Shipping emissions have already cost the world almost a trillion dollars in damages

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October 2026

Key points

- ZCA analysis estimates that the shipping industry's contribution to global emissions has imposed a heavy burden on the global economy, costing USD 963 billion between 1990 and 2020.
- Absolute damages are highest in the United States, followed by China, but relative damages are highest for countries in the Middle East and Africa.
- International shipping accounts for around 2% of global CO2 emissions, and its contribution to climate change has risen significantly since 1990.
- The International Maritime Organization (IMO) has proposed a Net Zero Framework for the shipping industry, aiming to reduce emissions and reach net-zero by around 2050, in line with 1.5°C pathways.
- The framework has been met with debate, in particular over the cost of implementation.
- Member states will meet again in the week starting 23 November 2026 to discuss its adoption.
- Implementing the Framework and reducing emissions would help prevent future damage and mortality. It could avoid an additional 1.5 million deaths by 2100 through reduced exposure to climate-induced temperature change.
- If business-as-usual continues, future economic damages could outweigh the cost of implementing the Framework, especially as the consequences of climate impacts are projected to worsen with continued emissions growth.

The shipping sector recognises the need to act on its growing carbon footprint

International shipping is responsible for around 2% of global CO_2 emissions.[1] As a sector that crosses international borders, implementing regulation has been challenging, requiring the development of global frameworks under the International Maritime Organization (IMO).

In 2023, the IMO committed to a set of emission-reduction targets that aimed to reduce the total annual greenhouse gas (GHG) emissions from international shipping by:[2]

- At least 20% and striving for 30% by 2030, compared to 2008
- At least 70% and striving for 80% by 2040, compared to 2008
- Reach net-zero emissions "by or around" 2050.

Yet, shipping emissions have risen since the commitments were made. In 2020, the *Fourth IMO Greenhouse Gas Study* projected that the sector's emissions would still be at 90-130% of 2008 levels by 2050 Under business-as-usual (BAU).

The IMO has developed a Net Zero Framework (NZF) as a blueprint for the shipping sector to reach net-zero emissions by or around 2050, in line with the goals of the Paris Agreement.

The Framework was approved in April 2025; if adopted, it would be the first global, legally-mandated and industry-wide mechanism that combines emissions limits and GHG pricing in any sector. However, political tensions, particularly over implementation costs, have so far prevented the framework from being enacted into law.

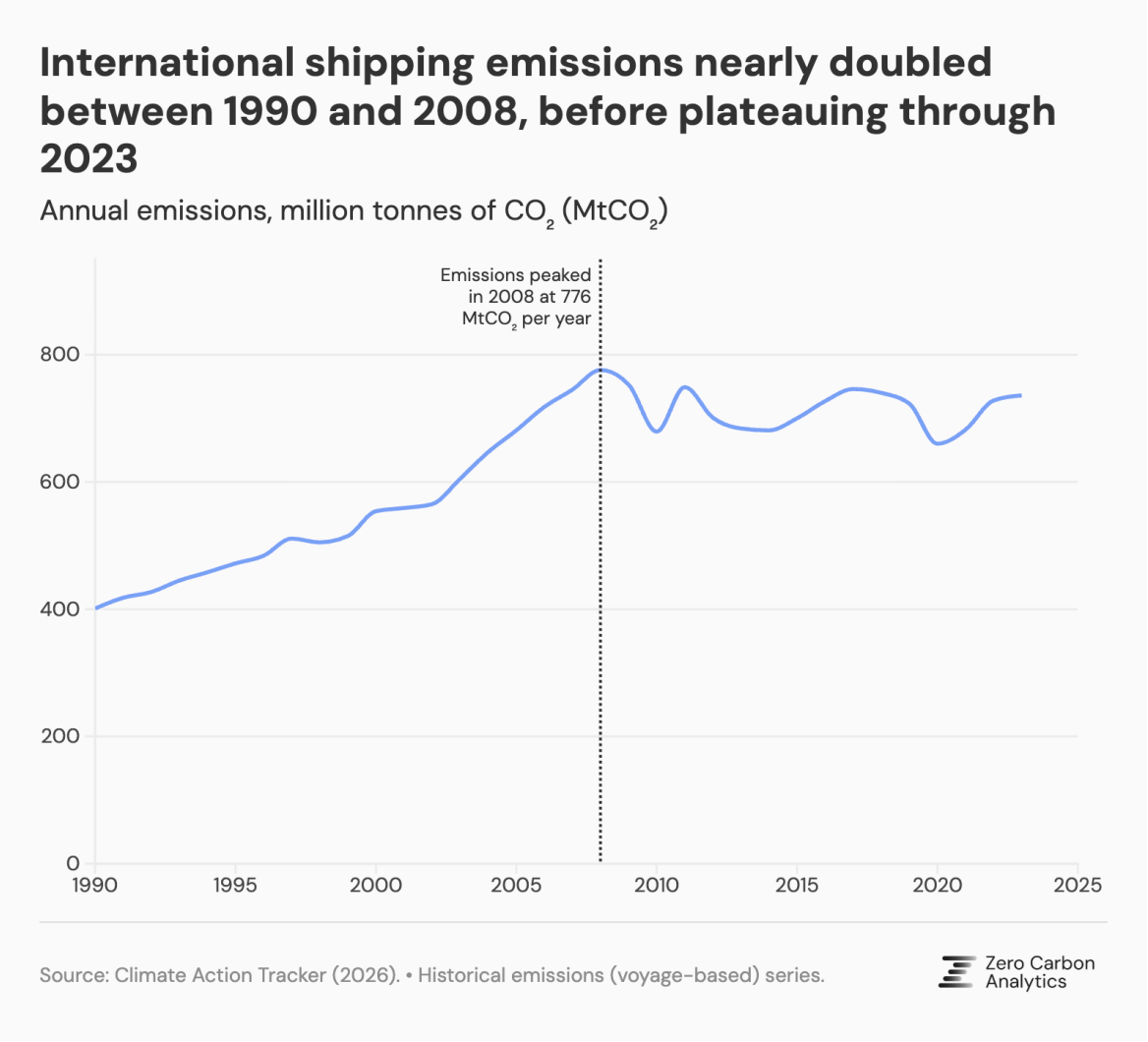
IMO member states are preparing to revisit the framework at meetings starting on 23 November 2026 and plan to vote on its adoption on 4 December.

[1] CO_2 is the predominant source of emissions from shipping. In 2018, CO_2 emissions made up just over 98% of total shipping emissions (international, domestic and fishing).
[2] The IMO only has responsibility for international shipping emissions, but regulations can be applied both to international and domestic emissions.

Emissions from international shipping from 1990 to 2020 have already caused an estimated 963 billion dollars in damages

Between 1990 and 2020, the international shipping industry emitted a cumulative total of 19,029 million tonnes of CO_2 ($MtCO_2$), according to IMO data analysed by Climate Action Tracker,[3] with emissions nearly doubling between 1990 and 2008 (Figure 1).

Figure 1.



[3] This uses a voyage-based approach to historical emissions data, which calculates emissions beyond national boundaries and therefore excludes domestic navigation emissions, from Climate Action Tracker (2026) [Accessed 1 September 2026]. This voyage-based scope matches the IMO NZF's regulatory boundary – international voyages only, excluding domestic navigation.

These emissions have contributed to climate change, which is causing significant harm worldwide and impacting GDP in every country.

Climate researchers at Stanford have developed a climate damage calculator that estimates the economic per-tonne impact of CO_2 emissions, using a method that links emissions to temperature increase and temperature increase to impacts on GDP growth.

Using this approach, we estimated the damage associated with each tonne of emissions from international shipping, along with the relative impact on different countries.

We found that international shipping's contribution to emissions between 1990 and 2020 is responsible for USD 962.7 billion in damages globally.[4]

Some of the world's largest economies are experiencing the greatest absolute impacts from CO_2 emissions. Our analysis finds that international shipping's share of these emissions caused USD 280.7 billion in damages in the US, USD 113.5 billion in China, and USD 66.8 billion in Japan.[5]

However, the relative damage caused by emissions - the share of GDP lost - tends to be highest in low-income countries and in the Middle East. We estimate that damages attributable to international shipping's emissions reduced the United Arab Emirates' 2020 GDP by 0.35%, Saudi Arabia's by 0.34%, Mali's by 0.32%, and Burkina Faso's by 0.3%.

[4] Calculated using the Burke et al. damage calculator with shipping sector emissions, 1990-2020, as inputs and a 2% discount rate.

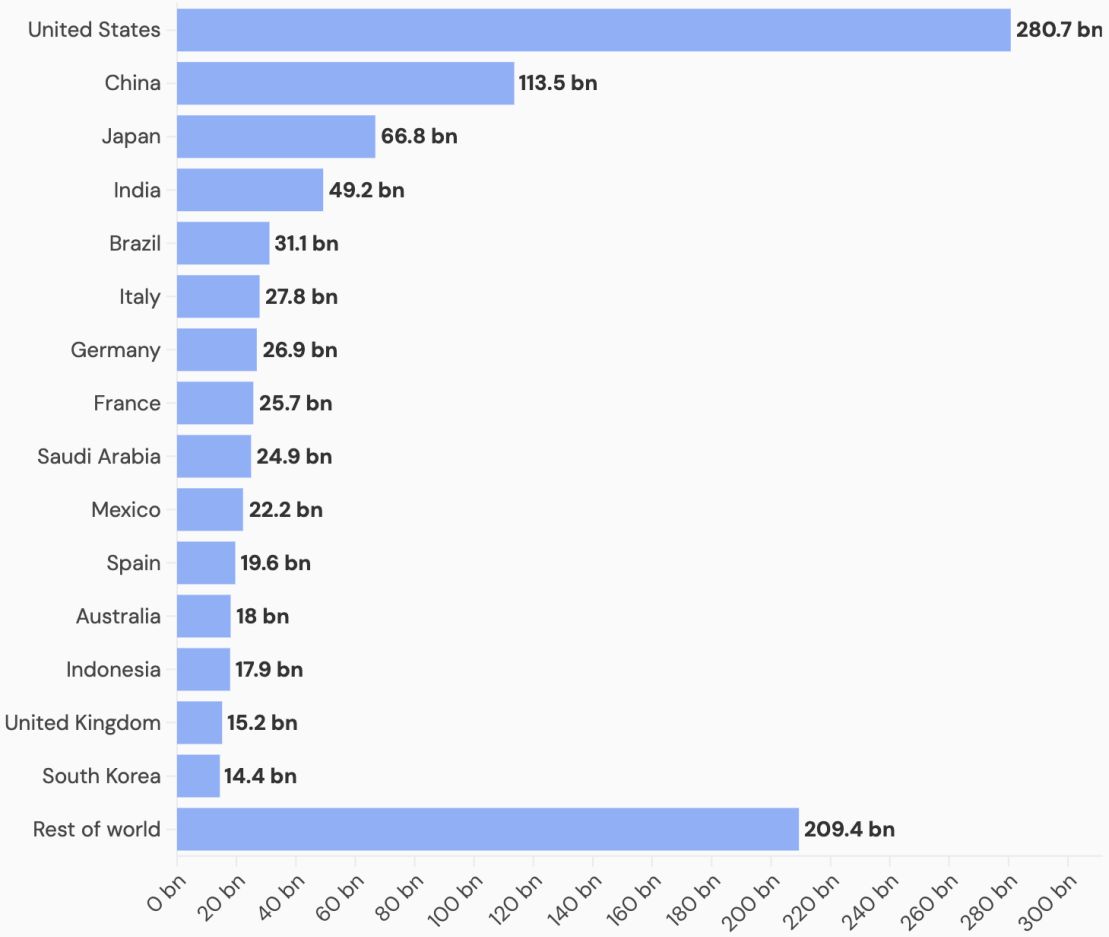
[5] Methodology: (1) Bilateral damage figures were taken from Burke et al.'s damage map and summed across all emitters for each receiving country, providing each country's total damages from cumulative global emissions, 1990-2020. (2) Country total damage was divided by the world total to get country damage share. (3) Country damage share was multiplied by shipping's global damage total from Burke et al., run on shipping's actual emissions series, to distribute shipping damage across countries. We assume shipping emissions cause damage in roughly the same country-by-country pattern as global emissions overall, as CO_2 has the same warming effect regardless of source and shipping emissions have grown at a similar pace to global emissions as a whole. This means that the proportion of damages by country is the same for total emissions and for other industries.

Figure 2.

Shipping emissions have caused the US USD 281 billion in damages, and China USD 113.5 billion

Economic damages from the shipping industry's contribution to global emissions 1990-2020

USD billion



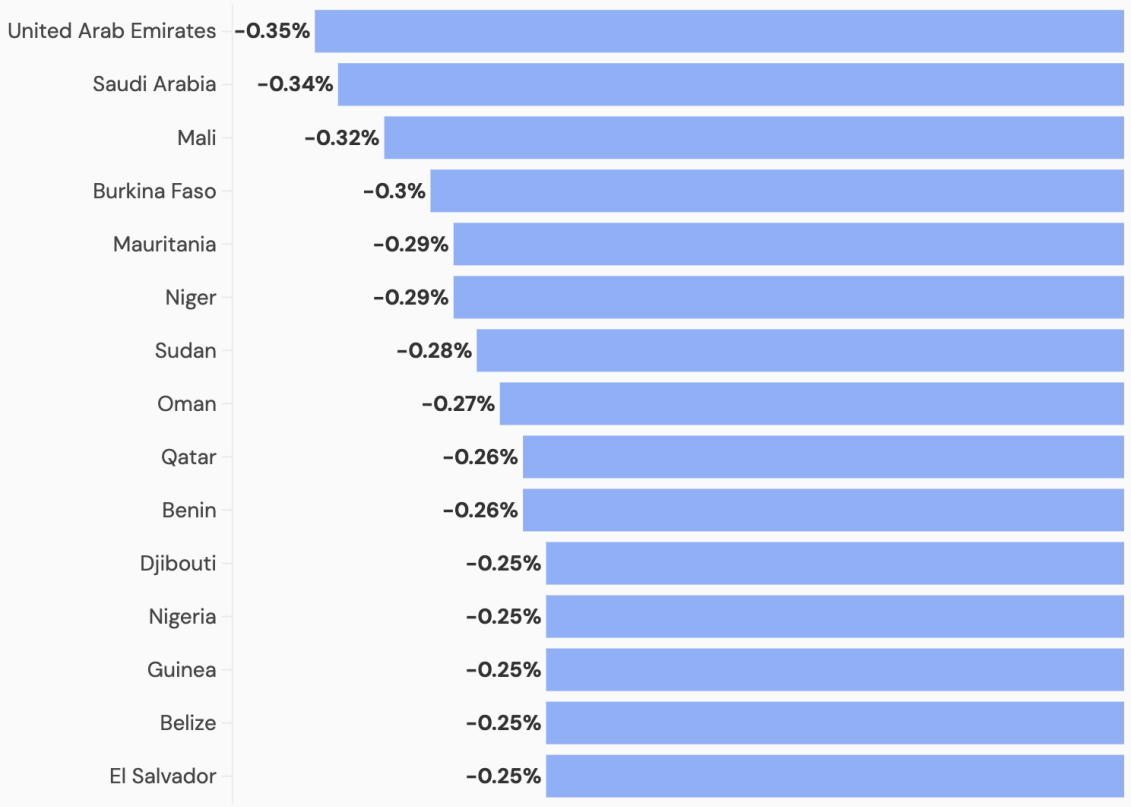
Source: Zero Carbon Analytics calculations, using Climate Action Tracker (2026) , estimates of shipping industry emissions between 1990-2020 and applying the ratio of GDP losses per country from , Burke et al damages calculator (2026)

Zero Carbon Analytics

Figure 3.

Shipping emissions cost the United Arab Emirates 0.35% of its 2020 GDP, Saudi Arabia 0.34%, and Mali 0.32%

Estimated impact on 2020 GDP caused by the shipping industry's contribution to global emissions 1990-2020



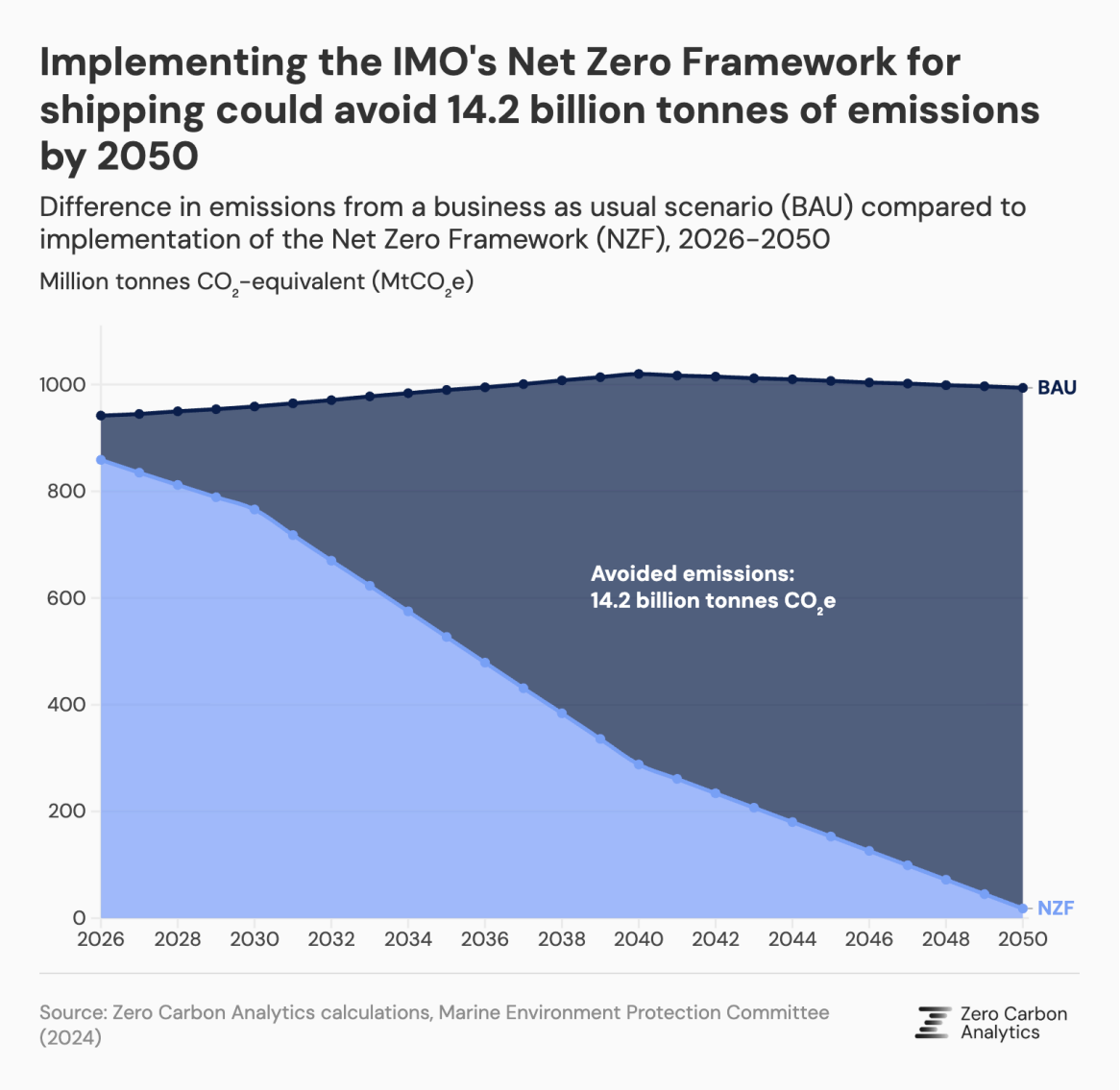
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Zero Carbon Analytics

Implementing the NZF for shipping could avoid an additional 1.5 million heat-related deaths

If the NZF is implemented and leads the shipping sector to reach its goal of net-zero emissions by 2050, it would avoid approximately 14.2 billion tonnes of CO_2-equivalent emissions between 2026 and 2050, compared to BAU (Figure 3).[6]

Figure 3.



[6] We estimate emissions avoided by implementing the IMO's NZF using the BAU low growth scenario and scenario 24 from the Marine Environment Protection Committee's 2024 official fleet impact assessment. Scenario 24 represents a similar, though not identical, policy mechanism to the NZF. The GHG emissions in the study include CO_2, nitrous oxide (N_2O), and methane (CH_4), calculated as CO_2-equivalents (CO_2eq) using the Global Warming Potential over a 100-year horizon (GWP100).

This could avoid approximately 0.00641°C of global warming by 2050.[7] While this may sound small, the Copernicus Climate Change Service finds that global warming reached an estimated 1.44°C in August 2026,[8] meaning 0.00641°C is approximately 10% of the budgeted warming before the 1.5°C Paris Agreement goal is exceeded.

In terms of impact on humans, this much additional warming could expose roughly 8 million more people to unprecedented heat by 2070[9] and lead to 1.5 million excess deaths from climate-induced, temperature-related impacts by 2100.[10]

For an example of the potential impacts on nature, increasingly likely coral bleaching events would become more severe. In a mass bleaching event like that seen in the Great Barrier Reef in 2016 – a record-breaking event, during which 93% of the reefs surveyed showed some sign of bleaching[11] – the additional warming could lead to the loss of roughly 260 million additional coral colonies.

Implementing the Framework and bringing the shipping industry to net-zero emissions by 2050 would help avoid these impacts.

The debate over the NZF leaves out the cost of inaction

The debate over the IMO NZF has centred on the implementation costs for the shipping industry, but this argument overlooks the high costs of inaction.[12] Plus, net

[7] Calculated using methodology by Abram et al. (2025), based on the IPCC best estimate assumption that every trillion tonnes of CO_2 emissions causes 0.45°C of additional warming.
[8] Based on 30-year linear trends.
[9] Calculated using methodology from Abram et al. (2025) based on a relationship from Lenton et al. (2023) that finds that in a world of 9.5 billion people (the mid-century population under a middle-of-the-road socioeconomic pathway ~2070), each 1°C of warming increases the share of the population exposed to unprecedented heat (local mean annual temperature over 29°C) by 13.8%.
[10] Avoided excess heat related deaths estimated using Bressler's (2021) mortality cost of carbon (MCC) equation, that estimates that every tonne of CO_2 emitted in 2020 will cause 1.07×10^{-4} deaths between 2020 and 2100 in an optimal emissions scenario that estimates 2.4°C of warming by 2100. This scenario is most closely aligned to projected temperature increase by 2100, which Climate Action Tracker estimates to be around 2.6°C based on current policies and 2.2°C based on national targets. The 2020 MCC equation is used for emissions in the years 2026-2050.
[11] Calculated using methodology from Abram et al. (2025) in which warming is converted into avoided thermal stress on the Great Barrier Reef based on the relationship that peak annual heat stress on the reef, measured in Degree Heating Weeks (DHW), has historically risen at 4.4 times the rate of global mean surface temperature. Avoided DHW-weeks are converted into coral colonies spared, using a relationship derived from a 2016 mass bleaching event, in which each additional DHW-week of heat stress caused a further 3.5% loss of coral cover. This percentage is applied to an estimated baseline of 265 billion coral colonies across the reef's 1.06 million hectares of coral habitat (using a conservative density of 250,000 colonies per hectare).
[12] The 2024 IMO comprehensive impact assessment of the basket of candidate mid-term measures for

implementation costs are likely lower than the upfront figures suggest, since some spending is reinvested in the shipping industry through channels like ship upgrades.

Our analysis finds that emissions from international shipping over the 30 years from 1990 to 2020 already caused USD 962.7 billion in damages, and the sector's emissions are now double what they were in 1990. While not quantified here, future economic damages are projected to worsen as emissions continue to grow.

These impacts will not be distributed evenly. Countries that have contributed comparatively little to global shipping emissions stand to bear a disproportionate share of the harm if the NZF is delayed further.

GHG reduction estimates that implementing a policy most similar to the NZF (Scenario 24 in the assessment, used here as a proxy for the IMO NZF) would cost USD 13.78 trillion between 2023 and 2050; USD 4.16 trillion more than continuing with business-as-usual in the sector (IMO BAU low growth scenario is used here as a proxy for business-as-usual, with aggregated costs between 2023 to 2050 estimated at USD 9.62 trillion). This includes "total aggregated costs split on annual capital costs, operational costs, fuel costs, CO2 deposit costs and regulatory expenses, including levy/fee and rewards." These do not represent net losses as a portion of capital would be reinvested in the shipping industry.