHG study and the MRV database do not match exactly, so we use the matching criteria of Table A1.1

Table A1.1: MRV and IMO ship type matching for type and size classification.

MRV Ship type	IMO matched ship type
Passenger ship	Cruise
Ro-pax ship	Ferry – ro-pax

---

[36] https://www.clarksons.net/portal

[37] https://www.alphaliner.com/

Other ship types	miscellaneous – other
Ro-ro ship	ro-ro
Gas carrier	liquefied gas tanker
Bulk carrier	Bulk carrier
General cargo ship	general cargo
Vehicle carrier	Vehicle
Chemical tanker	Chemical tanker
Container ship	Container
Refrigerated cargo carrier	refrigerated bulk
Container/ro-ro cargo ship	general cargo*
Oil tanker	oil tanker
Combination carrier	Bulk carrier
LNG carrier	liquefied gas tanker

**Note that we used the 3rd IMO GHG Report for general cargo ship size categories and classified ships by their DWT into the different size bins. However, for the purpose of analyzing their operational efficiency, we used official metrics under the MRV database, i.e. gCO*$_2$*/CBM-nm.*

Share of auxiliary engines

We use the ratios of auxiliary engine fuel consumption to main engines from the 3rd IMO GHG study 2014, Table 14, page 43 for each ship type at each size category. By simple multiplication of the total CO_2 by the proportion of fuel burn (directly correlated with emissions for fossil fuels and in lieu of clean technologies), we can determine the CO_2 associated with auxiliary engines. Only ships with these metrics available were treated when dealing with auxiliary engine loads.

CO_2 allocation to countries based on trade and passenger flows

We make use of Eurostat data to allocate emissions to member states. The two main tables are mar_pa_qm (accessed 01/10/2019) and mar_go_qm_* (accessed 12/09/0219), where the asterix is replaced by the country code. These tables provide passenger transport numbers and tonnes of cargo per cargo type to/from all European country ports, respectively. The share of transport is allocated to each member state, and the emissions from the respective ship types are then divided across each country based on these shares. Table A1.2 shows the Eurostat cargo category and the ship types allocated to them along with whether or not the cargo is a fossil fuel. As an example, the allocation of LNG carriers is split between countries based on the share of tonnes of liquified gas moving through its ports.

Table A1.2 - Allocation of Eurostat cargo to/from ports to ship type

MRV ship type	Eurostat transport good	Notes
LNG carrier	Liquid bulk - liquified gas	Fossil
Oil tanker	Liquid bulk - crude oil	Fossil
Oil tanker	Liquid bulk - refined oil products	Fossil
Chemical tanker	Liquid bulk - other	
Chemical tanker	Liquid bulk - unspecified	
Bulk carrier	Dry bulk - ores	
Bulk carrier	Dry bulk - coal	Fossil
Refrigerated cargo carrier	Dry bulk - agricultural products	
Bulk carrier	Dry bulk - other	
Bulk carrier	Dry bulk - unspecified	
Container ship	Large containers	
Vehicle carrier	Ro-Ro - road goods vehicles and accompanying trailers	
Vehicle carrier	Ro-Ro - passenger cars, motorcycles and accompanying trailers/caravans	
Vehicle carrier	Ro-Ro - trade vehicles (incl. import/export motor vehicles)	
Ro-ro ship	Ro-Ro - other mobile self-propelled units	
Ro-ro ship	Ro-Ro - unspecified mobile self-propelled units	
Ro-ro ship	Ro-Ro - unaccompanied road goods trailers and semi-trailers	
Vehicle carrier	Ro-Ro - unaccompanied caravans and other road agricultural and industrial vehicles	
Ro-ro ship	Ro-Ro - rail wagons, shipborne port-to-port trailers, and shipborne barges engaged in goods transport	
Ro-ro ship	Ro-Ro - other mobile non-self-propelled units	
Ro-ro ship	Ro-Ro - unspecified mobile non-self-propelled units	
General cargo ship	Other cargo not elsewhere specified	

Calculation of emission projections

To estimate the effect of CO_2 standards on the maritime sector, we used projections from the University College London LNG report for T&E [38]on transport demand (see Table A1.3). All other ship types are assumed to maintain 2018 demand (and thus emissions in the business as usual scenario). The total transport work in tonne-nm was back-calculated from the total CO_2 / the EEOI of a ship, to convert the emissions to demand. A 40% EEOI operational CO_2 efficiency standard was applied and assumed to be met by 2030, and the fleet of ships were assumed to improve linearly to the target multiplying the demand by the EEOI. Multiplication of the EEOIs by the projected demand gives the total CO_2.

Table A1.3 exogenous projected growth for maritime projections

Seaborne trade growth projections per year	
Oil tankers	-3.5%
Container	4.0%
Bulker	2.5%

Comparison of EEDI and EIV versus EEOI and CO_2 emission difference

Comparison of the design and operational efficiency of ship types was undertaken on ships where data was available, based on the filtering of values as described above. The units of EIV, EEDI, and EEOI are the same for most ships, i.e. in gCO2/t-nm. For LNG ships, which report operational efficiency in gCO_2/m^3-nm, these values were converted to t-nm using the liquefied density of natural gas of 450 kg/m^3. Given that cruise (passenger) ships and Ro-Pax ferries report their operational efficiency in different metrics than their design standards, i.e. gCO_2/pax-nm vs. gCO_2/DWT-nm. This made EEOI vs. EIV OR EEDI comparison for these ships impossible; hence, we excluded them from the scope this part of our report.

The emissions gap is defined as the difference between the total operational CO_2 and the CO_2 that would have been emitted had the ships been operating at their design efficiency. We define the CO_2 that would have been emitted had the ship operated at design efficiency as:

$$\text{Total } CO_2 \text{ if operated at EEDI} = \text{Total } CO_2 * \text{EEDI} / \text{EEOI}$$

To calculate the resulting emissions gap, it follows that:

$$\text{Real-world } CO_2 \text{ Gap} = \text{Total } CO_2 * (1 - \text{EEDI} / \text{EEOI})$$

---

[38] UMAS (UCL), LNG as a marine fuel in the EU, 2018. Accessible at: https://www.transportenvironment.org/publications/lng-marine-fuel-eu

A ship that that has an EEOI value that is higher than its EEDI or EIV value – which is the majority of the ships in the MRV – will yield a positive result, and thus a positive gap refers to additional emissions. A negative gap indicates the inverse, where EEOI < EEDI, resulting in a negative gap, and a ‘savings’ of emissions.

We don’t apply this formula to Passenger Ships, Ro-pax Ferries and container/Ro-Ro, as their EEOIs are not comparable with their EEDIs. Particularly for Ro-pax ferries, where the allocation between passengers and cargo can be accomplished with a mass, area, or combination mass-area formula, that can yield significant differences and there is no agreed standard in the industry on which method to use.

ANNEX II: Comparison of ship and car emissions

For city level emissions, country and city databases were consulted to obtain the number of registered vehicles in that country. Registrations to emissions were calculated based on 2t/CO_2/car/year.[39] This is a more conservative estimate than the 1.8t/CO_2/car/year that we use in our car modelling.[40] We chose not to use UNFCCC emissions for this comparison (even though the final CO_2 is comparable for nationwide fleet approximation) so that we had a consistent level of comparison based on a number of cars.

Table A.2.1: Detail calculations of car emissions per country/city

Country	City/commune /region	Number of registered passenger vehicles (cars)	Estimated passenger vehicle CO_2 (Mt)	Year	Geographical scope of passenger vehicles covered	Source
Netherlands	Total national	8,223,000	16.742	2017	Total national	EU Statistical pocketbook, 2018.
Estonia	Total national	703,000	1.431	2017	Total national	
Belgium	Total national	5,731,000	11.668	2017	Total national	
Latvia	Total national	664,000	1.352	2017	Total national	
Norway	Total national	2,663,000	5.422	2017	Total national	
Denmark	Total national	2,466,000	5.021	2017	Total national	
Malta	Total national	283,000	0.576	2017	Total national	
Greece	Total national	5,236,000	10.660	2017	Total national	
Cyprus	Total national	508,000	1.034	2017	Total national	
Slovenia	Total national	1,097,000	2.233	2017	Total national	
Lithuania	Total national	1,299,000	2.645	2017	Total national	
Bulgaria	Total national	3,144,000	6.401	2017	Total national	
Romania	Total national	5,472,000	11.141	2017	Total national	
Croatia	Total national	1,553,000	3.162	2017	Total national	
France	Paris	568,260	1.157	2019	Ville	Ministère de la Transition écologique et solidaire
	Lyon	189,492	0.386		Ville	
	Lille	81,409	0.166		Ville	
	Toulouse	192,388	0.392		Ville	
	Nice	143,778	0.293		Ville	
	Strasbourg	99,141	0.202		Ville	
	Nante	114,886	0.234		Ville	
	Bordeaux	98,410	0.200		Ville	
	Montpellier	112,534	0.229		Ville	

---

[39] For the purpose of total national car emissions, one could also use the UNFCCC reports. However, the latter is based on the fuel sold in each country. Therefore, e.g. emissions of Belgian cars refueling in the Netherlands would be reported under inventory of the latter. To avoid such a distortion, however small, we calculated total national car emissions too using the methodology explained above.

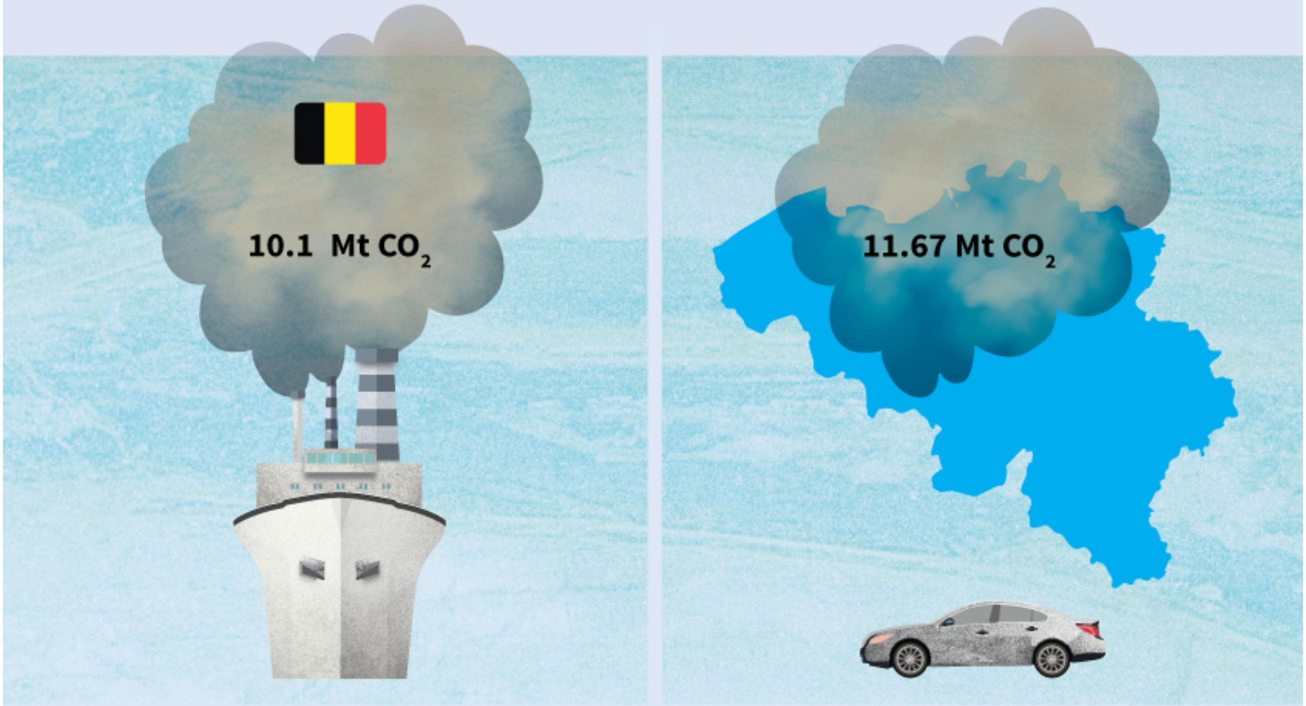
[40] See T&E (2018) CO2 from cars: the facts, figure 10, p15. Available: https://www.transportenvironment.org/publications/co2-emissions-cars-facts)

	Marseille	339,987	0.692		Ville	
	Grand Est	2,762,675	5.625		Région	
Germany	Bonn	174,990	0.356	2019	Stadt	https://www.kba.de/DE/Statistik/Produktkatalog/produkte/Fahrzeuge/fz3_b_uebersicht.html
	Koeln	482,847	0.983		Stadt	
	Berlin	1,210,790	2.465		Land	
	Hamburg	794,618	1.618		Land	
	Frankfurt am Main	336,413	0.685		Stadt	
	Stuttgart	301,793	0.614		Stadt	
	Duesseldorf	310,614	0.632		Stadt	
	Munich	245,522	0.500		Stadt	
	Dortmund	286,461	0.583		Stadt	
	Bremen	242,480	0.494		Stadt	
	Dresden	226,278	0.461		Stadt	
Italy	Rome	2,701,023	5.499	2017	Province	
	Milan	1,807,123	3.679		Province	
	Turin	1,505,637	3.065		Province	
	Bologna	609,681	1.241		Province	
Spain	Madrid	1,498,092	3.050	2019	municipio	https://sedeapl.dgt.gob.es/WEB_IEST_CONSULTA/configurarInformePredefinido.faces
	Barcelone	558,768	1.138		municipio	
	Valencia	362,267	0.738		municipio	
	Seville	328,426	0.669		municipio	
	Málaga	272,207	0.554		municipio	
	Zaragoza	267,194	0.544		municipio	
	Palma de Mallorca	248,189	0.505		municipio	
	Murcia	235,076	0.479		municipio	
	Palmas de Gran Canaria, Las	183,544	0.374		municipio	
	Alicante	158,046	0.322		municipio	
	Córdoba	153,439	0.312		municipio	
	Vigo	150,774	0.307		municipio	
	Bilbao	140,388	0.286		municipio	
	Valladolid	138,153	0.281		municipio	
	Santa Cruz de Tenerife	116,640	0.237		municipio	
	Vitoria-Gasteiz	114,439	0.233		municipio	
	Granada	113,037	0.230		municipio	
	Cartagena	112,860	0.230		municipio	
	Jerez de la Frontera	104,528	0.213		municipio	
	Aviedo	100,094	0.204		municipio	
	Almería	92,633	0.189		municipio	
	Santander	82,218	0.167		municipio	
	Albacete	80,214	0.163		municipio	

	Huelva	72,384	0.147		municipio	
	Tarragona	63,228	0.129		municipio	
	Salamanca	61,503	0.125		municipio	
	Algeciras	60,190	0.123		municipio	
	León	59,760	0.122		municipio	
	Cádiz	44,795	0.091		municipio	
	Alzira	23,302	0.047		municipio	
UK	Greater London Area	3,047,503	6.205	2019	City	https://www.gov.uk/government/collections/vehicles-statistics#vehicle-licensing-data-tables
	Edinburgh	175,870	0.358		City	
	Glasgow	261,731	0.533		City	
	Cardiff	151,325	0.308		City	
	Birmingham	684,470	1.394		City	
	Manchester	152,450	0.310		City	
	Leeds	326,408	0.665		City	
	Sheffield	213,487	0.435		City	
	Liverpool	188,824	0.384		City	
	Bristol	328,997	0.670		City	
	Leicester	432,386	0.880		City	
	Nottingham	128,823	0.262		City	
	Southampton	105,173	0.214		City	
	Coventry	159,068	0.324		City	
	Aberdeen	235,307	0.479		City	
	Belfast	164,850	0.336		City	
	Newcastle	99,369	0.202		City	
Sweden	Göteberg	189,509	0.386	2018	Kommun	Sveriges Officiella Statistik
	Stockholm	355,457	0.724		Kommun	
	Uppsala	84,736	0.173		Kommun	
	Västerås	70,022	0.143		Kommun	
	Linköping	69,469	0.141		Kommun	
	Jönköping	67,608	0.138		Kommun	
	Örebro	66,894	0.136		Kommun	
	Helsingborg	64,026	0.130		Kommun	
	Lund	63,493	0.129		Kommun	
	Malmö	119,255	0.243		Kommun	
	Sollentuna	33,505	0.068		Kommun	
	Norrköping	63,371	0.129		Kommun	
	Umeå	55,657	0.113		Kommun	
	Borås	54,026	0.110		Kommun	
	Sundsvall	50,818	0.103		Kommun	
	Halmstad	50,794	0.103		Kommun	
	Eskilstuna	49,220	0.100		Kommun	
	Gävle	47,411	0.097		Kommun	

	Södertälje	46,241	0.094		Kommun	
	Nacka	45,869	0.093		Kommun	
	Karlstad	44,710	0.091		Kommun	
	Växjö	44,087	0.090		Kommun	
	Kungsbacka	43,689	0.089		Kommun	
	Kristianstad	43,293	0.088		Kommun	
	Solna	40,948	0.083		Kommun	
	Luleå	39,623	0.081		Kommun	
	Skellefteå	39,104	0.080		Kommun	
	Huddinge	38,399	0.078		Kommun	
	Gotland	36,042	0.073		Kommun	
	Kalmar	35,298	0.072		Kommun	
	Varberg	34,728	0.071		Kommun	
	Karlskrona	34,270	0.070		Kommun	
Ireland	Dublin	499,691	1.017	2017	City	https://statbank.cso.ie/px/pxeirestat/Statire/SelectVarVal/Define.asp?maintable=THA18&PLanguage=0
	Cork	242,436	0.494		City	
	Limerick	84,244	0.172		City	
Finland	Helsinki	267,823	0.545	2018	City	http://pxnet2.stat.fi/PXWeb/pxweb/en/StatFin/StatFin__lii__mkan/statfin_mkan_pxt_11ic.px/
	Espoo	140,904	0.287		City	
	Vantaa	127,739	0.260		City	
	Tampere	113,093	0.230		City	
	Oulu	110,582	0.225		City	
	Turku	93,573	0.191		City	
	Jyväskylä	76,203	0.155		City	
	Kuopio	68,029	0.139		City	
	Lahti	66,953	0.136		City	
	Pori	58,229	0.119		City	
Poland	Warsaw	1,332,923	2.714	2018	City	https://bdl.stat.gov.pl/BDL/dane/podgrup/tablica
Portugal	Lisbon	417,120	0.849	2013	City	Marktest database
	Sintra	232,321	0.473		City	
	Vila Nova de Gaia	159,620	0.325		City	
	Porto	137,020	0.279		City	
	Cascais	130,980	0.267		City	
	Loures	119,868	0.244		City	
	Braga	96,326	0.196		City	
	Matosinhos	92,540	0.188		City	

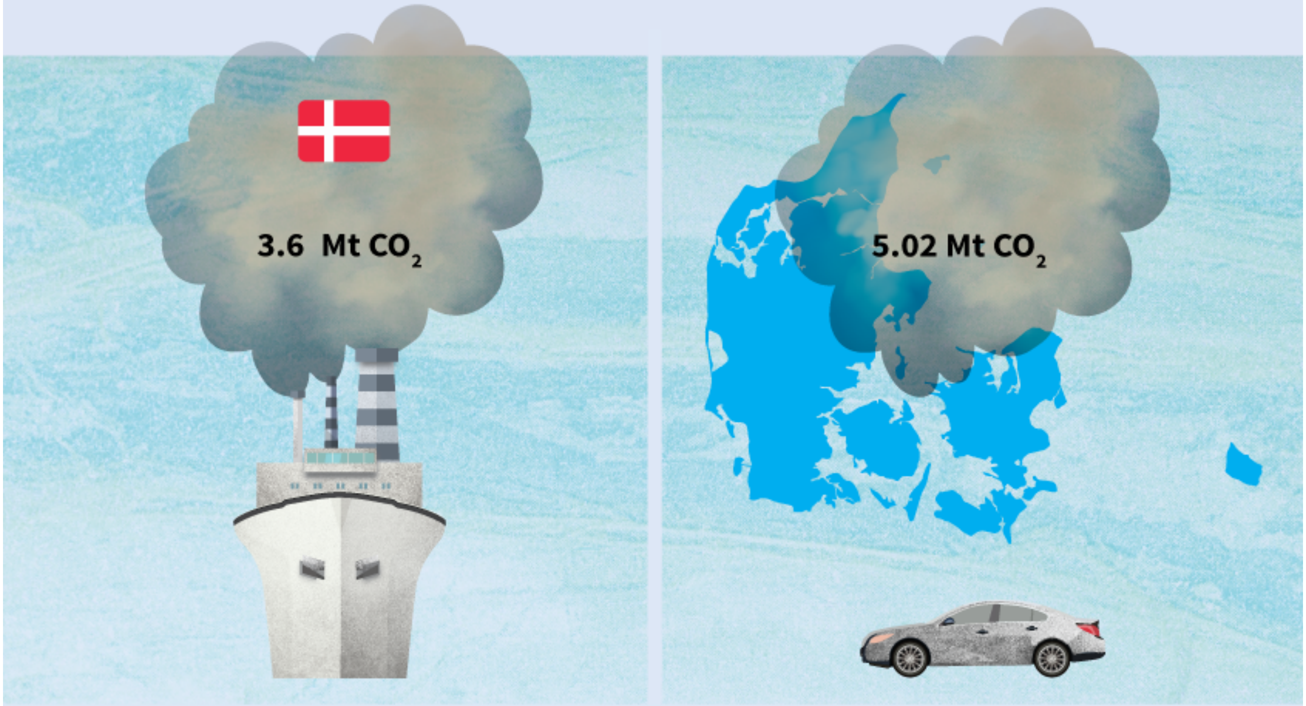
Shipping related to Belgium is comparable to CO_2 from all the passenger cars in the country combined



TRANSPORT & ENVIRONMENT @transenv transportenvironment.org

Source: Estimated by Transport & Environment using EU ship MRV data, maritime trade volumes handled by the national ports and passenger cars registered in the country

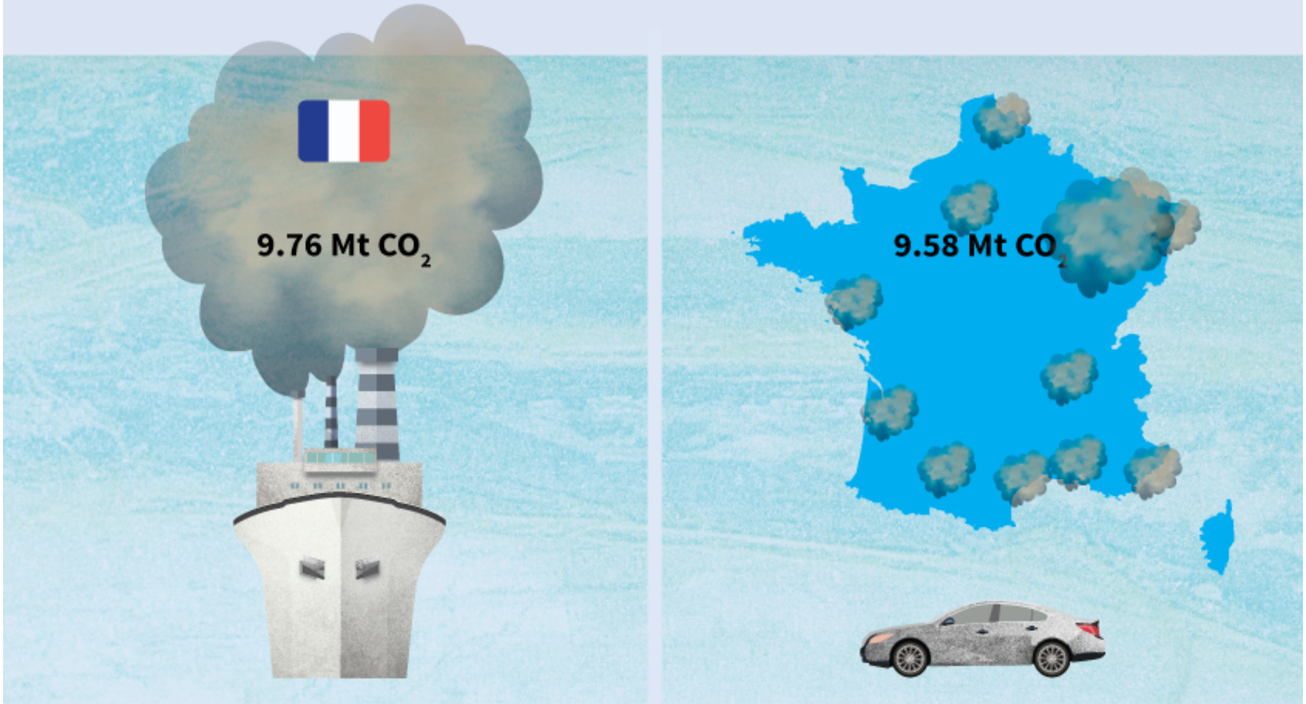
Ships sailing to and from Denmark emit as much CO_2 as two-thirds of all cars nationally



TRANSPORT & ENVIRONMENT @transenv transportenvironment.org

Source: Estimated by Transport & Environment using EU ship MRV data, maritime trade volumes handled by the national ports and passenger cars registered in the country

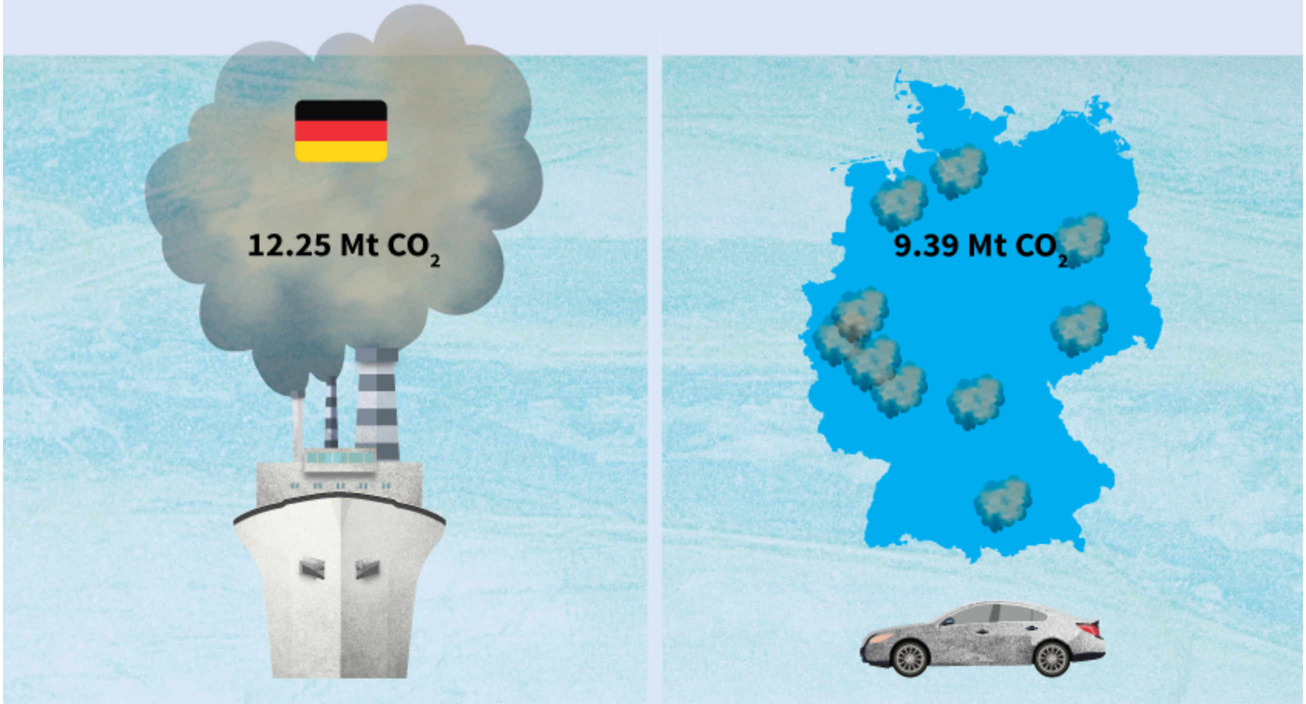
Ships sailing to and from France emit more CO_2 than all cars in 10 largest cities and Grand Est region



TRANSPORT & ENVIRONMENT @transenv transportenvironment.org

Source: Estimated by Transport & Environment using EU ship MRV data, maritime trade volumes handled by the national ports and passenger cars registered in the country

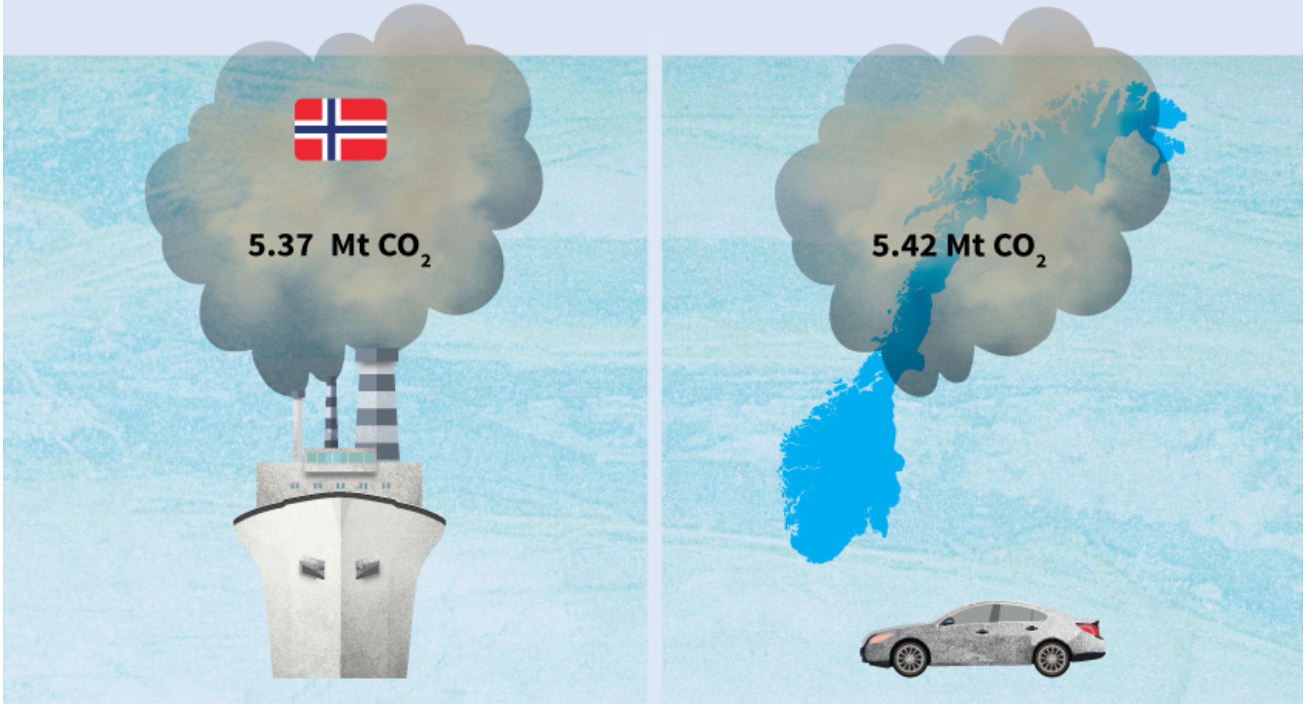
Ships sailing to and from Germany emit more CO_2 than all cars in 10 largest cities



TRANSPORT & ENVIRONMENT @transenv transportenvironment.org

Source: Estimated by Transport & Environment using EU ship MRV data, maritime trade volumes handled by the national ports and passenger cars registered in the country

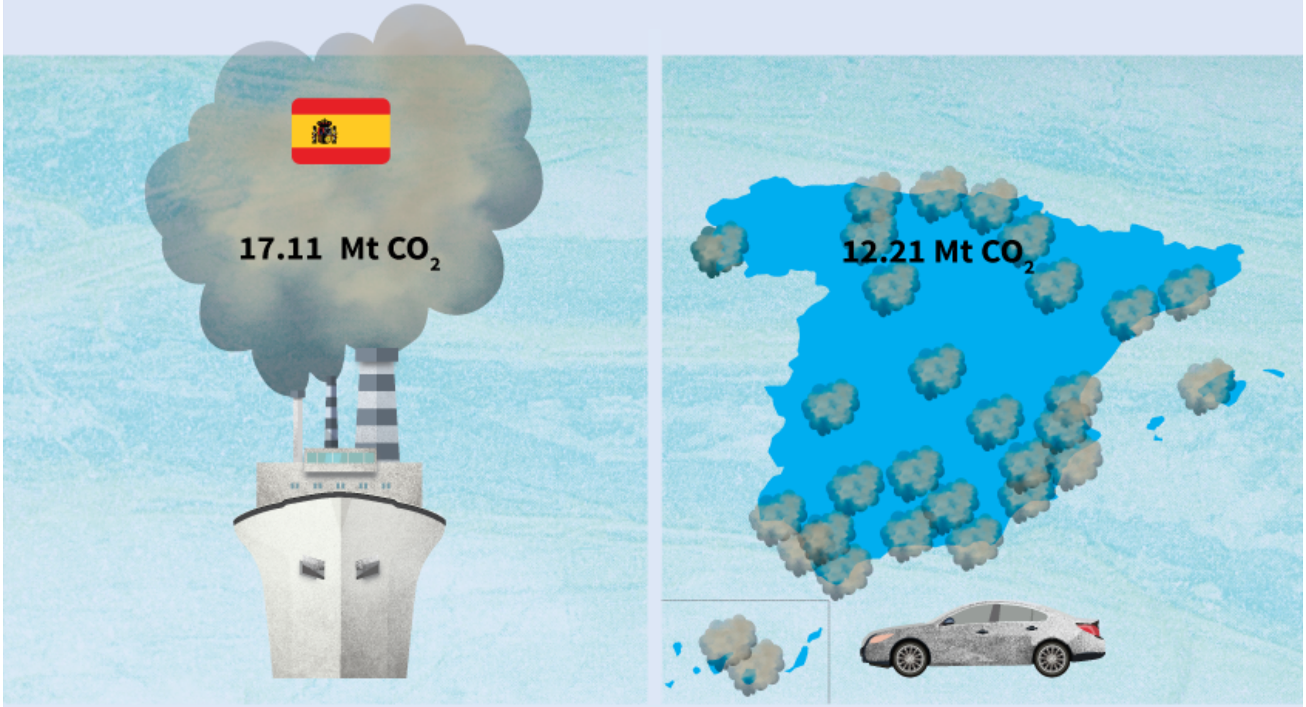
Ships sailing to and from Norway emit almost as much CO_2 as all cars nationally



TRANSPORT & ENVIRONMENT @transenv transportenvironment.org

Source: Estimated by Transport & Environment using EU ship MRV data, maritime trade volumes handled by the national ports and passenger cars registered in the country

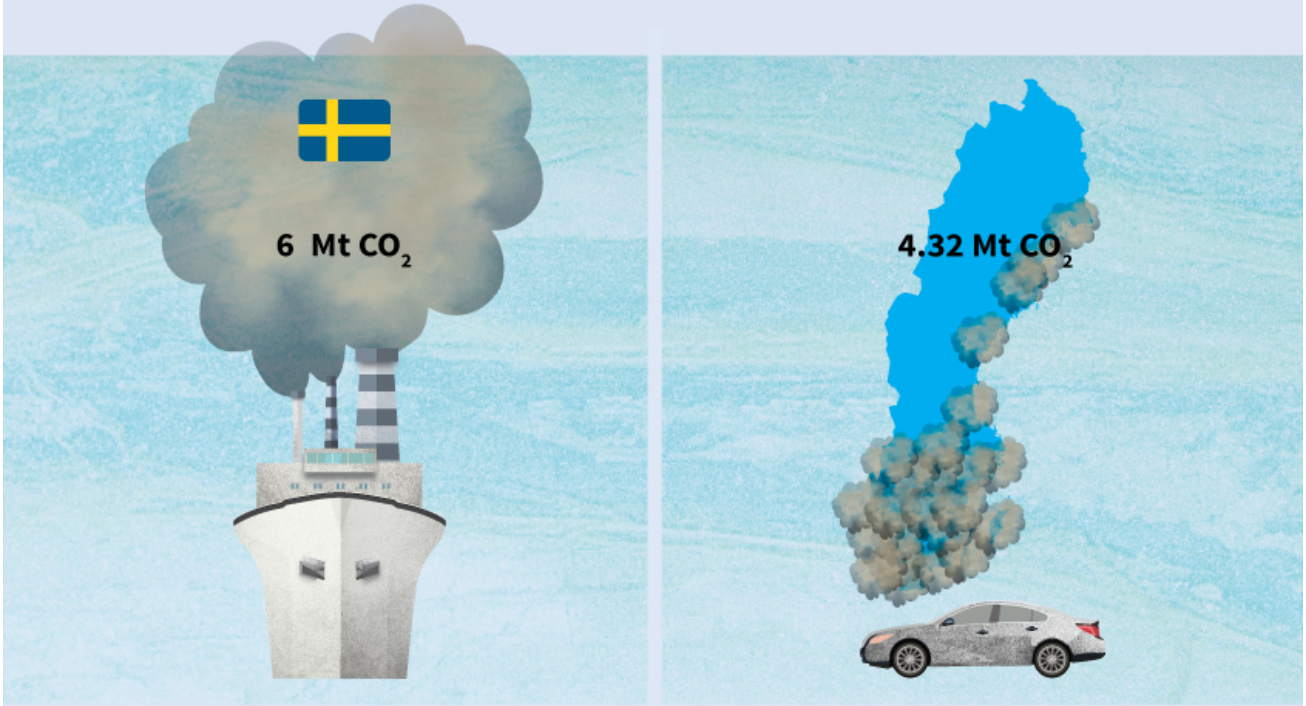
Ships sailing to and from Spain emit more CO_2 than all cars in 30 largest cities



TRANSPORT & ENVIRONMENT @transenv transportenvironment.org

Source: Estimated by Transport & Environment using EU ship MRV data, maritime trade volumes handled by the national ports and passenger cars registered in the country

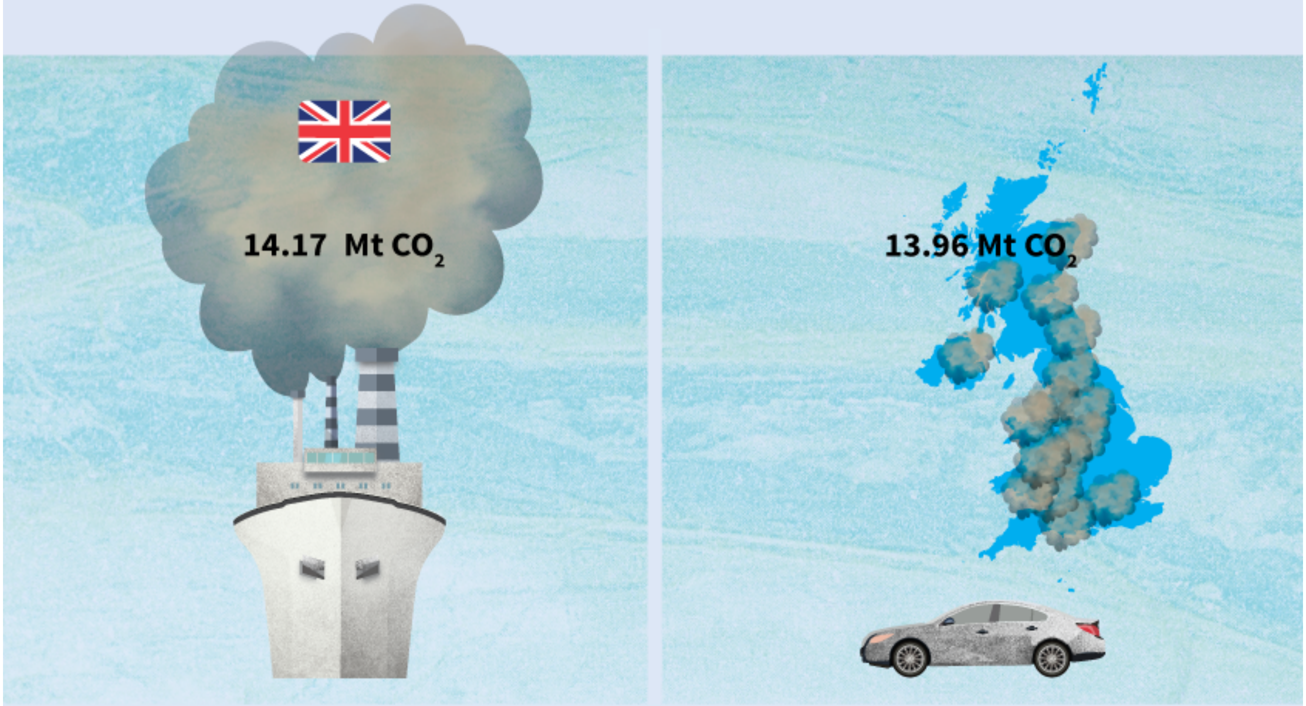
Ships sailing to and from Sweden emit more CO_2 than all cars in 30 largest cities



TRANSPORT & ENVIRONMENT @transenv transportenvironment.org

Source: Estimated by Transport & Environment using EU ship MRV data, maritime trade volumes handled by the national ports and passenger cars registered in the country

Ships sailing to and from the UK emit more CO_2 than all cars in 15 largest cities



TRANSPORT & ENVIRONMENT @transenv transportenvironment.org

Source: Estimated by Transport & Environment using EU ship MRV data, maritime trade volumes handled by the national ports and passenger cars registered in the country

ANNEX III: Detailed results on real-world performance gaps

Table A.3.1: CO_2 weighted performance of cargo ships per size category

Size unit	MRV ship type	Size bins	# ships	CO_2 (Mt)	EEDI or EIV	EEOI
					gCO_2/t-nm	gCO_2/t-nm
dwt	Ro-ro ship	0-4999	19	0.28	20.14	243.02
dwt	Ro-ro ship	5000-1000000000	231	5.59	19.00	106.26
dwt	General cargo ship	0-4999	7	0.04		
dwt	General cargo ship	5000-9999	383	1.70	16.75	34.84
dwt	General cargo ship	10000-1000000000	614	3.77	12.13	27.63
vehicle	Vehicle carrier	0-1000000000	410	4.58	19.97	80.23
teU	Container ship	0-999	150	1.87	32.51	51.92
teU	Container ship	1000-1999	263	3.22	24.93	40.16
teU	Container ship	2000-2999	205	3.70	19.89	30.37
teU	Container ship	3000-4999	257	6.53	19.64	23.98
teU	Container ship	5000-7999	222	6.08	17.91	17.83
teU	Container ship	8000-11999	259	8.01	13.28	15.65
teU	Container ship	12000-14499	133	4.63	11.82	9.31
teU	Container ship	14500-1000000000	137	7.59	9.12	8.03
gt	Other ship types	0-1000000000	61	0.58	15.56	110.69
dwt	Gas carrier	0-1000000000	288	2.34	13.62	68.55
dwt	Bulk carrier	0-9999	13	0.06	13.64	18.59
dwt	Bulk carrier	10000-34999	412	1.57	7.24	12.55
dwt	Bulk carrier	35000-59999	932	3.35	5.64	9.52
dwt	Bulk carrier	60000-99999	1202	6.49	4.21	7.92
dwt	Bulk carrier	100000-199999	377	3.15	3.28	5.51
dwt	Bulk carrier	200000-1000000000	41	0.15	2.61	4.67
dwt	Chemical tanker	0-4999	1	0.01		
dwt	Chemical tanker	5000-9999	96	0.63	16.57	42.68
dwt	Chemical tanker	10000-19999	325	2.00	11.34	27.71
dwt	Chemical tanker	20000-1000000000	672	4.99	7.79	16.84
dwt	Refrigerated cargo carrier	0-1000000000	135	1.71	23.42	125.09
dwt	Container/ro-ro cargo ship	0-4999	2	0.01		
dwt	Container/ro-ro cargo ship	5000-9999	10	0.20	18.98	87.06
dwt	Container/ro-ro cargo ship	10000-1000000000	60	1.25	18.98	81.56
dwt	Oil tanker	0-4999	1	0.00		
dwt	Oil tanker	5000-9999	39	0.18	14.79	34.50
dwt	Oil tanker	10000-19999	68	0.52	12.86	27.33
dwt	Oil tanker	20000-59999	374	3.10	7.17	17.61
dwt	Oil tanker	60000-79999	195	1.24	5.69	10.17

dwt	Oil tanker	80000-119999	480	5.73	3.89	9.40
dwt	Oil tanker	120000-199999	337	4.17	3.51	6.65
dwt	Oil tanker	200000-1000000000	109	1.29	3.03	4.73
dwt	Combination carrier	0-4999	0	0.00		
dwt	Combination carrier	5000-9999	0	0.00		
dwt	Combination carrier	10000-1000000000	5	0.07	8.09	19.16
cbm	LNG carrier	0-49999	3	0.02		
cbm	LNG carrier	50000-199999	155	4.22	8.56	28.45
cbm	LNG carrier	200000-1000000000	34	0.91	43.46	24.44

Table A.3.2: Efficiency breakdown of containerships per size category

Container ship	**CO_2 weighted EIV OR EEDI (gCO_2/DWT_t-nm)**							
min size bin	0	1000	2000	3000	5000	8000	12000	14500
max size bin	999	1999	2999	4999	7999	11999	14500	+
1 MSC	26.15	24.41	18.90	18.77	15.74	13.26	12.66	
2 APM-Maersk	31.20	23.39	20.43	20.03	16.25	10.26	11.83	8.09
3 CMA CGM Group	33.49	24.21	20.24	19.18	21.89	11.28	11.53	8.81
4 Hapag-Lloyd	29.00	25.20	18.53	19.42	19.39	11.61		15.89
5 COSCO Group	26.60	18.64	19.56	19.85	18.23	15.10	12.10	8.04
6 ONE			18.72	23.92	23.13	19.47	9.12	11.32
7 Evergreen Line	32.98	24.54		20.63	18.72	14.70	9.39	8.87
8 Yang Ming				15.95		18.90		
9 UniFeeder	33.20	28.03						
10 X-Press Feeders	30.76	29.13						

Container ship	**CO_2 weighted EEOI (gCO_2/cargo_t-nm)**							
min size bin	0	1000	2000	3000	5000	8000	12000	14500
max size bin	999	1999	2999	4999	7999	11999	14500	+
1 MSC	52.37	38.01	28.21	23.23	18.15	14.00	10.87	8.79
2 APM-Maersk	55.96	41.17	27.68	23.66	15.80	18.03	10.05	7.79
3 CMA CGM Group	54.39	41.95	33.07	26.44	17.19	12.71	9.09	8.34

4 Hapag-Lloyd		30.34	25.08	21.35	19.69	13.71	10.00	7.88
5 COSCO Group	49.90	27.95	23.44	19.98	19.62	15.75	9.50	7.49
6 ONE			61.77	21.63	19.93	12.96	7.97	8.45
7 Evergreen Line	39.35	33.46		47.35	14.59	11.96	8.51	8.13
8 Yang Ming		26.10		20.97		12.37	7.94	
9 UniFeeder	51.15	34.11						
10 X-Press Feeders	47.86	41.28	31.65					

Container ship	**Real-world efficiency gap (gCO2/t-nm)***							
min size bin	0	1000	2000	3000	5000	8000	12000	14500
max size bin	999	1999	2999	4999	7999	11999	14500	+
1 MSC	26.22	13.59	9.31	4.45	2.41	0.74	-1.78	
2 APM-Maersk	24.76	17.78	7.25	3.63	-0.45	7.76	-1.78	-0.30
3 CMA CGM Group	20.90	17.75	12.83	7.26	-4.69	1.43	-2.45	-0.47
4 Hapag-Lloyd		5.14	6.56	1.94	0.30	2.09		-8.01
5 COSCO Group	23.30	9.31	3.88	0.13	1.39	0.64	-2.59	-0.55
6 ONE			43.05	-2.29	-3.20	-6.52	-1.15	-2.86
7 Evergreen Line	6.37	8.92		26.72	-4.14	-2.74	-0.88	-0.74
8 Yang Ming				5.02		-6.53		
9 UniFeeder	17.95	6.08						
10 X-Press Feeders	17.10	12.14						

* *positive values mean worse efficiency in real-life than on the paper. Negative values mean the opposite. Efficiency gets better as the colours change from red to green. Real-world emissions gap decreases as the colours change from red to blue.*

ANNEX IV: Publications and references

1. BBC, Biofuels: 'Irrational' and 'worse than fossil fuels', 2013. Available at: https://www.bbc.co.uk/news/science-environment-22127123
2. BRS Group, *Shipping and Shipbuilding Markets,* Annual Review 2019.
3. Carnival 2018 sustainability Report. Available at: https://carnivalsustainability.com/download-files/2018-carnival-sustainability-full.pdf
4. CE Delft, *Regulating speed: a short-term measure to reduce maritime GHG emissions*, 2017.
5. CE Delft, The share of aviation and maritime transport in the EU's transport related fossil fuel demand, 2016. Available at: https://www.transportenvironment.org/publications/share-aviation-and-maritime-transport-eu%E2%80%99s-transport-related-fossil-fuel-demand
6. International Transport Forum, *Maritime Subsidies: Do They Provide Value for Money?*, 2019.
7. Knudsen, K. (1997), "The economics of zero taxation of the world shipping industry", Maritime *Policy and Management*, Vol. 24:1, pp. 45-54.
8. Royal Caribbean Environmentally Sustainability Report, 2017. http://sustainability.rclcorporate.com/download/report/
9. Simonsen, M. (2014) "Cruise Ship Tourism - A LCA Analysis", Western Norway Research Institution, p.5. Available at: http://transport.vestforsk.no/Dokumentasjon/pdf/Skip/Cruise.pdf
10. T&E, *EU shipping's €24 bn a year fossil tax holidays: Maritime ETS is urgent to cut shipping's fuel subsidies,* 2019.
11. T&E, Mission Possible: How carmakers can reach their 2021 CO2 targets and avoid fines, 2019. Available at: https://www.transportenvironment.org/publications/mission-possible-how-carmakers-can-reach-their-2021-co2-targets-and-avoid-fines
12. T&E, *One Corporation to Pollute Them All: Luxury Cruise Air Emissions in Europe,* 2019.
13. T&E, *Roadmap to decarbonising European shipping*, 2018. Available at: https://www.transportenvironment.org/publications/roadmap-decarbonising-european-shipping
14. UMAS and CE Delft, *Study on methods and considerations for the determination of greenhouse gas emission reduction targets for international shipping Final Report: Short-term Measures*, 2019.
15. UMAS, LNG as a marine fuel in the EU, 2018. Available at: https://www.transportenvironment.org/sites/te/files/2018_06_LNG_marine_fuel_EU_UMAS_study.pdf
16. Ursula von de Leyen, A Union that strives for more: My agenda for Europe, Political guidelines for the next European Commission 2019-2024, 2019.