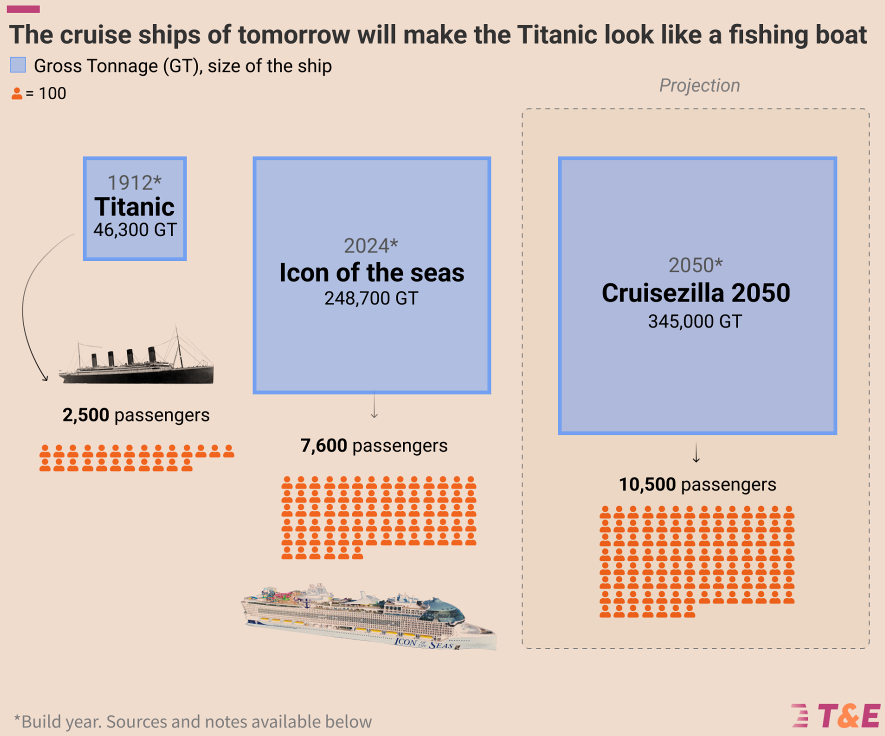
BRIEFING - August 2024

“Cruisezillas”: How much bigger can cruise ships get?

Cruise ships are getting larger and more numerous. This is a problem for the environment

Summary

For cruise ships, only the sea is the limit. Over the last half of a century, the global cruise industry has been growing rapidly. The number of ships has increased more than twentyfold from only 21 ships in 1970 to 515 vessels today. Cruise ships are also getting bigger. Today's largest vessels are twice as big as they were in 2000. If they continue to grow at this rate, the biggest cruise ships could reach the size of 345,000 gross tonnage (GT) in 2050, making them eight times larger than the Titanic.



While cruise vacations still maintain an image of luxury, they are becoming a mainstream holiday option in developed countries, with nearly 36 million holidaymakers projected to take a cruise voyage in 2024.

As a result of such rapid growth, these floating cities emit more greenhouse gases and pollutants than ever before. Between 2019 and 2022, CO_2 emissions from cruise ships in Europe grew by 17% despite the COVID-19 pandemic, and methane emissions increased by 5 times.

Cruise companies invest heavily in liquified (fossil) natural gas (LNG) as a cleaner alternative to heavy fuel oil. But cruise lines have the economic power to become the pioneers of truly green renewable hydrogen-based e-fuels.

There is significant potential for e-fuels production in Europe, which could power 4% of EU shipping by 2030. However, these projects require investment guarantees from shipping companies to ensure they will purchase these fuels. A deep dive into the six most popular European seven-day cruise routes shows that using e-fuels can become an economically efficient strategy in 2030 for cruise ships to comply with European regulatory requirements.

The EU's carbon price on ships took effect from the beginning of this year, and the FuelEU Maritime penalties for using dirty marine fuels will be progressively increasing from 2025.

This means that from 2030, sailing exclusively on very low sulphur oil (VLSFO) and paying penalties will be 13% more expensive than blending small amounts of e-methanol into the fuel mix as a regulatory compliance option. In 2030, a typical cruise ship running only on fuel oil would pay almost €114,000 more for the fuel and associated regulatory (penalty) costs during a seven-day cruise than the same ship using enough e-methanol. With more stringent FuelEU Maritime targets, the cost increase when sailing on exclusively fossil fuel oil compared to blending e-fuels could reach above 30%, amounting to almost €400,000 in 2040 and nearly €1.3 million, or over 80% more in 2050 for every week sailed.

Additionally, cruise ship voyages could become a valuable new source of climate finance. According to the International Transport Forum (ITF), cruise ships are typically not subject to any effective corporate tax under the inefficient existing tonnage tax schemes. Similar to other ship types, they are also exempt from fuel taxes that most other modes of transport are subject to. Against this backdrop, ticket taxes on cruise voyages have the potential to raise significant new revenues. For example, a mere €50 tax on a typical cruise ticket could bring €1.6 billion in revenues globally per year, and €410 million in Europe alone.

To accelerate cruise ship decarbonisation and contribution to the EU's and global climate goals, T&E makes the following policy recommendations:

1. Put cruise ships at the forefront of shipping decarbonisation by introducing **faster and more stringent climate requirements compared to the rest of the fleet, such as earlier life-cycle decarbonisation deadline, connection to shore-side electricity at anchorage and a larger share of e-fuels to be used onboard cruise ships**. Cruise ships spend considerably more time in ports than other ship types and cause immediate health risks to the human population and nature. Considering their luxury status and extensive greenwashing practices, cruise companies should be required to lead shipping's decarbonisation efforts and deliver on their green claims.
2. Explore **implementing a tax on cruise tickets to raise additional climate finance without burdening the general public**. Cruises are a luxury form of entertainment currently exempt from many corporate and consumer taxes applied to other transportation modes. Such a tax would generate billions in revenues globally that could be used to facilitate energy transition, especially in developing and least developed countries.
3. **Limit cruise ship traffic in areas vulnerable to marine and air pollution and establish no-cruise zones in the most fragile sites.** Where cruise traffic remains permissible, only ships meeting the highest environmental standards and appropriate size should be allowed to operate.
4. **Ensure transparency and reduce cruise greenwashing by requiring full disclosure of emissions from cruise ships**, verified and accessible through public databases. This

would help debunk cruise greenwashing claims and educate the consumers by, for example, showing the negative climate impact of fossil LNG.

5. **Address methane emissions from cruise ships by ensuring that the EU legislation correctly reflects the level of methane slippage.** This can be done by revising the methane slip factor set by the FuelEU Maritime Regulation to represent the real level of methane emissions that slip from the LNG engines.

1. Introduction

We are at the height of summer and the cruise ship industry is the fastest-growing tourism sector.[1] Although cruise ships represent a small segment of the shipping industry, with only 515 ships out of over 100 thousand vessels globally,[2] they spend much more time in ports and coastal areas than other types of ships, burning dirty fossil fuels. In Europe, the number of cruise ships and the time they spent in ports has grown by a quarter between 2019 and 2022.[3] Consequently, air and water pollution in those areas has also grown. Overall, Europe's cruise ships emitted more sulphur oxides than 1 billion cars in 2022.[4] Besides pollutants, cruise ships release increasing amounts of greenhouse gases into the atmosphere, such as CO_2 and methane, but also black carbon - a potent climate pollutant.

Nevertheless, the cruise industry appetite continues to grow: in January 2024, the world's largest cruise ship, the Icon of the Seas, was launched: with 40 restaurants, 7 swimming pools and the capacity to host 7600 passengers.[5] It is longer than 15 blue whales, the largest animals to have ever lived on Earth. Yet shipbuilders say they are "not even close" to approaching technical limits for such ships.[6]

Due to their growing climate impact, cruise ships should step up and lead the decarbonisation of the shipping industry. Beyond the full deployment of much-needed efficiency measures, a switch to green hydrogen-based fuels will be essential to achieve that. The early transition to green e-fuels could become the most economically efficient and beneficial strategy for the major cruise lines. They have the economic power to absorb and/or pass through the higher costs of clean fuels, allowing their customers to enjoy a luxurious vacation without harming the local communities living around the most beautiful summer destinations, world heritage sites and port cities.

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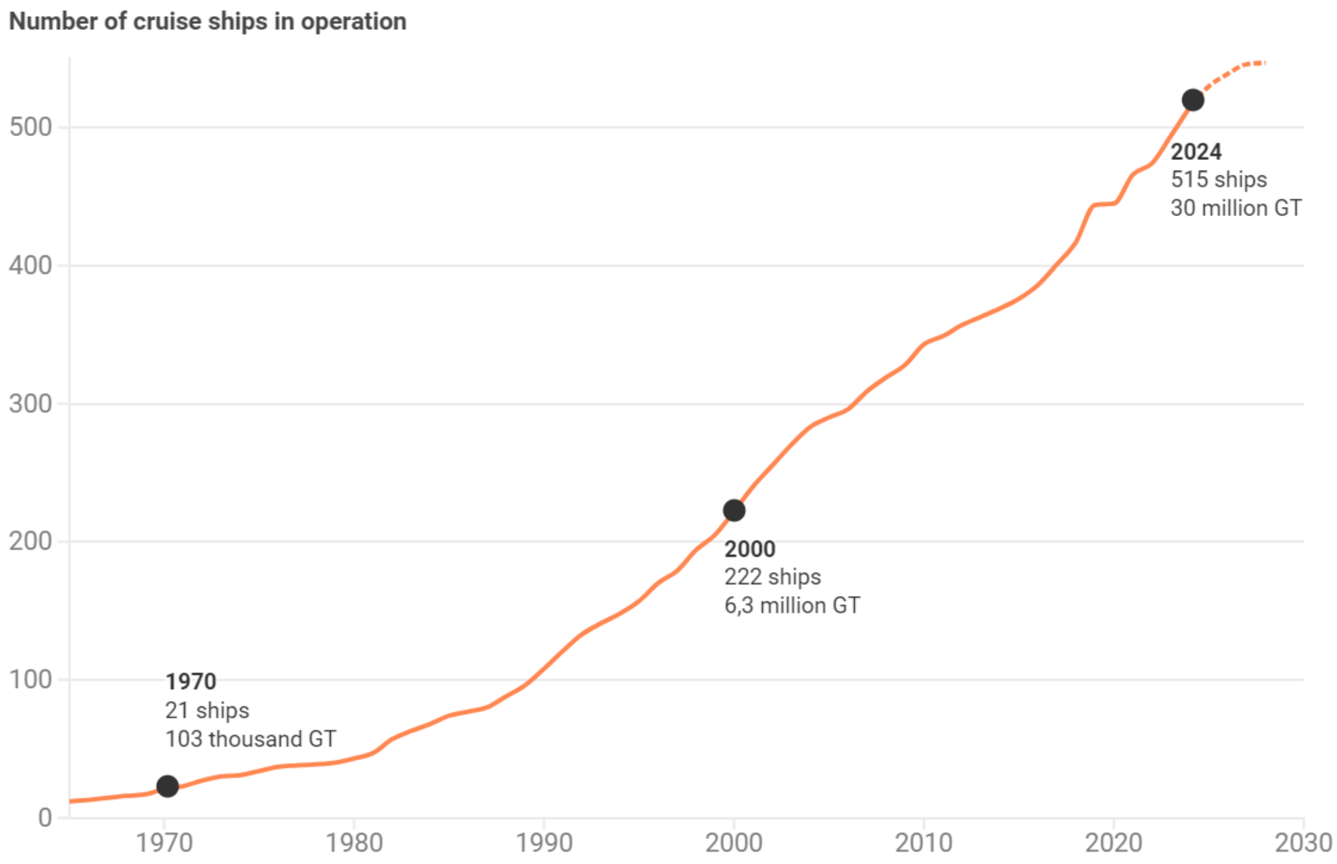
[1] Future Market Insights (2023). Cruise Tourism Market Snapshot (2023 to 2033). Retrieved from: https://www.futuremarketinsights.com/reports/cruise-tourism-sector-overview
[2] Clarksons (2024). Clarksons Data. Retrieved from https://www.clarksons.net/
[3] Transport and Environment (2023). The return of the Cruise. Retrieved from https://www.transportenvironment.org/uploads/files/2023-Cruise-ship-study.pdf
[4] Ibid.
[5] Clarksons data 2024.
[6] Sara Macefield, The Telegraph (2024). Why even bigger cruise ships could follow Icon of the Seas. Retrieved from: https://www.telegraph.co.uk/travel/cruises/articles/why-even-bigger-cruise-ships-could-follow-icon-of-the-seas/

2. Cruise ships - the growth

2.1 There are many more cruise ships than ever before

The number of cruise ships increased by twenty times in the last 50 years - a remarkable growth, reflecting trends in tourism and maritime engineering. Back in 1970, only 21 cruise ships were registered worldwide, with a cumulated gross tonnage (GT) of 103,300. Starting from the 1980s, this number increased rapidly as the industry expanded to meet rising consumer demand. Today, 515 cruise ships are sailing globally, representing a staggering total of 30 million GT.

The number and size of cruise ships have increased rapidly over the past 5 decades



Source: T&E analysis based on Clarksons and EU MRV databases. From 2025, data are derived from cruise ship orderbook.

Figure 1: The growth of the number of cruise ships globally

2.2 Cruise ships are bigger than ever before

The cruise ships are not just multiplying in number. Since the 1990s, the size of the largest cruise ships has been rapidly increasing, too. Today, the average size of the ten largest cruise ships is double what it was 24 years ago, averaging 205,000 GT. If this growth rate continues, large cruise ships are projected to become more than 1.5 times larger in 20 years compared to today. By 2050, the average large cruise ship could be almost eight times the size of the Titanic.

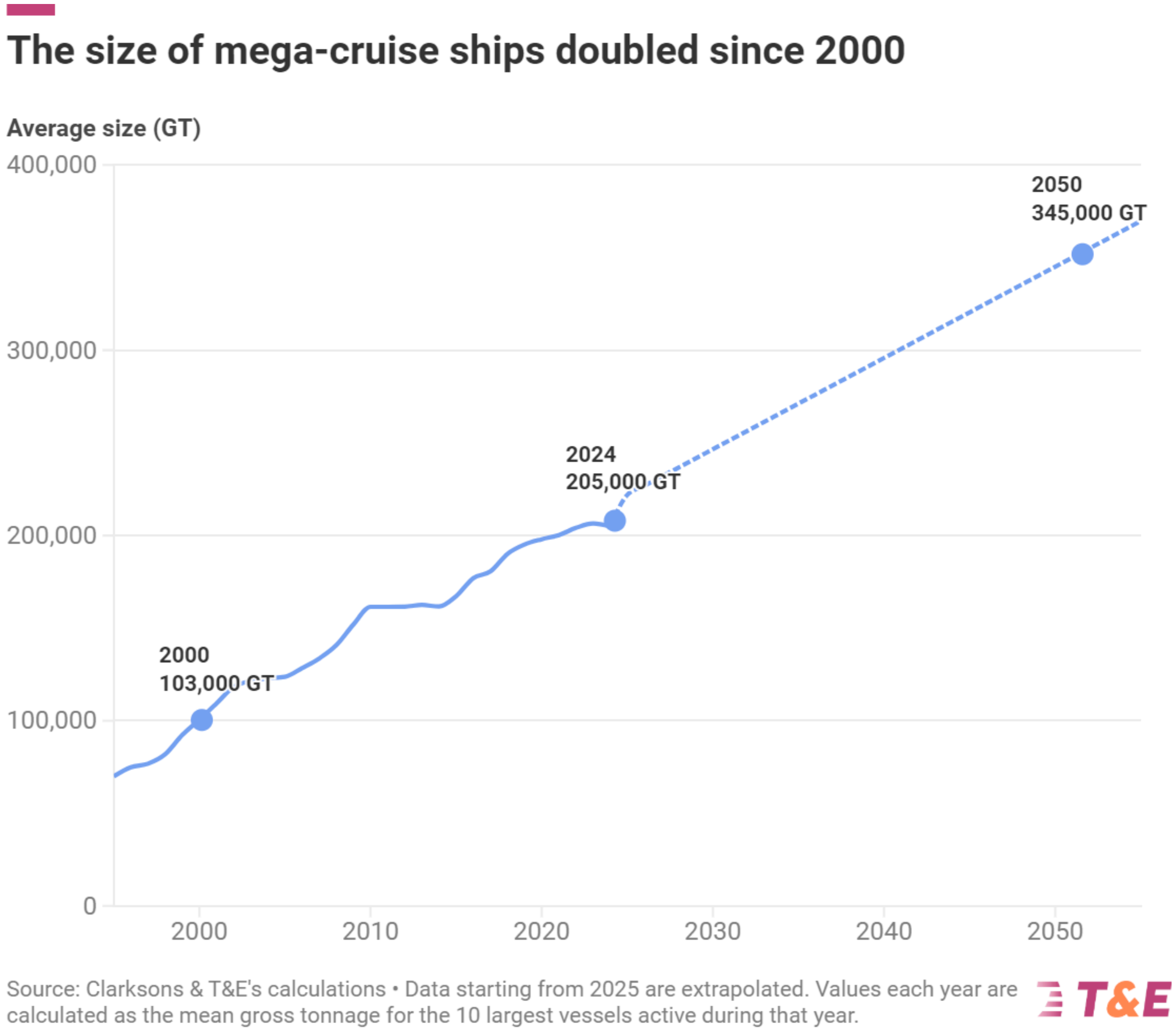


Figure 2: Evolution of the average size of the top 10 largest cruise ships over the years

For comparison, the largest ship built before 2005, Voyager of the Sea, was able to carry 3938 passengers, while today's biggest vessel can transport 7600, equaling a 93% increase in passenger capacity. Today's biggest cruise ships are 2 to 3 times larger than the Titanic in terms of the number of passengers. Compared to the Icon of the Sea, the Titanic seems a lot less *titanic*.

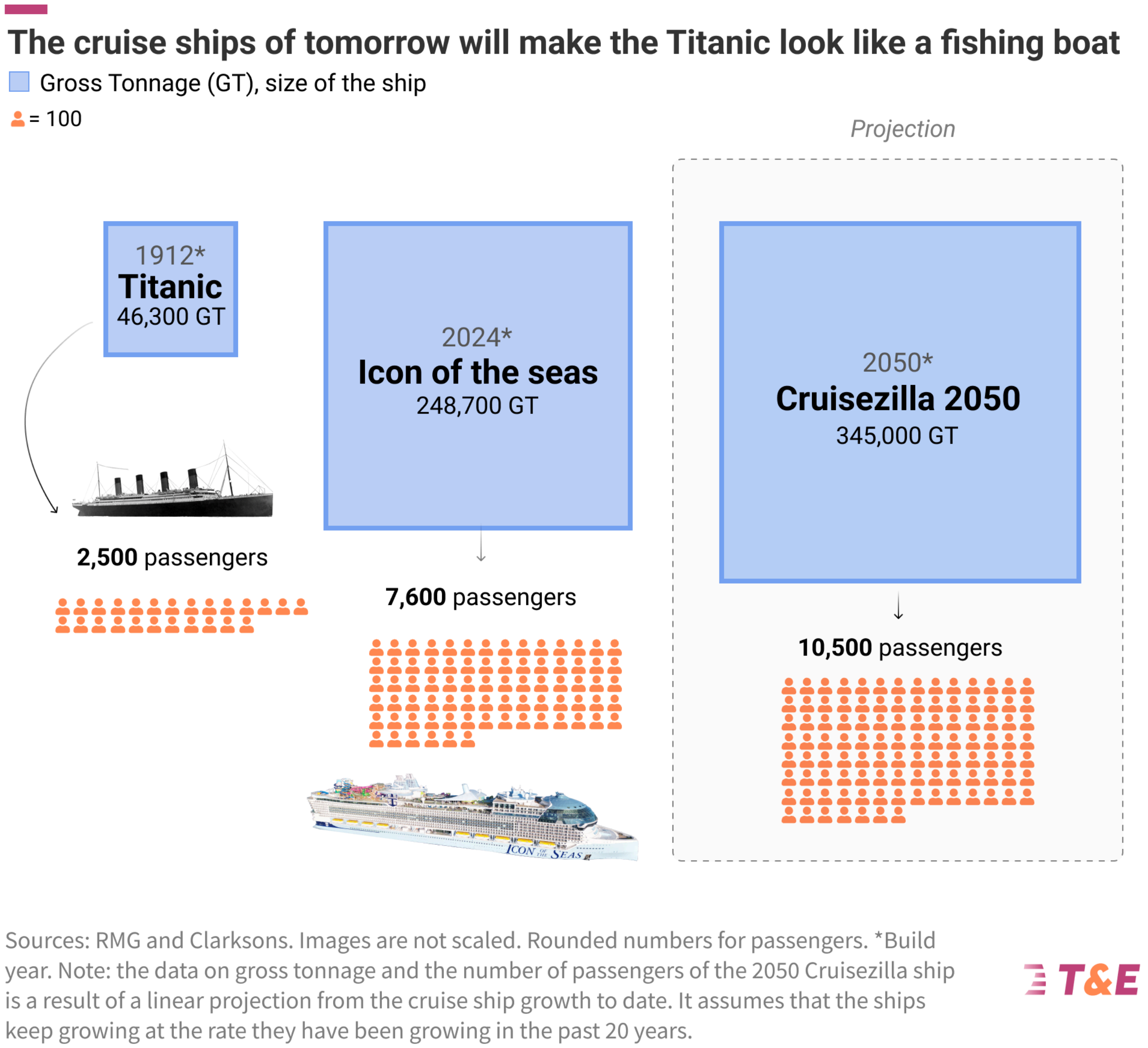


Figure 3: Titanic, compared to the largest cruise ship today and a future cruise ship

Mega-cruise ships, defined here as those carrying more than 3,500 passengers, represent about 18% of the global cruise ship fleet, but account for over 50% of passenger capacity, with a particularly swift expansion from 2000. This change highlights the industry's shift toward larger vessels to accommodate the increasing demand for cruise vacations. Compared to the 1970s, when such vacations were relatively niche, cruising has become a mainstream holiday option in developed countries, with projections indicating a record high of nearly 36 million passengers worldwide in 2024.[7]

[7] Statista (2024). Number of ocean cruise passengers worldwide from 2009 to 2023, with a forecast until 2027. Retrieved from: https://www.statista.com/statistics/385445/number-of-passengers-of-the-cruise-industry-worldwide/#:~:text=The%20number%20of%20global%20ocean,the%20impact%20of%20 COVID%2D19

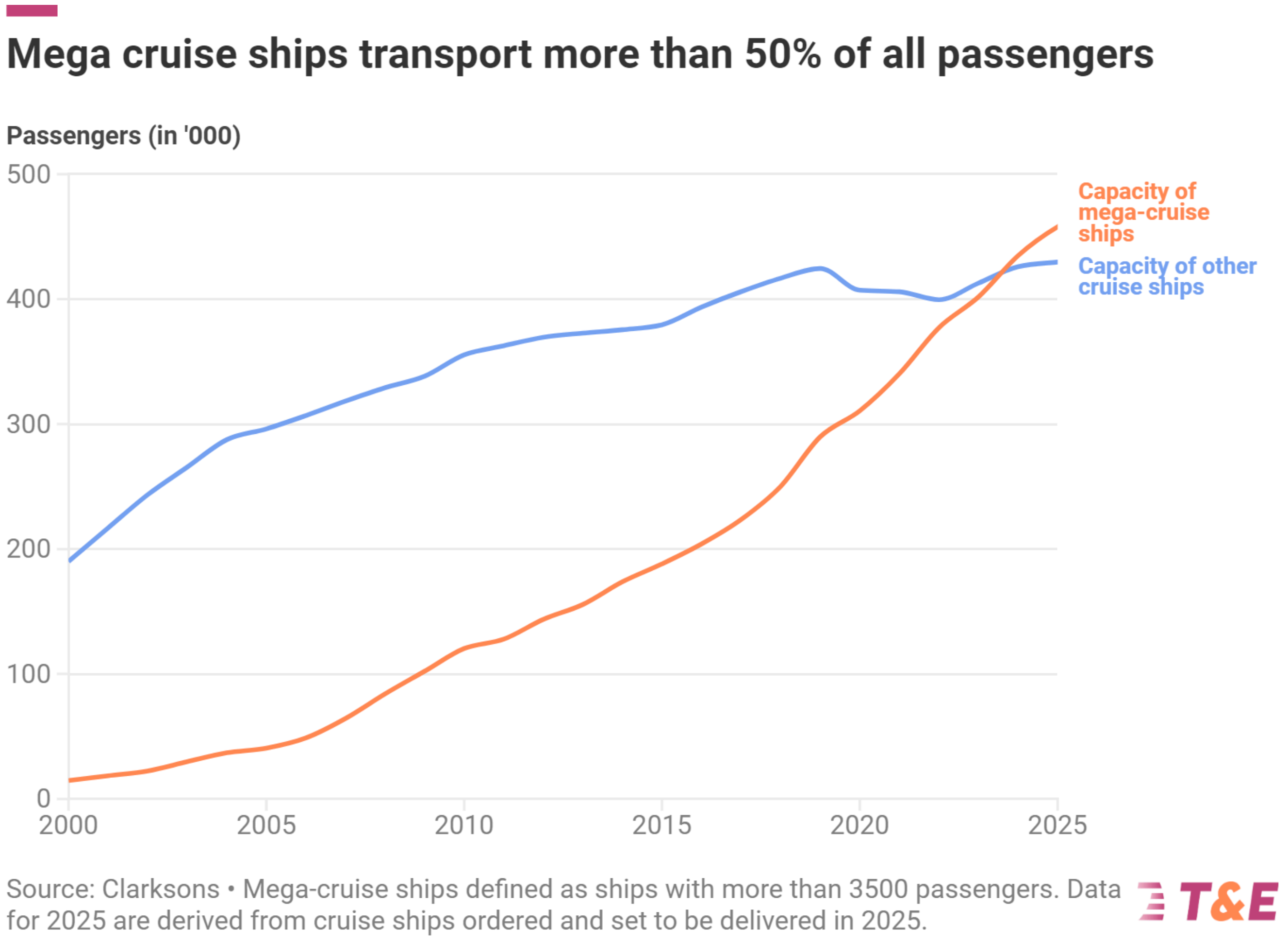


Figure 4: Passengers transported by mega-cruise ships and other cruise ships

2.3 Cruise ships' emissions and impact on global warming is increasing

As a result of the ever-growing cruise ship fleet, the industry's harmful emissions are also increasing. T&E's 2023 cruise ship emission analysis found that between 2019 and 2022, pollutants such as sulphur oxides (SO_X), nitrogen oxides (NO_X), and fine particles ($PM_{2.5}$) have increased by 9%, 18% and 25%, respectively, around European ports, affecting the health of millions of people and other living beings. The absolute amount of CO_2 emissions in the European Exclusive Economic Zones (EEZ) grew by 17%, reaching 8.1 $MtCO_2$.[8] This is the equivalent in CO_2 emissions of 50,000 flights between Paris and New York.[9] Emissions of other potent global warming agents - methane and black carbon - also grew.[10] Finally, many cruise passengers fly to their departure destinations, adding even more emissions, which we have not accounted for in our calculations due to the lack of publicly available data.

Even the most efficient cruise ships will emit more carbon dioxide per passenger kilometre (CO_2/pax-km) than a passenger aircraft. If we compare a 5-day cruise with the same distance

[8] Transport and Environment (2023). The return of the Cruise.
[9] Ibid.
[10] Ibid.

travelled by airplane plus hotel costs for the same period, the amount of CO_2 per cruise passenger would be twice as large.[11]

Therefore, as cruise ships have been successfully growing in number and size, accommodating more passengers and entertainment activities, their absolute negative climate impact also continues to increase.

3. Regulatory implications for shipping's energy transition

While the EU's Fit-for-55 package will improve the environmental performance of cruise ships through fuel switching, these changes will be too slow in the short term. The FuelEU Maritime Regulation mandates large ships to increasingly adopt cleaner fuels but due to low ambition in the early years, LNG and biofuels are likely to be popular compliance options because of their lower costs. However, biofuels offer climate benefits only if they are truly sustainable and made from waste. But these resources are scarce, not scalable, and face competition from other sectors. Fossil LNG, meanwhile, is not a real climate solution due to the underestimated negative climate impact of methane slippages.[12]

Additionally, the EU's Alternative Fuels Infrastructure Regulation (AFIR) mandates ports to establish LNG refuelling infrastructure, but there is no similar requirement for green hydrogen refuelling stations. This may change following the review of the regulation in 2026 if policy-makers muster enough political will and if the shipping industry sends positive signals. AFIR also requires large ships to connect to shore-side electricity or use an alternative zero emissions technology while the ship is at berth from 2030.

Lastly, the inclusion of shipping in the EU Emission Trading System (ETS) from 2024 means that, for the first time ever, large cruise companies will pay for their climate pollution. The shipping ETS won't decarbonise the sector on its own but will reduce the price gap between clean and dirty fuels and should incentivise more eco-friendly behaviour, such as slowing down vessels and/or investing in energy efficiency technologies.

These relatively lax early regulatory requirements could be strengthened for the cruise ships specifically. This segment could lead the shipping industry towards decarbonization by switching to sustainable e-fuels earlier than the other ship types and adopting zero-emission requirements not only when the ship is at berth, but also in the wider port area.

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[11] The calculations do not include the climate impact of other climate pollutants and greenhouse gases.
The International. Council on Clean Transportation (2022). What if I told you cruising is worse for the climate than flying? Retrieved from: https://theicct.org/marine-cruising-flying-may22/

[12] Refer to the infobox on methane slip for more details.

4. Cruise ships could become green sooner

The largest cruise ship companies have invested heavily in green communications about their ships and operations. The same cannot be said about their actual practices. This section focuses on the perspective of cruise companies switching to sustainable e-fuels.

4.1 Green(er) fuels - LNG is not a solution, e-fuels are a real option

As of July 2024, 38% of new cruise ships in the global orderbooks are powered by LNG.[13] This means that ships will be able to run on fossil gas, bio-LNG made from biomass, as well as e-methane, produced with green hydrogen.

In 2023, MSC Cruises announced plans to start using "sizeable volumes of e-methane by 2026."[14] However, no publicly announced offtake agreement has been established beyond a letter of intent, signed with a fuel provider Gasum, aimed at cooperating on the supply of this fuel. For a keen observer in shipping, this may seem as a smokescreen. In the meantime, the company sailed on fossil LNG and purchased 400 tonnes of bio-LNG last year. To put this number into perspective, a large LNG-powered cruise ship uses around 112 tonnes of fuel per day, meaning that 400 tonnes of bio-LNG could fuel a cruise ship for less than 4 days.[15]

Another large cruise company, Carnival Corporation also champions LNG as a key enabler of its sustainability transition. LNG vessels currently make up 17% of Carnival's fleet, with plans to increase to 25% by 2030.[16] Running their LNG ships almost entirely on fossil gas, Carnival has reportedly trialed the use of bio-LNG on several voyages. They indicated, however, that the supply of biofuels is limited. Regarding e-fuels, Carnival's 2023 Sustainability Report indicates that clean hydrogen-based fuels will play a major role from 2035 onwards but cites their unavailability as of yet.[17] While it is true that e-methane is not currently available, lack of demand signals from the cruise industry only perpetuates this situation.

[13] Data from Clarksons (2024). Clarksons Order Book Data. Retrieved from https://www.clarksons.net/
[14] MSC Cruises (2023). The cruise division of MSC Group and Gasum partner for LNG and renewable e-LNG to achieve 2050 net zero greenhouse gas emissions goal. Retrieved from: https://www.msccruises.co.nz/news/msc-group-gasum
[15] T&E's calculations based on fuel consumption for the cruise ship AidaNova.
Data from Meyer Werft. (2024). *AidaNova*. Retrieved: https://www.meyerwerft.de/en/ships/aidanova.jsp
[16] Carnival Corporation (2023).Sustainability report. Retrieved from: https://sustainability.nyc3.cdn.digitaloceanspaces.com/assets/content/pdf/Carnival_Corporation_plc_FY2023-Sustainability-Report.pdf
[17] Ibid.

Info box: Methane slip - the elephant in the room

Methane gas slipping from the ship shown on infrared camera

While LNG technology-equipped ships can use green hydrogen-based e-fuels like e-methane, most cruise operators prefer fossil gas, labelling it as the cleanest readily available fuel. But even if they use renewable bio-LNG or e-methane as a drop-in alternative for fossil LNG, methane slip will remain a problematic source of GHG emissions.[18]

Because methane is 80 times more potent than CO_2 in the short term,[19] the methane slip from LNG engines can make this fuel more harmful to the climate than traditional fossil fuel oil. Alarmingly, methane emissions from cruise ships increased fivefold in Europe between 2019 and 2022.[20] In 2022, one of the largest cruise ships, MS Iona, emitted as much methane as 10,500 cows do in a year.[21] To add to the already large scale of the issue, recent scientific findings have shown that methane emissions from engines used primarily by cruise ships could be emitting twice more than what the EU regulations assume.[22,23] This underscores the urgent need for stricter and more accurate regulatory measures to reduce the methane slip.

Cruise ships could already start introducing clean, renewable hydrogen-based e-fuel such as e-methanol into their operations in the immediate future. T&E's 2024 shipping fuels observatory[24] found that there is significant e-fuels production potential in Europe for shipping in this decade. There are at least 17 potential shipping e-fuels projects in Europe, but they need investment security and a signal that the industry is willing to use them. If all

[18] Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping (MMMCZCS) (2024). Tackling Methane Slip in Shipping. Retrieved from: https://www.zerocarbonshipping.com/publications/tackling-methane-slip-in-shipping/
[19] Faber, J., Kleijn, A., Hanayama, S., Zhang, S., Pereda, P., Comer, B., … Xing, H. (2020). Fourth IMO Greenhouse Gas Study. Retrieved from https://www.imo.org/en/OurWork/Environment/Pages/Fourth-IMO-Greenhouse-Gas-Study-2020.aspx
[20] Transport and Environment (2023). The return of the Cruise.
[21] Ibid.
[22] The ICCT indicates that a 6% methane slip factor is more accurate than the 3.1% currently in the FuelEU Maritime Regulation. The International Council on Clean Transportation (ICCT) (2024). Real-world methane emissions from LNG-fueled ships are higher than current regulations assume, new study finds. Retrieved from https://theicct.org/pr-real-world-methane-emissions-from-lng-fueled-ships-are-higher-than-current-regulations-assume-new-study-finds-jan24/
[23] Paul Balcombe et al. (2022) Total Methane and CO_2 Emissions from Liquefied Natural Gas Carrier Ships: the First Primary Measurements. Retrieved from: https://pubs.acs.org/doi/pdf/10.1021/acs.est.2c01383;
[24] Transport and Environment (2024). Shipping e-fuels Observatory. Retrieved from: https://www.transportenvironment.org/e-fuels

shipping-dedicated projects materialised, they could meet almost 4% of EU shipping's total energy demand in 2030.

Shipping companies play an important role in energy transition by providing security for the development of the e-fuels projects. Danish containership company Maersk launched its first methanol-powered container vessel in 2023 and placed an order for another 24 such vessels to be delivered by 2027. To ensure these ships will have access to green fuels, Maersk signed several offtake agreements with e-methanol producers. One such project, European Energy Kassø in Southern Denmark is set to become operational already in 2024, producing 32,000 tonnes of e-methanol annually.[25] The plant is one of the very few in Europe that have received a final investment decision and will produce e-methanol for shipping on a commercial scale, in large part due to a clear commitment from the consumers such as Maersk and LEGO.

But alongside containerships, cruise companies, flagrantly advertising their sustainability ambition, should be the first in line to invest in the production and uptake of clean fuels. Cruises are the shipping segment most closely connected to people, directly influencing their health and the surrounding environment. Availability of e-fuels and their bunkering infrastructure should not pose a large issue for cruise ships since they sail on established routes and have predictable schedules; their fuel needs and refuelling timings are relatively easy to plan compared to, for example, charter cargo ships. Cruise ship companies could facilitate the development of green corridors between the most popular ports, establishing a balance between supply and demand for clean fuels.

The proximity of hydrogen and e-fuels to the cruise industry is proven by the fact that 20% of cruise ships in the order book are to be powered by alternative fuels - there will be 11 ships equipped with hydrogen fuel cells and 2 ships with methanol engines, coming into operation in this decade.[26] All cruise companies should prioritise sustainable e-fuel options in their future fleet expansions.

4.2 Economic efficiency of sailing on e-fuels compared to fossil fuels

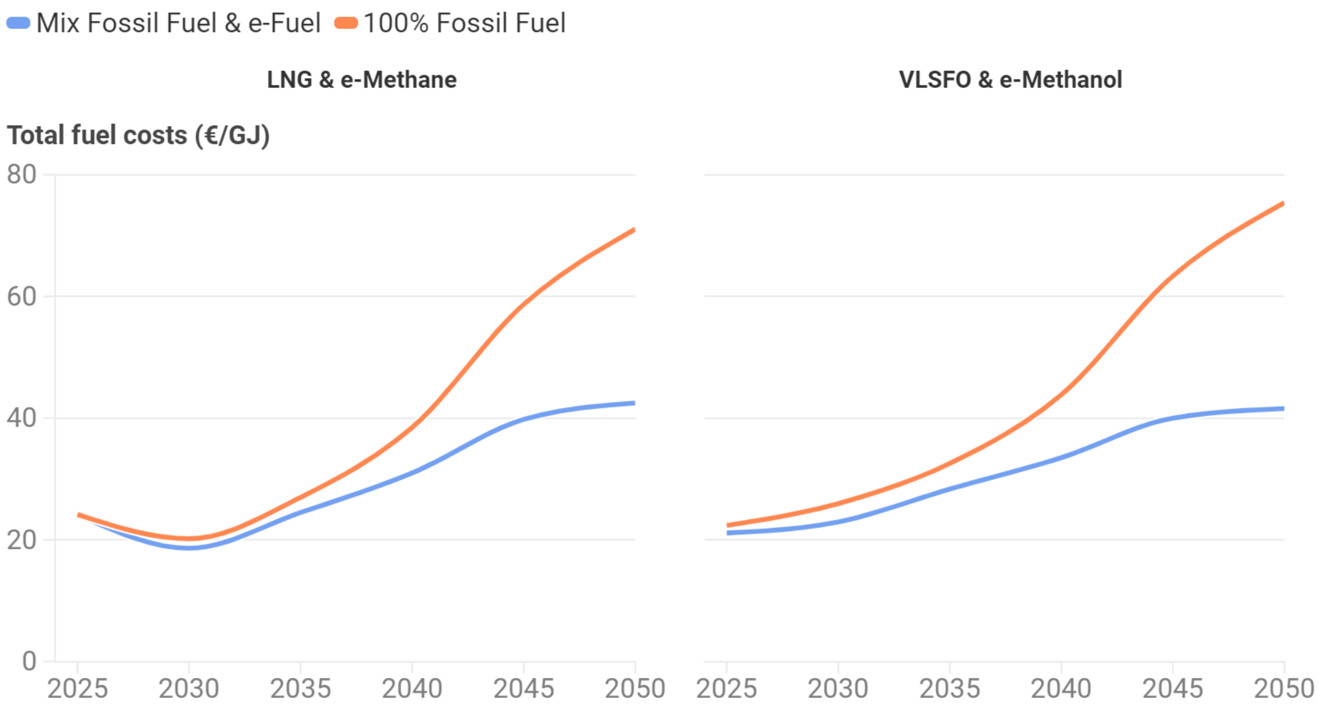
To explore the economic rationale and cost implications of the e-fuel uptake by cruise ships, we examined 6 of the most popular European 7-day cruise routes and ships sailing on them in the Mediterranean and the North Sea. Four vessels - Costa Toscana, MSC World Europa, AidaNova and Iona - have LNG propulsion technology and two vessels - Voyager of the Sea and MSC Grandiosa - have VLSFO engines.

Assuming that the cruise ship owners want to minimise the cost of their operations, our analysis found that blending e-fuels into the fuel mix, as opposed to sailing on only fossil fuels,

[25] European Energy (2024).Danske Commodities and Solar Park Kassø sign agreement to optimise world's largest commercial Power-to-X facility. Retrieved from: https://europeanenergy.com/2024/06/25/danske-commodities-and-solar-park-kasso-sign-agreement-to-optimise-worlds-largest-commercial-power-to-x-facility/
[26] Data from Clarksons (2024). Clarksons Order Book Data. Retrieved from https://www.clarksons.net/

will become the most economically efficient strategy from 2025 for VLSFO-powered ships and from 2030 for LNG-powered ones. This is due to 1) the cost of the FuelEU Maritime penalty, which is increasing every 5 years due to progressively stringent requirements for clean fuels, 2) the price for the CO_2 emitted imposed by the ETS[27] and 3) the cost of fuel. For this briefing, we assumed VLSFO ships will use e-methanol to their fuel mix and LNG ships will use e-methane. We compare two strategies: using only fossil fuels and paying the FuelEU Maritime penalty, and blending/co-combusting enough e-fuels to comply with the targets. Our analysis does not take into account CAPEX and opportunity costs of retrofitting vessels to use e-fuels if pooling with other e-fuel-enabled ships is not possible. More detailed methodology can be found in the Appendix.

Sailing using only fossil fuels will become increasingly unprofitable



Source: T&E's calculations based on EU MRV & Clarksons data • Total fuel costs include the price of fuel, the FuelEU Maritime penalties (if applicable) and the ETS costs. In the Mix Fossil Fuel & e-Fuel scenario, the vessel uses just enough e-fuels to comply with the FuelEU Maritime targets.

Figure 5: Cost comparison of sailing on only fossil fuels vs. blending in e-fuels into the mix over time, across two engine technologies

By 2030, VLSFO ships sailing only on fossil fuel will incur 13% higher fuel-associated costs than those blending 4% of e-methanol into the fuel mix. In 2030, a typical cruise ship running only on fuel oil would pay nearly €114,000 more for the fuel and associated regulatory costs during a

[27] Methane (CH_4) and nitrous oxide (N_2O) emissions will also be accounted for from 2026. ETS costs are based on T&E's 2023 FuelEU Maritime Impact assessment.

seven-day cruise trip than the same ship using enough e-methanol to avoid the FuelEU Maritime penalty. With more stringent FuelEU Maritime targets, the cost increase when sailing on exclusively fossil fuel oil compared to blending e-fuels could reach above 30%, amounting to almost €400,000 in 2040 and nearly €1.3 million, or over 80% more in 2050 for every week sailed.[28]

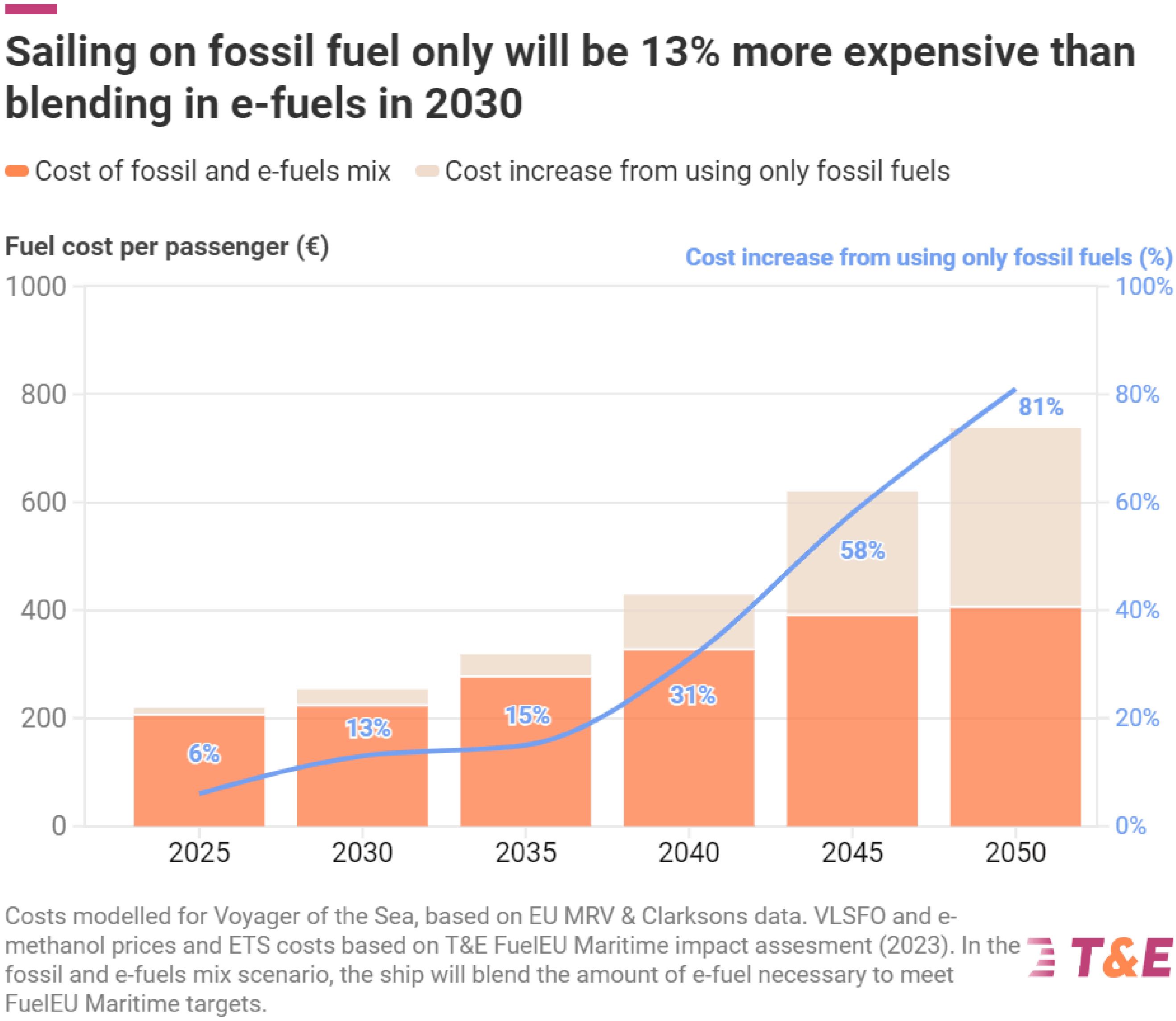


Figure 6: Projected cost increase if using 100% fossil fuels instead of mixing e-fuels over the years for cruise ship Voyager of the Sea

For LNG ships, sailing purely on fossil LNG will also become increasingly more expensive than blending a share of e-methane, starting with a 8% cost increase in 2030, and going up to 67% in 2050.[29] Fossil LNG is compliant with FuelEU Maritime for longer than VLSFO, hence the smaller

[28] The analysis is based on the cruise ship Voyager of the Sea. More information can be found in the Appendix.
[29] The analysis is based on the cruise ship MS Iona. More information can be found in the Appendix.

cost increase when moving from fossil LNG to e-methane, when compared to VLSFO ships shifting to e-methanol. However, the inaccurately accounted-for methane slippages from LNG use misrepresent its true impact, making this fuel seem better for the climate than it is. Unfortunately, e-methane combustion has a similar issue with methane slip as fossil LNG. This means that, compared to e-methanol, much larger amounts of e-methane would be needed to achieve the same emissions savings.

While it is possible that the cruise companies would absorb the fuel cost increase due to the blending of e-fuel or FuelEU Maritime penalties and slash their profits, it is more likely they will pass on the added cost to the passengers. Therefore, the gradual introduction of e-fuels into the fuel mix also means smaller fuel-related price increases for the passengers, alongside better economic performance of the cruise companies and timely investment into technological advancements, necessary for the decarbonised future of shipping.

5. Cruise ticket taxes - an unexplored source of climate finance

While in Europe emissions are becoming costly for shipping companies from 2024, this industry has historically operated largely outside of the bounds of climate regulations and financial obligations, navigating the vast "no man's waters".

Compared to other modes of transportation, such as road or rail, cruise ships typically follow a different tax structure. According to the ITF, cruise ships are currently subject to 0% effective corporate profit taxes.[30] Similar to other ship types, they are also exempt from fuel taxes,[31] except for inefficient tonnage taxes. Due to their highly international operational context, cruise lines can benefit from various exemptions and/or register their companies in countries offering the most favourable taxation regimes. Although the cruise industry incurs customer-related service charges, such as port fees, tourist and sometimes environmental taxes, they vary significantly by country and city. For example, Barcelona currently imposes a €7 cruise stopover passengers tax, and the city mayor has recently announced plans to substantially increase this tax for cruise passengers visiting the city for less than 12 hours.[32] In Svalbard, Norway, each tourist pays 150 NOK or around €13 environmental tax.[33] Overall, however, the cruise industry operates under a more advantageous tax regime, compared to other transport modes. This disparity in the tax burdens and emissions pricing leads to unequal financial and environmental accountability, undermining fair competition and joint efforts to reduce greenhouse gas emissions across the transport industry. Additionally, as Europe and the international

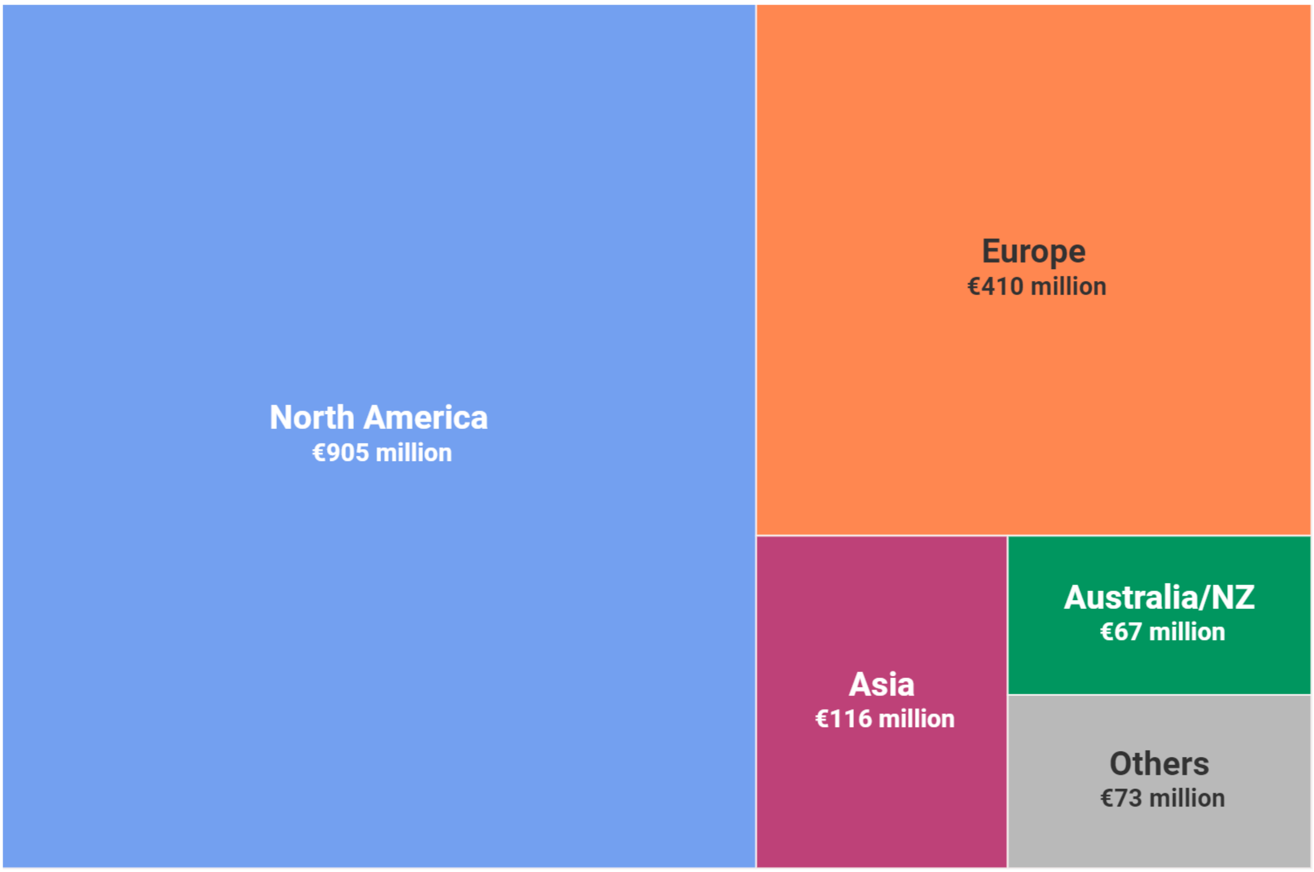
[30] Merk, O.M. Quantifying tax subsidies to shipping. Marit Econ Logist 22, 517–535 (2020). https://doi.org/10.1057/s41278-020-00177-0
[31] Pascal Saint-Amans, Bruegel (2023). Tax for climate finance should start with shipping. Retrieved from: https://www.bruegel.org/first-glance/tax-climate-finance-should-start-shipping
[32]Graham Keeley. Barcelona will raise tourist tax for cruise passengers, mayor says (2024). Retrieved from: https://www.reuters.com/world/europe/barcelona-will-raise-tourist-tax-cruise-passengers-mayor-says-2024-07-21/
[33] Svalbard Environmental Protection Fund (2024). Retrieved from: https://www.miljovernfondet.no/en/about-svalbard-environmental-protection-fund/#:~:text=From%20April%201st%202007,to%20Svalbard%20Environmental%20Protection%20Fund.

community are looking for new sources of climate finance, the cruise industry could provide a source of revenue to be potentially shared with developing countries, especially least developed countries (LDCs) and small island developing states (SIDS).

To understand how much-unexplored revenue the cruise industry could bring into the global and European new revenues pot, we looked into a typical cruise journey at a global scale, based on 2023 data, across all ocean cruise lines.[34] A €50 tax applied to each passenger ticket could generate €1.6 billion climate revenues a year globally, €410 million of which would be raised in Europe.

A €50 tax on cruise ship tickets could generate €1.6 billion annual climate revenues globally

Results for 2023 by region



Source: for the financial breakdown of the typical cruise, we used data from the Royal Caribbean Cruises, Ltd., Carnival Corporation and plc, NCL Corporation Ltd., Cruise Lines International Association (CLIA), The Florida-Caribbean Cruise Association (FCCA) and DVB Bank. For the global cruise passenger numbers, we used cruising.org database.

Figure 7: Potential new global climate revenues from cruise ticket tax (€/year) for 2023

[34] Cruise Market Watch (2024). Financial Breakdown of Typical Cruiser Cruise Lines International Association Retrieved from: https://cruisemarketwatch.com/financial-breakdown-of-typical-cruiser/

If a bigger ticket tax was applied, the new climate revenues could amount to €3.1 billion (with a €100 tax) and €6.3 billion (with a €200 tax) per year globally. Introduction of such a tax would not be an unprecedented policy move - for comparison, in the aviation sector, the current UK air passenger duty on long-haul flight lowest class seats is £88 (€104) per passenger.[35]

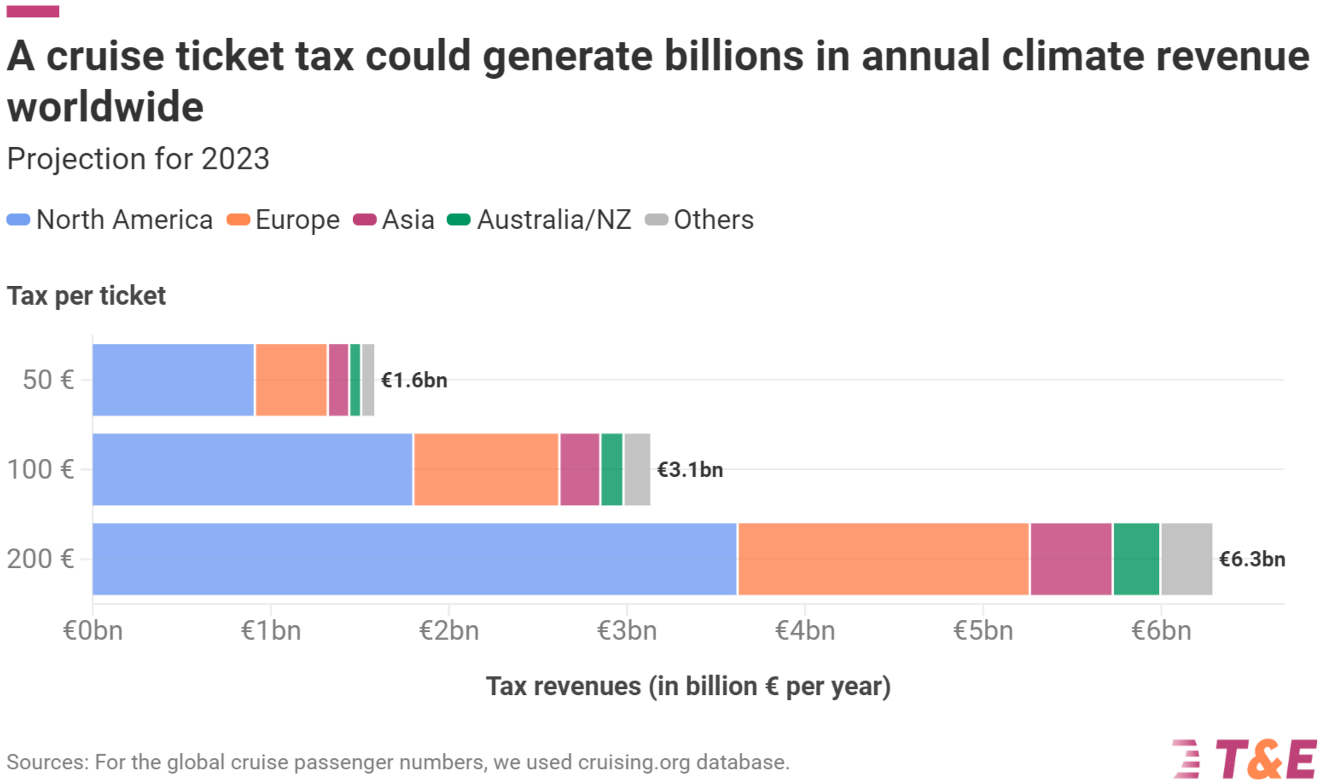


Figure 8: Potential new global climate revenues, depending on the cruise ticket tax rates (€/year) for 2023

6. The impact of green shipping laws and a tax on cruise ship ticket prices

The cost of (fossil) fuel for cruise ships has started increasing with the ETS carbon pricing this year and will continue to grow progressively from next year when FuelEU Maritime comes into force. Assuming that shipping companies will pass on these costs and that an additional €50 flat tax is added to each ticket, T&E modelled the potential cost impact per passenger, travelling on a 7-day cruise voyage across the Mediterranean Sea from 2025 to 2050.

Figure 7 shows what the fuel, regulation and tax costs could be for the passenger of a VLSFO cruise ship Voyager of the Sea. We have already found in section 4, that for the most cost-efficient operations, it should start blending in e-fuels from 2030 at the latest. Whilst in 2030, the difference in fuel cost increase per passenger will not be very large even if the ship

[35] UK Government. Rates for Air Passenger Duty (2024). Retrieved from: https://www.gov.uk/guidance/rates-and-allowances-for-air-passenger-duty

sails on 100% fossil fuel, in the later periods, powering a cruise ship with dirty fuels will become much more expensive than with a fossil and e-fuels mix.

To avoid a FuelEU Maritime penalty in 2050, the Voyager of the Sea would have to use 83% or about 1566 tonnes[36] of e-methanol for a 7-day cruise. Such a mix of VLSFO and e-methanol translates into €456 per passenger for the fuel costs and the ticket tax combined. At first glance, this seems like a big increase compared to the 2025 scenario. However, sailing on purely VLSFO in 2050 would cost €787 per passenger, which is 1.7 times more than in the case of an e-methanol blend.[37]

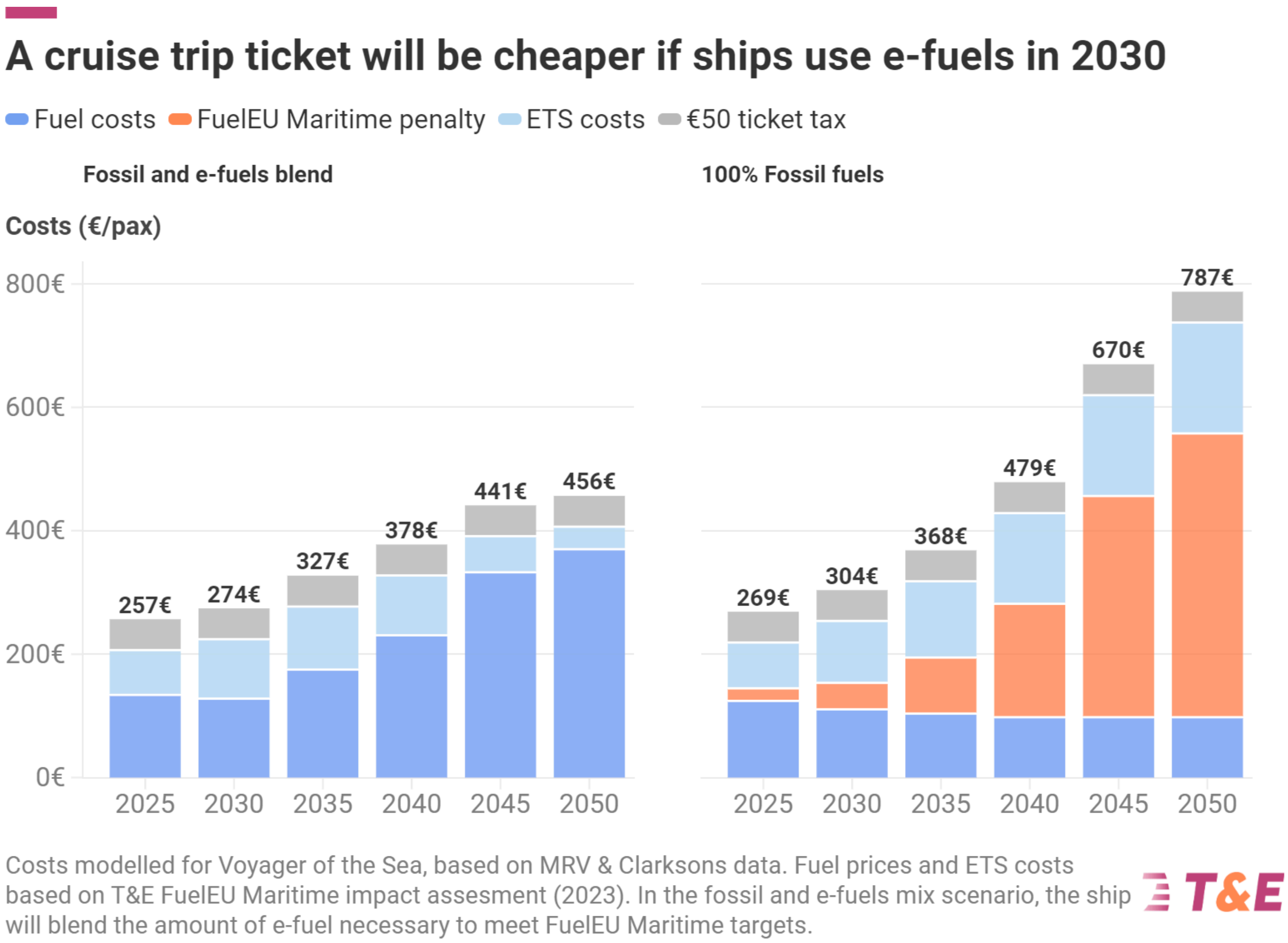


Figure 9: Cost comparison between fossil fuel-only and e-fuel mix cruise voyages, including a ticket tax of €50, FuelEU Maritime penalties and ETS costs

Cruise ship voyages will become more expensive over time due to increasingly stringent clean shipping regulations. However, cruise companies that invest in innovative engine technologies and clean e-fuels today will have a better chance of meeting these requirements well-prepared

[36] T&E calculations based on MRV data for the energy consumed by the vessel during a 7-day cruise in the Mediterranean.
[37] More detailed explanation can be found in the Appendix.

and perhaps well ahead, for their benefit and that of the climate and environment. Also, with economies of scale, some of these cost increases will likely be mitigated in the future.

7. Policy recommendations

Cruise ships are growing in size, number, and emissions. The cruise industry's significant economic influence presents an opportunity to lead decarbonisation efforts in shipping. However, despite the economic and ecological advantages of a gradual shift to e-fuels, the cruise sector lacks the ambition to decarbonise. To address this gap, T&E recommends the following actions to national and EU policy-makers.

1. **Incentivise cruise ships to decarbonize and accelerate the adoption of e-fuels by implementing more stringent and rapid requirements for the cruise industry compared to other shipping segments.** For example, introduce an earlier life-cycle decarbonisation deadline, require a larger share of sustainable e-fuels, and ensure connection to shore-side electricity both at anchorage and at berth. Cruise ships spend considerably more time in ports than other ship types and cause immediate health risks to the human population and nature. The small uptake of e-fuels would not create a drastic cost increase per passenger. It could be absorbed through the economies of scale of the large cruise ships - either by cruise companies reducing their gigantic profits or by passing on the costs to the passengers embarking on luxurious trips. This would also provide an opportunity for the cruise industry to finally stop misleading their customers with environmentally positive claims and take real action to adopt clean fuels. By doing so, they can lead the way in sustainability, achieve long-term profitability, and start mitigating their negative impact on the environment.

2. **Explore a possibility to introduce a tax on cruise tickets to raise additional climate finance** - cruise companies are profitable businesses with negligible taxation, compared to other modes of transport. They represent a luxurious tourism activity that is not part of global trade and does not impact the economic competitiveness or geopolitical security of countries. Introducing a tax on cruise ship tickets could generate billions in climate revenues globally, all without imposing a burden on the general public and not affecting their daily lives and activities. These funds could be used to facilitate energy transition, especially in developing and least developed countries. It would also contribute to creating a more equitable tax system across different transport industries.

3. **Restrict cruise ship traffic in areas particularly vulnerable to marine and air pollution and only allow ships meeting the highest environmental standards to operate. In some critically impacted sites, establish no cruise zones**. In Europe, Norwegian Fjords, Venice in Italy, Barcelona in Spain and Dubrovnik in Croatia are some of the best-known examples of cruise ship traffic damage, where some restrictive policies, e.g. related to the maximum permissible cruise ship size, have already been introduced. However, as cruise ships continue to grow in number and size, such policies need to be reviewed and

strengthened to mitigate the negative impact on biodiversity and climate. Other areas in Europe, increasingly overwhelmed with cruise tourism, should also consider limiting cruise ship traffic.

4. **Require full transparency from the cruise industry about their emissions**, both pollutants and greenhouse gases. This data should be independently verified and made accessible through a standardised public database. This would help debunk cruise greenwashing claims and educate the customers by, for example, showing the negative climate impact of fossil LNG, contributing to the reduction of its use.

5. **Address methane emissions from cruise ships by ensuring that the EU legislation correctly reflects the level of methane slippage from the vessels.** LNG ship orders are on the rise globally and in the cruise ship segment particularly. Even if ships transition from purely fossil LNG to blending bio-LNG or e-methane, the issue of methane slip remains. EU shipping laws will address methane emissions through the ETS pricing and FuelEU Maritime requirements on the GHG intensity of the fuels. However, to accurately reflect the quantity of methane that slips from the LNG engines, the methane slip emission factor under the FuelEU Maritime should be revised based on recent scientific evidence from real-world measurements.

Appendix

I. Data

Data Sources			
Data		**Unit**	**Source**
Ship - specific characteristics	Build year	N/A	Clarksons
	Ship status		
	Ship type		
	Main fuel used		
	Gross Tonnage		
	Number of Passengers		
Emissions & Fuel Consumption Data	Fuel Consumption	Tonnes	MRV
	Fuel Consumption per nautical mile	kg / nautical mile	
	Total CO_2 emissions	Tonnes of CO_2 eq	
	CO_2 emissions per nautical mile	kg CO_2 eq / nautical mile	
Price forecasts	Fuel price forecast	€/GJ	Transport & Environment (2023). Modelling The Impact Of FuelEU Maritime On EU Shipping
	ETS price forecast	€/tCO_2	
Fuel - specific data	Tank to Wake (TTW) & Well to Wake (WTW) emission factors	gCO_2 eq / g of fuel	
	LCVs	MJ / kg of fuel	
Others	Fuel EU Maritime Targets	gCO_2 eq / MJ	
	Cruise voyage distance sailed	Nautical mile	T&E's calculations based on companies' website information

Table 1: Data sources

II. Limitations of the analysis

The analysis presented above is limited in scope. Notably, it does not take into account CAPEX and opportunity costs of retrofitting vessels to use e-fuels if pooling with other e-fuel powered vessels is not available. In consequence, it is likely that when the costs of the two strategies are close, ship owners

T&E

would decide to only use fossil fuels. In addition, the demand and supply for cruise voyages are considered constant no matter the increase in costs and whether those are passed through.

For the modelling part, we do not take into account the possibility of pooling between different ships offered by the Fuel EU Maritime regulation since we examine six ships individually. In addition, we do not model the introduction of the RFNBO sub-target included in the regulation since it is contingent on vessels bunkering less than 1% of RNFBOs by 2031. Moreover, we used MRV data for fuel consumption and CO_2 emissions data from 2022 as it is the latest available year with full availability at the time of writing.

Finally, the analysis considers that cruise voyages offered in the future will have the same length, duration and energy consumption as the cruise voyages offered today.

III. Analysis

Vessel data is extracted from Clarksons. We retrieve each ship labelled 'Cruise Ship' in the database. The database contains 585 vessels, 515 of which are vessels sailing in 2024. The remainder are vessels that existed before 2024 but were demolished, or vessels that are on order and not yet delivered.

1. Cruise ships - the growth

1.1 Increase in cruise ship number

We computed the total gross tonnage and passenger capacity of all cruise ships in service. To do so, we followed the method below:

- For each year, we counted the number of ships built and summed the gross tonnage of all ships built during that year.
- For each year, we counted the number of ships demolished and we summed the gross tonnage of all ships demolished during that year.
- We computed the difference in each year between the values calculated for the ships built and demolished each year, establishing the net creation/destruction of cruise ships during a given year.
- We then calculated a cumulative sums, which gave us the total number of ships and total gross tonnage of those ships in use in any given year.

1.2 Increase in cruise ship size

- We classified all ships with more than 3500 passengers as mega-cruise ships. Ships smaller than 3500 passengers were grouped as well in the category "other cruise ships."
- For each year, we summed the number of ships built and the added passenger capacity of the two categories of cruise ships.
- We repeated the same process for ships demolished for each year.

- We computed the difference in each year between the values calculated for the ships built and demolished each year for passenger numbers and for ship counts.
- We then computed the cumulative sum for net passenger numbers and net number of ships for each year from 1970 to 2024. This gave us the total passenger capacity and number of ships available in a given year.

1.3 Cruisezilla 2050 projection

- The projection for the 2050 cruise ship is T&E's computation using data from Clarksons. It assumes that the trend for large cruise ships is linear and will remain stable for the next 25 years.
- For every year between 1990 and 2024, we selected the largest cruise ship in terms of passenger capacity built that year and averaged their gross tonnage and passenger capacity. This sample, composed of 35 observations, was used to make the projection.
- We then fitted two OLS linear regressions with the independent variable being the year of construction and the dependent variable being respectively the gross tonnage and the passenger capacity.
- The equations are:

$$Gross\,Tonnage = B_o + B_1 * YEAR$$

$$Passengers = B_o + B_1 * YEAR$$

- Using the coefficient (slope) and the intercept computed by the linear regressions based on historical data, we calculated the gross tonnage and passenger values for the years 2025 to 2050.

Regression Results		
Dependent variable	Coefficient (B_1)	Intercept (B_o)
Gross Tonnage	5061.5	-10021561.4
Passengers	142.9	-282844.7

Table 2: Regression results

2. Economic efficiency of sailing on e-fuels compared to fossil fuels

Ship	IMO number	Cruise route	Travel Distance nm	Energy used GJ
Voyager of the Sea	9161716	Ravenna - Mediterranean- Barcelona	2324	37541
AidaNova	9781865	Kiel - Norway - Kiel	2005	44026

Costa Toscana	9781891	Marseille - Mediterranean- Marseille	2312	45416
MSC Grandiosa	9803613	Genova - Mediterranean - Genova	1925	38095
Iona	9826548	Southampton - Norway - Southampton	1979	45710
MSC World Europa	9837420	Barcelona - Mediterranean- Barcelona	2332	47196

Table 3: 6 cruise ship routes, distance sailed and energy used for cruises offered in 2023. Distance and energy used are T&E's calculations based on cruise itineraries and MRV data

2.1 Estimating distance, energy use and emissions for each ship:

- We used QGIS to measure distance. We drew a succession of straight segments exclusively over sea to connect two ports. We repeated the process for all ports visited by each ship, reconstructing the vessels' voyages.
- We then computed the distance for each segment by using the haversine formula using the latitude and longitude of the first and last point on the segment. We computed it as:

  $$n = sin((lat_b - lat_a) * 0.5))^2 + cos(lat_b) * cos(lat_a) * sin((lon_b - lon_a) * 0.5)^2$$

  with a and b the two points between which we evaluate the distance.

  $$c = 2 * arctan(n^{0.5}, (1 - n)^{0.5})$$

  And finally:

  $distance = R_{nautical\ miles} * c$ with R the radius of the Earth in nautical miles

- We computed the sum of all segments' distances to obtain the total distance for a cruise voyage.
- We used CO_2 emissions per nautical mile and fuel consumed per nautical mile from the MRV data with the distance we calculated to estimate the total CO_2 emitted and fuel consumed by each ship.

2.2. Cost modelling

We estimated the costs based on a model with two scenarios:

- Ships can use a pure fossil fuel loadout and incur the FuelEU Maritime penalty or use a mix of fossil fuels and e-fuels to remain under the FuelEU Maritime intensity targets.
- In the scenario where a ship owner uses a mix of fossil and e-fuels to stay under the FuelEU Maritime target, the optimal mix is set to have a fuel intensity equal to the target. It is calculated as:

$$Mix_t = (T_t - ef_{CO2, wtw, fossil\ fuel}) * (ef_{CO2, wtw, efuel, t} - ef_{CO2, wtw, fossil\ fuel} - T_t * (RWD - 1))^{-1}$$

with T the target and RWD the reward factor at time t.

- Before 2034, the reward factor is 2. Starting from 2034, it is 1.
- Fossil fuels' emission factors are time-invariant, while e-fuel emission factors can vary depending on the CO_2 intensity of the electricity used to make them.
- Every 5 years starting in 2025, Fuel EU Maritime GHG intensity reduction targets are increased, forcing ship owners to reevaluate the best strategy for the coming period. Ship owners will select the scenario that minimises cost for each period based on three costs:

1. The cost of the fuel consumed during the cruise calculated as:

$$Fuel\ Cost_t = \Sigma(Q_{i,t} * P_{i,t})$$

for each fuel i at period t, with $Q_{i,t}$ the quantity of fuel consumed and $P_{i,t}$ - the price

2. The cost of the Fuel EU penalty if using the scenario of a pure-fossil fuel mix, calculated based on the vessel's WTW emission factor as:

$$Penalty_t = 2400 * (ef_{CO2,\,wtw} - T_t) * (ef_{CO2,\,wtw} * LCV_{vlsfo})^{-1}\ if\ (ef_{CO2,\,wtw} - T_t) > 0\ else\ 0$$

for the target T at period t, with $ef_{CO2,\,wtw}$ the WTW emission factor for a given fuel.

3. The cost of the ETS, based on the TTW emissions of the vessel, is calculated as:

$$ETS\ Cost_t = \Sigma(Q_{i,t} * ef_{ttw,\,i}) * P_{ETS,\,t}$$

for fuel i at period t, with Q_i the quantity of fuel consumed and P_{ETS} the forecasted ETS price.

Each fuel's TTW emission factor is defined in gCO2eq per MJ is computed based on its emission factors for CO2, methane and nitrous oxide.

In addition, we zero-rated TTW CO2 emissions for fuels that are RED compliant. Hence only methane and nitrous oxide TTW emissions are used when computing ef_{ttw} for e-fuels.

For 2025 in accordance with the EU Emissions Trading System Directive, only CO2 emissions are used to compute ef_{ttw} for all fuels.

We then computed for all ships:

$Total\ Cost_t = Penalty_t + Fuel\ Cost_t + ETS\ Cost_t$ for each period t and for both strategies.

For the mixing strategy, $Penalty_t$ is always 0.

- The strategy with the lower total cost is then selected as the strategy for the vessel for the given period. If the penalty strategy is chosen, then the optimal mix of e-fuels is set as 0. This process is repeated for each ship and each period.

- We added the ticket tax proposed in part III to the Total Cost to all strategies. Since the ticket tax is a flat increase, it does not change the ranking of best strategies.

The fuels used in the modelling are the following:

Ship	Fossil Fuel	e-Fuel
MSC Grandiosa	VLSFO	e-Methanol
Voyager of the Sea		
AidaNova	Fossil LNG	e-LNG
Iona		
Costa Toscana		
MSC World Europa		

Table 4: Fuels used in the modelling

E-LNG was selected as an e-fuel of choice for the LNG ships as it is compatible with the existing technology. E-methanol was selected for the VLSFO ships due to its better availability at the commercial market compared to ammonia, better predicted suitability for passenger transportation, and a relatively lower price compared to e-diesel[38].

- For fossil- and e-LNG, we used emission factors consistent with 4-strokes low pressure engines, to match the engines currently on board the four cruise ships examined.
- We assumed that the engine slip factors would stay constant over time.
- When fossil LNG was used (alone or in a mix), we assumed 1% of the fuel combusted is pilot fuel.

Voyager of the Sea				
	Mix VLSFO & e-Methanol		100% VLSFO	
Year	E-fuel share	Cost per Passenger (€/pax)	Cost per Passenger (€/pax)	**Cost increase if using 100% fossil fuels instead of mixing e-fuels**
2025	2%	€207	€219	6%
2030	4%	€224	€254	13%

[38]Transport & Environment (2023). FuelEU Maritime Impact Assessment. Retrieved from: https://www.transportenvironment.org/uploads/files/FuelEU-Maritime-Impact-Assessment.pdf

Voyager of the Sea				
2035	18%	€277	€318	15%
2040	35%	€328	€429	31%
2045	67%	€391	€620	58%
2050	83%	€407	€737	81%

Table 5: Different fuel scenarios and cost impact per passenger for Voyager of the Sea

MS Iona				
	Mix fossil LNG & e-Methane		**100% fossil LNG**	**Cost increase if using 100% fossil fuels instead of mixing e-fuels**
Year	E-fuel share	Cost per Passenger (€/pax)	Cost per Passenger (€/pax)	
2025	0%	€212	€212	0%
2030	2%	€163	€177	8%
2035	17%	€215	€236	10%
2040	38%	€272	€337	24%
2045	76%	€349	€514	48%
2050	95%	€373	€623	67%

Table 6: Different fuel scenarios and cost impact per passenger ticket for MS Iona

3. Cruise passenger taxes

The data on cruise ships' costs and passenger numbers for 2023 are extracted from the *2023 Global Passenger Report* of the Cruise Lines International Association.[39] We convert values from dollars to euros assuming an exchange rate of 1$ = 0.92€.

The ticket tax is added to the costs per passenger. We calculated profit per passenger as:

$$Profit_{pax} = Revenues_{pax} - Costs_{pax} - Ticket\ tax_{pax}$$

Overall tax revenues are calculated as

$$Revenues_{taxes} = Ticket\ Tax_{pax} * N_{pax}$$

Detailed results are:

Potential new billions-worth revenues from cruise ticket taxes (€/year) - 2023		
Region	**Passengers (in '000)**	**Revenues with a €50 tax (in €)**
North America	18103	€905,150,000
Europe	8205	€410,250,000
Asia	2329	€116,450,000
Australia/NZ	1339	€66,950,000
Others	1459	€72,950,000
Total global	31435	€1,571,750,000

Table 7: Potential new global revenues from cruise ticket taxes for 2023

[39] Cruise Lines International Association (2024). *2023 Global Passenger Report.* Retrieved from: https://cruising.org/-/media/clia-media/research/2024/2024-state-of-the-cruise-industry-report_updated-050824_web.ashx

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