WORKING PAPER

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Environmental and health benefits of designating a North Atlantic Emission Control Area

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SUMMARY

This study assesses the environmental and public health benefits of reducing emissions from ships in the North Atlantic Ocean by designating part of the region as an emission control area. The North Atlantic Emission Control Area (AtlECA) would impose stricter regulations aimed at reducing emissions of sulfur oxides (SO_X), fine particulate matter ($PM_{2.5}$), and nitrogen oxides (NO_X). The possible AtlECA includes the territorial seas and exclusive economic zones of the Faroe Islands, France, Greenland, Iceland, Ireland, Portugal, Spain, and the United Kingdom.

This study follows our previous assessment of potential shipping emission reductions in the proposed AtlECA under different compliance scenarios. The results of this and previous studies are intended to be a part of a submission to the International Maritime Organization's Marine Environment Protection Committee on designating the AtlECA and follow the requirements of the International Convention for the Prevention of Pollution from Ships (MARPOL) Annex VI.

The AtlECA region is home to more than 190 million people, with a substantial share of older adults and young children who are particularly vulnerable to the adverse health effects of air pollution. Moreover, Greenland's population, predominantly indigenous Greenlandic Inuit residing in coastal areas, faces higher levels of air pollution and limited access to healthcare infrastructure. With nearly all residents living in coastal settlements affected by shipping-related pollution, this contributes to lower life expectancy and higher infant mortality compared with non-indigenous populations.

Despite substantial improvements in air quality due to land-based control measures across the proposed AtlECA region, the contribution of shipping emissions remains

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largely unaddressed. We estimate that implementing the AtlECA could reduce the shipping-attributable share of air pollution concentrations in the AtlECA by 77%–86% for sulfur dioxide (SO_2), 3% for nitrogen dioxide (NO_2), and 31%–59% for $PM_{2.5}$ in our plausible compliance scenarios. Shipping-attributable population-weighted exposure to $PM_{2.5}$ could be reduced by 35%–54% in the median member state.

Our analysis estimates that the introduction of the AtlECA could prevent between 118 and 176 premature deaths in 2030 alone in the plausible compliance scenarios. Cumulatively, between 2,900 and 4,300 premature deaths could be avoided between 2030 and 2050. The cumulative economic value of these health benefits could reach €19–€29 billion between 2030 and 2050.

Furthermore, the AtlECA could play a critical role in protecting the region's marine biodiversity and cultural sites. The AtlECA encompasses more than 1,500 marine protected areas, 17 important marine mammal habitats, and 148 UNESCO World Heritage sites. Reducing SO_x and NO_x emissions from shipping could mitigate pollutant deposition and ocean acidification, thus benefitting these ecosystems and heritage sites.

INTRODUCTION

The North Atlantic is a vital artery for international maritime shipping, facilitating around 32% of global trade between North America, Europe, and other continents (Endresen et al., 2010). This makes the region one of the world's busiest shipping corridors; numerous cargo vessels, tankers, and cruise ships transit the region every day. Our previous study estimated that the designation of the North Atlantic Emission Control Area (AtlECA) could reduce shipping emissions up to 82% for sulfur oxides (SO_x), 67% for fine particulate matter ($PM_{2.5}$), and 3% for and nitrogen oxides (NO_x) emissions in 2030, with future potential reductions of NO_x emissions of up to 71% due to fleet turnover and gradual retrofitting of all new ships to comply with Tier III standards (Osipova et al., 2024). This study expands on that previous evaluation of potential shipping emission reductions in the proposed AtlECA by assessing potential health and environmental benefits.

This and the previous study support the potential designation of an Emission Control Area (ECA) to control shipping SO_x, PM, and NO_x emissions covering the territorial seas and exclusive economic zones of the Faroe Islands, France, Greenland, Iceland, Ireland, Portugal, Spain, and the United Kingdom. Portugal's Directorate-General for Natural Resources, Safety, and Maritime Services appointed the International Council on Clean Transportation (ICCT) to conduct a technical assessment in partnership with the Faculty of Engineering at the University of Porto. Proposals for the ECA must include a submission of proof that there is a need for the designation, following the full eight criteria specified in the International Convention for the Prevention of Pollution from Ships (MARPOL) Annex VI, Appendix III (MEPC 58/23/Add.1 Annex 13).

This study addresses the following criteria of MARPOL Annex VI, Appendix III:

- For criterion 3.1.1, the study provides a clear delineation of the proposed AtlECA with references and a map where the area is marked.
- For criterion 3.1.3, the study provides a description of the human populations and environmental areas at risk from the impacts of ship emissions.
- The study partly addresses criterion 3.1.4 by assessing the ambient concentrations of air pollution and adverse environmental impact. It includes a description of the impacts of the relevant emissions on human health and the environment, including impacts on vulnerable ecosystems, critical habitats, and areas of cultural and scientific significance.

» For criterion 3.1.7, the study describes the control measures taken by the proposing Parties to address land-based sources of NOX, SOX, and PM emissions affecting the human populations and environmental areas at risk. These measures are in place and operating concurrent with the consideration of measures to be adopted in relation to provisions of regulations 13 and 14 of Annex VI.

BACKGROUND

Air pollution is a major global health hazard. In 2015, it was responsible for 9 million premature deaths, accounting for 16% of global mortality, and led to costs equivalent to 6.2% of the world's economic output (Fuller et al., 2022). Exposure to air pollution causes a range of acute and chronic health issues, including respiratory and cardiovascular diseases, cerebrovascular and metabolic disorders, neurological conditions, and birth defects (Tong, 2019).

One of the primary pollutants of concern is $PM_{2.5}$ (particulate matter with a diameter of less than 2.5 micrometers). When inhaled, $PM_{2.5}$ can penetrate deep into the lungs and induce oxidative stress and inflammation (Garcia et al., 2023). In 2020, exposure to fine particulate matter levels that exceeded the 2021 World Health Organization (WHO) guidelines, set at an average of 5 $\mu g/m^3$ over a year, resulted in 238,000 premature deaths in European Union Member States (European Environment Agency, 2022). Ozone, another critical pollutant, is a major component of smog and can cause respiratory problems, worsen asthma, and reduce lung function even at low exposure levels. Chronic exposure to these pollutants is linked to increased mortality rates and significant morbidity, particularly related to chronic obstructive pulmonary disease (Zhang et al., 2019).

In recent years, a growing body of research has focused on the impact of shipping emissions on air quality and human health. Maritime shipping has traditionally relied on large diesel engines fueled by heavy fuel oil, which emit harmful air pollutants like SO_x and NO_x. These pollutants adversely affect air quality, particularly in coastal areas, and significantly contribute to the formation of $PM_{2.5}$ (Nunes et al., 2020). Particulate matter emitted from ships can travel hundreds of kilometers in the atmosphere, and inland populations and environments can be affected by shipborne emissions as well (Rodríguez et al., 2020). Additionally, NO_x emissions are directly associated with an increased incidence of asthma, particularly among children (Sofiev et al., 2018).

According to Sofiev et al. (2018), global shipping emissions were responsible for approximately 266,000 premature deaths in 2020, which account for roughly 0.5% of global mortality. Without International Maritime Organization (IMO) regulations limiting the sulfur content of marine fuels to 0.5% (Global Sulfur Cap, 2020), the number of premature deaths from maritime emissions would have exceeded 400,000 in 2020. Another study by the ICCT estimated that the transport sector contributed to 385,000 deaths globally in 2015, with about 15%, or 60,000, deaths attributed to the shipping sector (Rutherford & Miller, 2019). Zhang et al. (2021) estimated that exposure to $PM_{2.5}$ from the shipping sector caused 94,200 premature deaths globally in 2015, with 83% of these deaths linked to international shipping activities and 17% linked to domestic.

Discrepancies between these findings are primarily due to variations in the assumptions used to correlate pollutant concentrations with health impacts. For example, Sofiev et al. (2018) based their estimates on linear functions that relate pollutant concentrations to health impacts, while Rutherford and Miller (2019) used methodology from the 2017 Global Burden of Disease (James et al., 2018). Kiihamäki et al. (2024) conducted a systematic review of the scientific literature on the health and economic impacts of emissions from the shipping sector. Their review concluded that, despite differences in risk functions and health assessments, the findings consistently show that excess air pollution from shipping contributes to increased all-cause mortality and specific-disease mortality.

Emission control areas can reduce premature mortality from shipping emissions. The North American ECA, proposed in 2009 (MEPC 59/6/5), was projected to prevent between 3,700 and 8,300 premature deaths in 2020 in a population of more than 330 million people. Similarly, the Mediterranean Sea SOx ECA, proposed in 2022 (MEPC 78/11), was predicted to prevent 1,118 premature deaths among more than 500 million people residing in Mediterranean coastal states in 2020. Cofala et al. (2018) estimated that an ECA established in the Mediterranean Sea regulating SO_x and NO_x emissions would lead to approximately 4,200 avoided deaths in 2030, with around one-third of these occurring in European Union Member States. In 2050, this is expected to avert more than 11,000 premature deaths annually in the Mediterranean region.

DELINEATION OF THE PROPOSED AREA

The proposed area of application of the AtlECA, shown in Figure 1, consists of:

» The mainland exclusive economic zones and territorial seas of Portugal, Spain, France, United Kingdom, Ireland, and Iceland;

» The exclusive economic zones and territorial seas of the autonomous territories of Faroe Islands and Greenland within the Kingdom of Denmark;

» Excluding where the combined area intersects with the North Sea ECA in the east; bound by latitude 62°N, longitude 4°W of the North Sea; and by latitude 48°30'N, longitude 5°W of the English Channel as described in MARPOL Annex V 1.14.6 (IMO, 2016); and

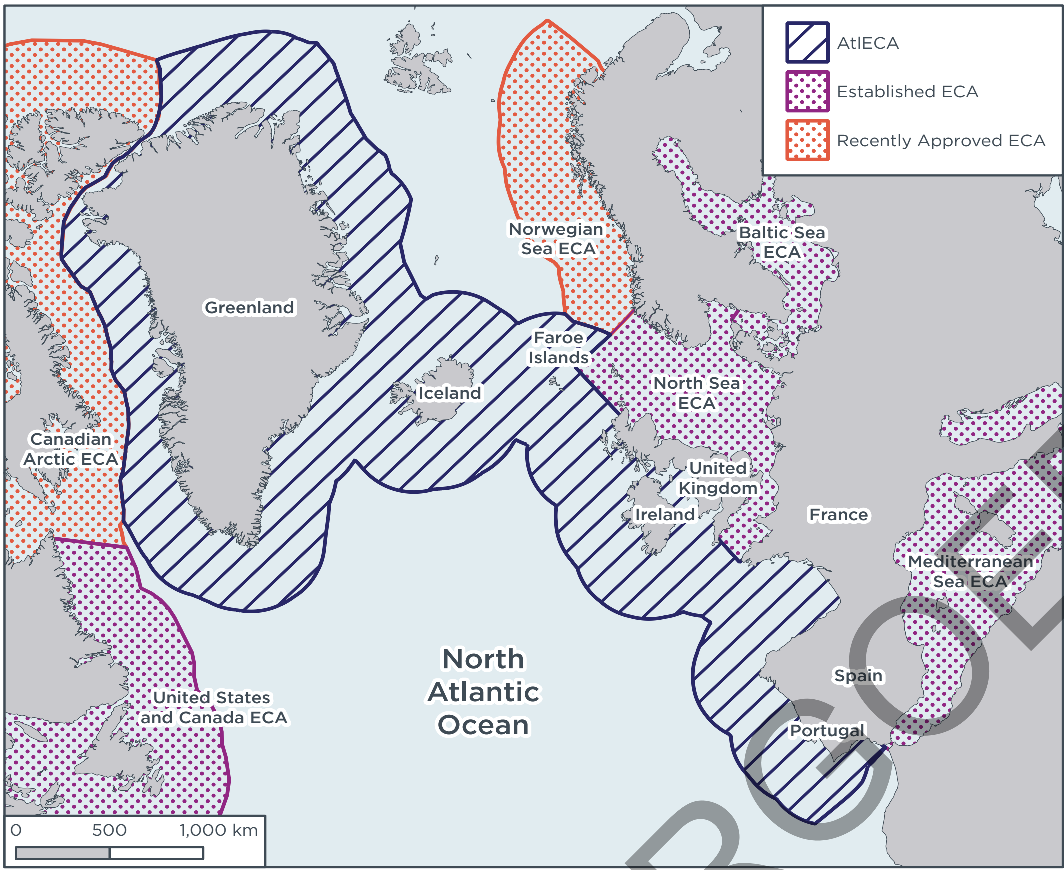
» Excluding where the combined area intersects with the Mediterranean ECA in the south by a line joining the extremities of Cape Trafalgar–Spain and Cape Spartel–Morocco (IMO, 2022).

The exclusive economic zone definition is based on the United Nations Convention on the Law of the Sea (UNCLOS) Part V Article 57, as amended by relevant delimitation and delineation legislations and treaties established by the countries (United Nations, 1994).[1]

1 A list of national claims to maritime jurisdiction can be found at: https://www.un.org/depts/los/LEGISLATIONANDTREATIES/toc.htm

Figure 1

The North Atlantic Emission Control Area and other established and recently approved emission control areas



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CONTROL OF LAND-BASED SOURCES

This section reviews existing land-based measures for controlling SO_X, NO_X, and PM emissions within the AtlECA member states. It includes an inventory of land-based emissions, analyzes temporal trends, and evaluates the outcomes of policy interventions.

Air quality statistics for this analysis were obtained from the European Environment Agency (2023b), EU Copernicus Atmospheric Monitoring Research (Inness et al., 2019), and the UK Department of Environment, Food & Rural Affairs (2023 a,b). Additionally, temporal trends in land-based emissions were analyzed for each member state using the European Environment Agency (2023a), UK Government (2024), and European Environment Information and Observation Network (2023) databases.

The analysis focuses on air quality levels for the year 2021 across the AtlECA member states. Air quality levels were evaluated against the following standards:

» EU Ambient Air Quality Directive (EU-AAQD) for the European Union and European Economic Area countries (European Council, 2008; 2016)

» National Emission Ceilings Directive (EU NECD) for EU countries (European Council, 2016)

» UK Air Quality Standards Regulations (UK AQSR) (UK Government, 2010)

» National Emission Ceilings Regulations for the United Kingdom (UK Government, 2018)

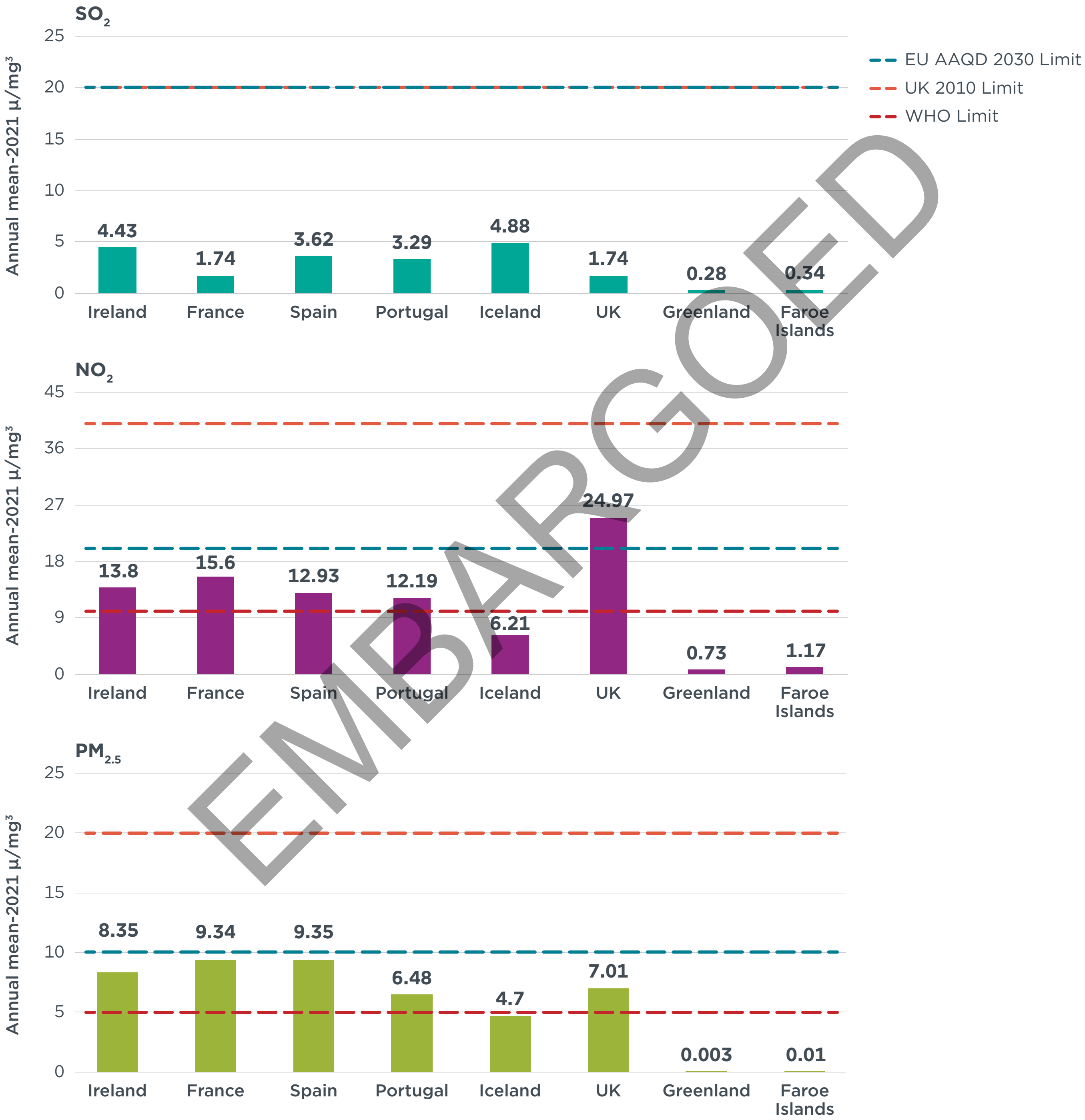
» World Health Organization air quality guidelines (Global) (World Health Organization, 2021).

» Key sector-specific and regional emissions regulations (see Appendix A for further details).

Figure 2 shows the 2021 ambient air concentrations of sulfur dioxide (SO_2), nitrogen dioxide (NO_2), and $PM_{2.5}$ from land-based sources in AtlECA member states, plotted against EU-AAQD limits, UK AQSR standards, and WHO global guidelines. Detailed assessments are provided in Appendix A (review of existing land-based measures) and Appendix B (time series trends for land-based emissions).[2]

Figure 2

Mean ambient air concentrations of SO_2, NO_2, and $PM_{2.5}$ in AtlECA member states in 2021 compared with EU Ambient Air Quality Directive 2030 limits, UK 2010 limits, and World Health Organization guidelines



Note: Concentrations for Greenland and the Faroe Islands are also shown for informational purposes, despite the absence of specific territory-wide emission limits.

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2 The Faroe Islands are not included in the emissions inventory due to the unavailability of relevant data.

Our findings show that all EU and European Economic Area AtlECA member states (France, Iceland, Ireland, Portugal, and Spain) meet the EU-AAQD 2030 thresholds, and the United Kingdom complies with its domestic UK AQSR limits. However, only the Faroe Islands, Greenland, and Iceland meet the WHO-recommended air quality guidelines. The Faroe Islands and Greenland, as self-governing autonomous territories, are not required to comply with EU regulations; they instead implement independent regional environmental policies.

France, Ireland, Portugal, and Spain meet their NECD 2020–2029 reduction targets for SO_2, NO_X, and $PM_{2.5}$. However, NO_X and $PM_{2.5}$ emission levels are projected to exceed post-2030 targets, indicating a need for additional policy intervention. Similarly, the United Kingdom has achieved its National Emission Ceilings Regulations 2020–2029 reduction targets for SO_2 and NO_X but has not achieved its $PM_{2.5}$ reduction commitments. Projected reduction levels for the United Kingdom also have not met post–2030 targets, suggesting further policy improvements may be needed. Iceland, as a member of the European Economic Area, has not yet implemented the revised EU NECD reduction targets; it is the only member state experiencing a noticeable increase in non-transport SO_2 emissions (Appendix A).

Overall, the implementation of land-based air quality control measures has considerably improved air quality in most AtlECA member states (see Appendix B), and temporal trends reveal a reduction in SO_X, NO_X, and $PM_{2.5}$ emissions from both transport and non-transport sectors. However, exceptions such as the increase in non-transport-related SO_2 emissions in Iceland, and the fact that only the Faroe Islands, Greenland, and Iceland meet WHO-recommended air quality thresholds, highlight the potential need for targeted interventions in specific areas.

POPULATIONS AT RISK FROM THE IMPACTS OF SHIPPING EMISSIONS

Table 1 shows the total populations in selected jurisdictions in 2021, 2030, and 2050 population projections, while population densities and distributions are shown in Figure 3 and Figure 4. There are approximately 193 million people within the borders of proposed AtlECA member states, with more than 90% in France, Spain, and the United Kingdom. Overall, the region is expected to see population growth from 2021 to 2030 and 2050, except in Portugal, Spain, and Greenland, where gradual declines are expected (Table 1). The most populated major port cities in the AtlECA are Lisbon, Porto, Dublin, Liverpool, and Bilbao.

Table 1

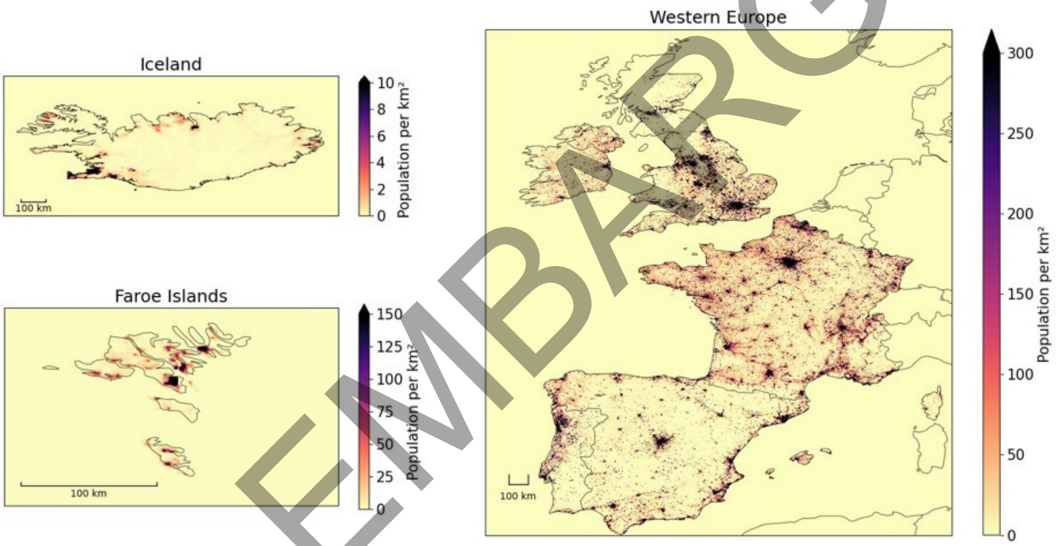
Total population of AtlECA member states for 2021, 2030, and 2050

Regions	2021	2030	2050
United Kingdom	68,207,104	70,485,467	74,081,967
France	65,426,162	66,695,690	67,586,716
Spain (excluding the Canary Islands)	44,566,273	43,794,600	41,201,397
Portugal (excluding Azores & Madeira)	9,676,424	9,408,766	8,580,664
Ireland	4,982,900	5,248,025	5,677,610
Iceland	343,345	359,693	376,669
Greenland	56,421	56,544	56,330
Faroe Islands	53,370	56,341	58,743
Total:	**193,311,999**	**196,105,126**	**197,620,096**

Sources: Population data for 2021 and projections for 2030 and 2050 for France, Iceland, Ireland, Portugal, Spain, and the United Kingdom are from the United Nations (2022). Data for the Faroe Islands are from Statistics Faroe Islands (2022). For Greenland, population data for 2021 are from Statistics Greenland (2023). The 2030 and 2050 population projections for Greenland were estimated by the ICCT, assuming the population growth pattern follows historical trends for each 5-year age group.

Figure 3

Population densities in 2021 for Iceland, the Faroe Islands, the United Kingdom, Ireland, France, Spain, and Portugal



Source: GPWv4.

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Figure 4
Population density in 2021 for Greenland

Source: Statistics Greenland (2023).

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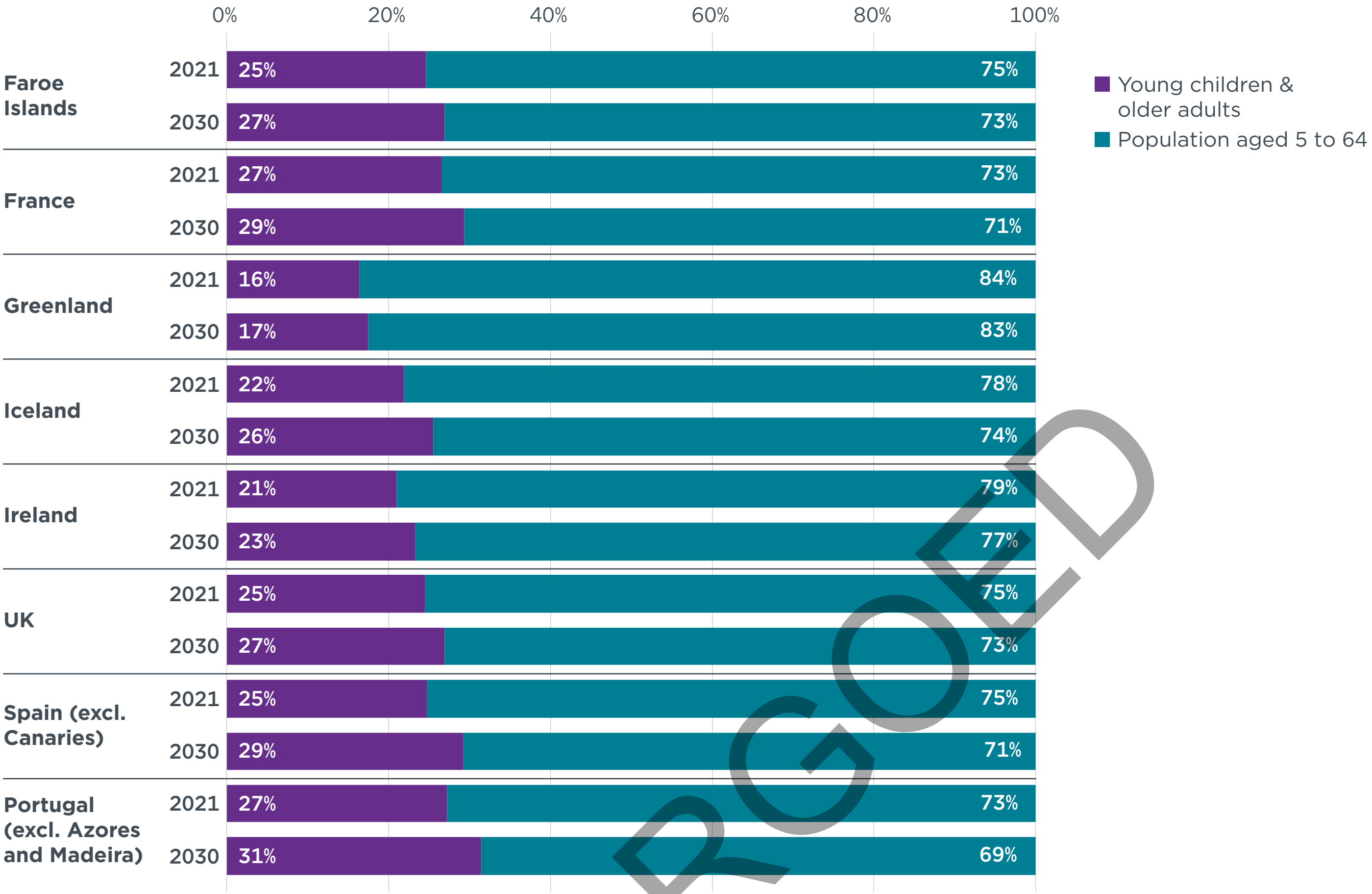
Research shows that children aged 0–4 and adults aged 65 and above are the age groups most vulnerable to air pollution, as they have an increased mortality risk from asthma, respiratory diseases, and cardiovascular diseases caused by air pollution (Boing et al., 2022; Yap et al., 2019). In 2021, the combined share of young children and older adults in the proposed AtlECA member states made up 25% of their total population, and their share is projected to increase by 3% by 2030. This rising vulnerability to adverse environmental factors is expected in every member state bordering the ECA, with Portugal (4.2%) and Spain (4.5%) showing the greatest increases in their ratio of vulnerable population to total population between 2021 and 2030 (Figure 5).

Figure 5

Projected share of children aged 0–4 and adults aged 65+ in AtlECA regions in 2021 and 2030



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In 2016, the indigenous Greenlandic Inuit comprised 89% of Greenland's population (Organisation for Economic Cooperation and Development, 2018). Though they are covered by the United Nations Declaration on the Rights of Indigenous Peoples, when compared with non-indigenous people, these communities have lower life expectancy, higher infant mortality, and worse economic conditions (Anderson et al., 2016). Almost all of Greenland's population resides near coastal settlements and cities in southern and western Greenland, and are affected directly by air pollution generally and shipping-related pollution specifically (Figure 4). Although healthcare is a publicly financed government responsibility in Greenland, long travel distances, lack of specialized medical personnel in sparsely populated areas, and cultural factors complicate access to healthcare infrastructure and may delay treatment (Niclasen & Mulvad, 2010).

AMBIENT AIR QUALITY AND HEALTH IMPACT ASSESSMENT

This section presents an analysis of the influence of shipping emissions on ambient air quality in the AtlECA region and an evaluation of associated health impacts. It highlights the projected increases in pollutant concentrations of SO_X, NO_X, and $PM_{2.5}$ due to shipping activities, both with and without implementation of the AtlECA, and examines the reductions that could be achieved through regulatory measures. Additionally, it quantifies the health benefits of reducing these emissions, including the number of avoidable deaths and the associated monetized health benefits under different compliance scenarios.

INFLUENCE OF SHIPPING EMISSIONS ON AMBIENT AIR QUALITY

For this study, shipping's contribution to ambient air quality in the AtlECA region was estimated by the Faculty of Engineering of Porto University (FEUP). FEUP used the European Monitoring and Evaluation Programme (EMEP) chemical transport model to derive air quality at a gridded 0.5x0.5° resolution (Simpson et al., 2012). Emission inventories from anthropogenic sectors other than shipping were taken from the International Institute for Applied Systems Analysis ECLIPSE inventory (V6b) (International Institute for Applied Systems Analysis, n.d.). Additionally, Saharan dust and NO_x emissions from lightning and forest fires were considered (Nunes et al., 2020).

Emission inventories from the shipping sector at a gridded 0.5x0.5° resolution were developed by the ICCT (Osipova et al., 2024). These inventories include business-as-usual projections of SO_x, NO_x, and primary $PM_{2.5}$ emissions from the shipping sector in 2021 and 2030, as well as projections of four AtlECA compliance scenarios in 2030, assuming different fuel mixes and scrubber usage (Figure 6).[3]

The scenarios and assumptions applied in this study are as follows:

Business-As-Usual (BAU) (2030): This scenario assumes that the AtlECA is not implemented in the study area.

MGO Mix (plausible): This scenario assumes that vessels currently using very-low sulfur fuel oil (VLSFO) will transition to marine gas oil (MGO). Ships already operating on distillates, liquified natural gas, and methanol are assumed to maintain their behavior. Ships with scrubbers are expected to adjust their performance to match a fuel sulfur content of 0.1%, compared with the 0.5% sulfur content in the BAU scenario.

ULSFO Mix (plausible): This scenario mirrors the MGO Mix scenario, with the key difference being that vessels using VLSFO are assumed to switch to ultra-low sulfur fuel oil (ULSFO) instead of MGO. It is assumed that ULSFO's sulfur content remains at 0.1%, with other properties and emissions staying consistent with VLSFO.

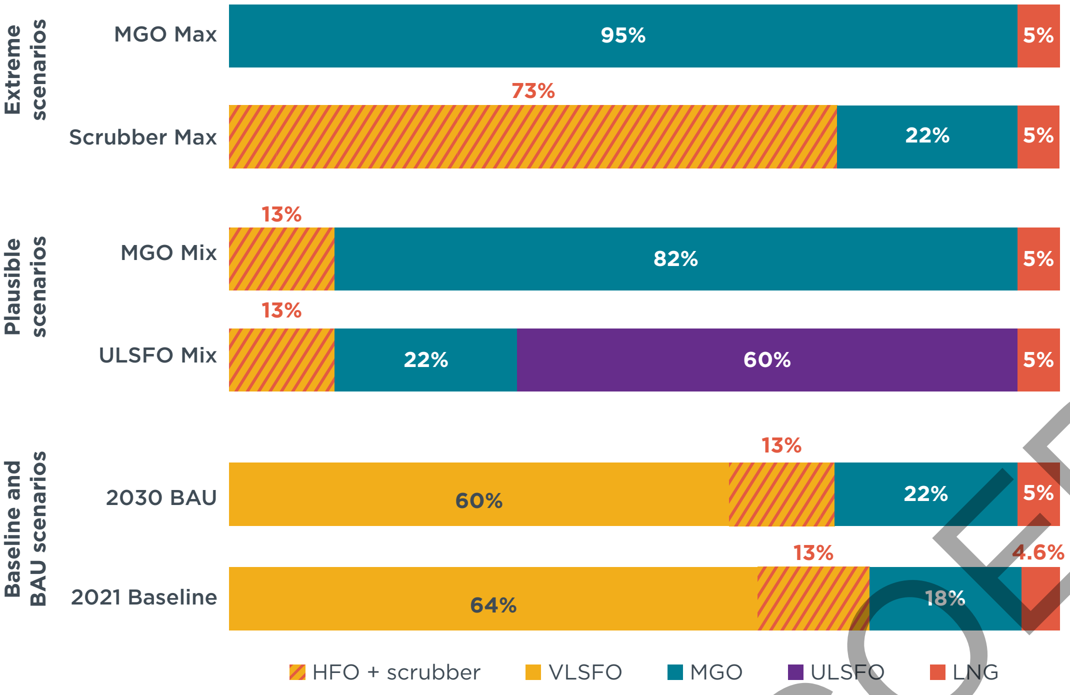
MGO Max (extreme): This scenario assumes that scrubbers are prohibited as an alternative method for sulfur compliance, requiring ship owners to use only MGO. Under this scenario, no ships would have scrubbers installed by 2030.

Scrubber Max (extreme): This scenario assumes that all ships currently operating with heavy fuel oil and scrubbers will continue to do so. Additionally, vessels using VLSFO are assumed to install scrubbers and switch to heavy fuel oil, instead of choosing fuels compliant with 0.1% sulfur content. Ships already using MGO, liquified natural gas, and methanol for compliance are assumed to maintain their current fuel usage.

3 See Osipova et al. (2024) for the detailed methodology and scenarios description.

Figure 6

Shipping fuel mix assumptions for the AtlECA compliance scenarios from Osipova et al. (2024)



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EMEP modeling performed by FEUP indicates that, absent AtlECA implementation, shipping-attributable air pollution concentrations will increase by 12% for SO_2, 16% for NO_2, and 12% for $PM_{2.5}$ on average over waters in the AtlECA region in 2030. In absolute terms, the increase in ambient pollutant concentrations driven by increased shipping emissions is expected to be greatest along the coastal regions of the Faroe Islands, France, Ireland, Portugal, and the United Kingdom (Figure 7). NO_x concentrations also show substantial percentage increases near the Faroe Islands, Iceland, and Western Greenland. Shipping-attributable population-weighted $PM_{2.5}$ exposure within the member states increases by 9% to 34% within the member states, with a median of 14%, between 2021 and 2030.

Under our compliance scenarios, implementing the AtlECA would address a large portion of shipping's contribution to pollutant concentrations. We estimate that AtlECA compliance under the MGO Mix scenario would mitigate 86% of shipping-attributable (2.6% of ambient) SO_2, 59% of shipping-attributable (0.4% of ambient) $PM_{2.5}$, and 3% of shipping-attributable (1.2% of ambient) NO_2 averaged concentrations in the AtlECA region. Following the ULSFO Mix scenario, the reductions are 77% for shipping-attributable (2.3% of ambient) SO_2, 31% for shipping-attributable (0.2% of ambient) $PM_{2.5}$, and 3% for shipping-attributable (1.2% of ambient) NO_2 (Figure 8).

Figure 7

Projected increase in total $PM_{2.5}$, SO_2, and NO_2 concentrations (2021–2030) without proposed AtlECA implementation

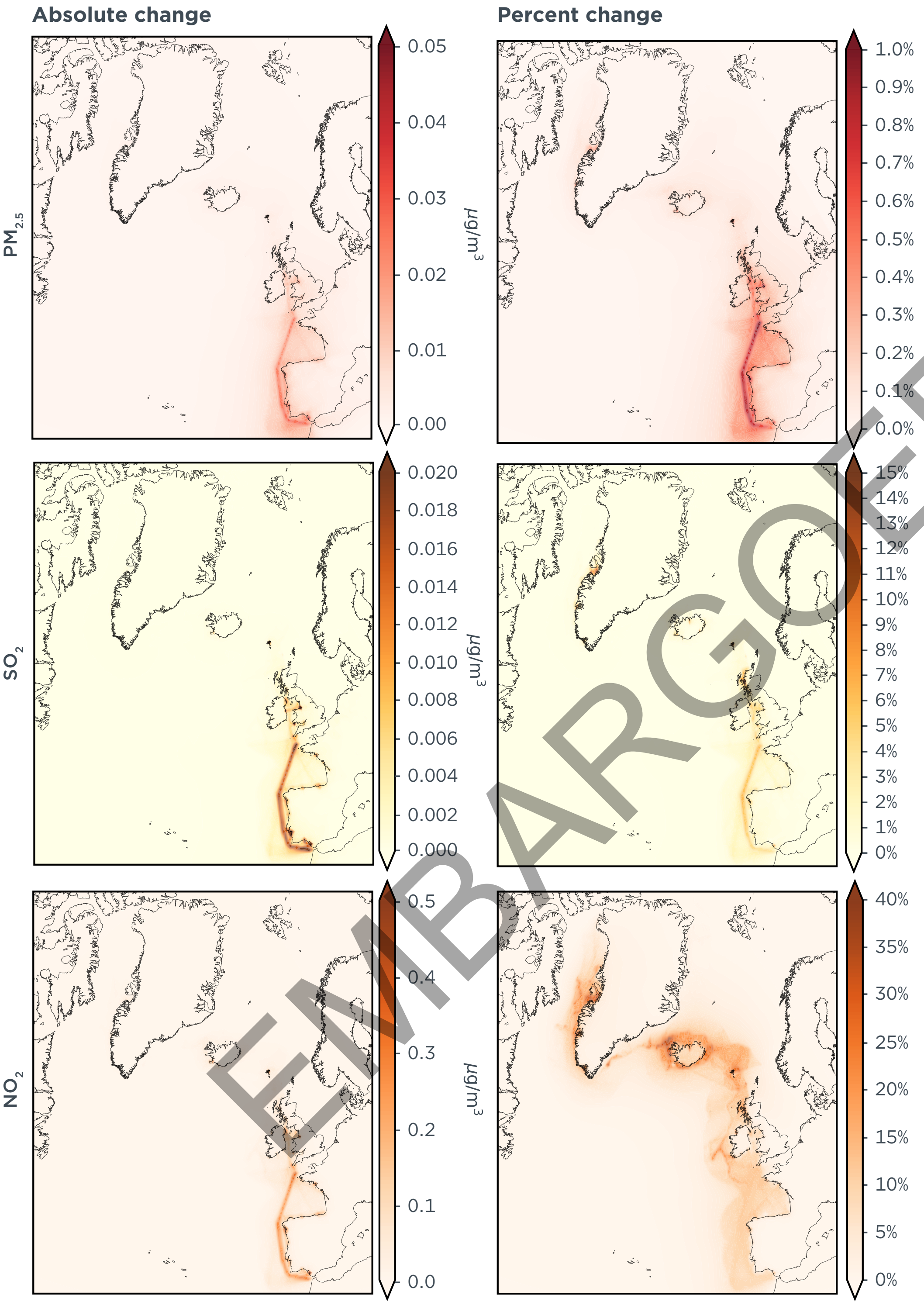

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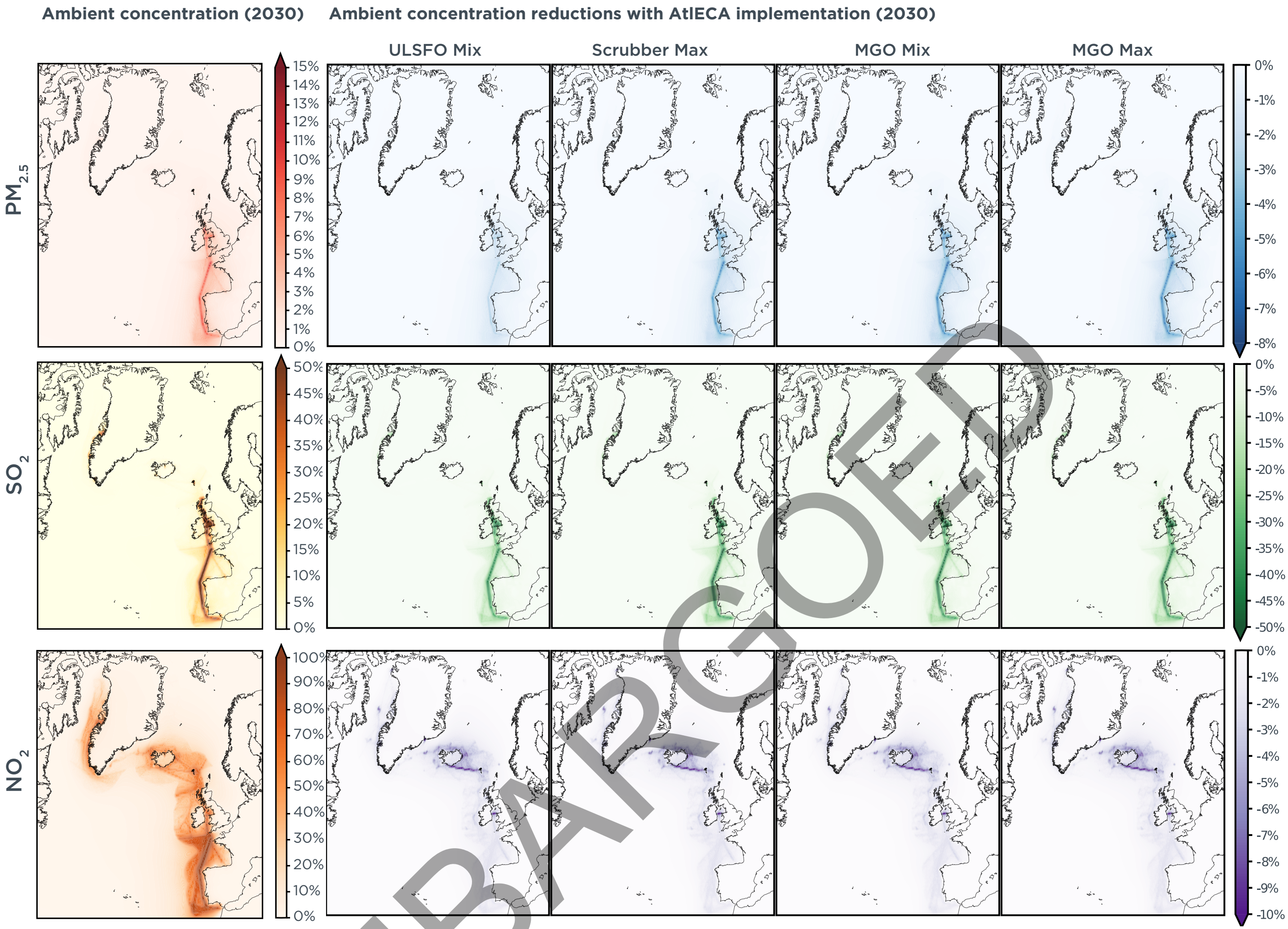
Figure 8

Shipping-attributable share of ambient $PM_{2.5}$, SO_2, and NO_2 concentrations in 2030 and predicted reductions in ambient concentrations following AtlECA implementation compared with BAU 2030 under different compliance scenarios



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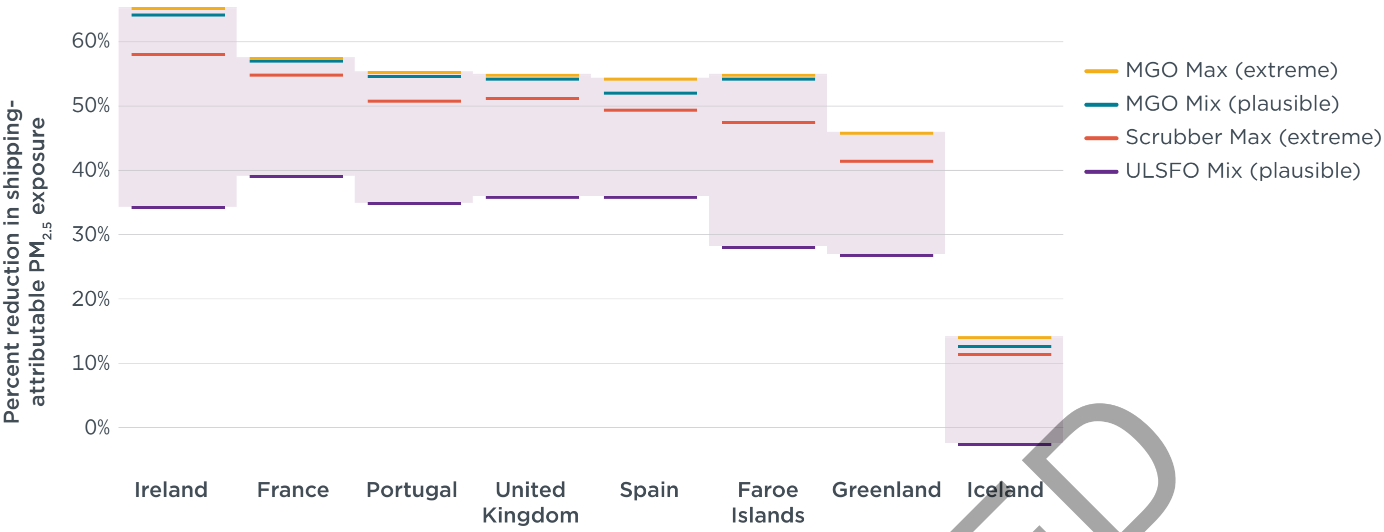
Establishing the AtlECA would also be expected to reduce shipping-attributable population-weighted $PM_{2.5}$ exposure in the most populous regions in the study area by 35% – 55%, depending on whether ULSFO or MGO is used as the main compliance strategy (Figure 9). These reductions vary across scenarios, with the greatest reductions achieved when MGO is used for compliance and the lowest reductions when ULSFO is used. While shipping-related SO_2 and $PM_{2.5}$ reductions are substantial under all scenarios, NO_2 reductions are modest. This is because NO_2 emissions depend primarily on engine type and technical specifications, with the type of fuel used for ECA compliance playing only a minor role.

Figure 9

Percent reduction in national population-weighted shipping-attributable $PM_{2.5}$ exposure in each AtlECA compliance scenario



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HEALTH BENEFITS OF REDUCING SHIPPING EMISSIONS IN THE ATLECA

For this study, we evaluated the health impact associated with exposure to shipping emissions in the AtlECA region using the Fast Assessment of Transportation Emissions (FATE) model (International Council on Clean Transportation, 2023), which applies health methods from the 2019 Global Burden of Disease (Murray et al., 2020). Using FEUP's gridded air quality outputs for each scenario, we combined these with population data to calculate the changes in national-average pollutant exposures for each compliance scenario compared with the 2030 BAU scenario.

Population growth projections through 2030 and 2050 considered expected age-specific changes in demographic trends and disease rates and are based on the data published by United Nations (2022), Statistics Faroe Islands (2022), and Statistics Greenland (2023). Although some populations are expected to decline in the designated member states, the calculation of avoidable deaths accounts for changes in population structure by age group. Since these diseases primarily affect older adults, and the population in this region is projected to age, the estimated number of avoidable deaths reflects both demographic shifts and changes in baseline disease rates (Murray et al., 2020).

We quantified the health burden by assessing population exposure to $PM_{2.5}$ from both primary sources and secondary formation and ozone. The health burdens assessed by the model are strokes, ischemic heart disease (IHD), chronic obstructive pulmonary disease (COPD), lower respiratory infection (LRI), lung cancer, and diabetes mellitus type 2; for ozone, cases of COPD are considered. The methodology for selected diseases per age category follows the methods used in the Global Burden of Disease (Murray et al., 2020). A detailed description of the methods used for estimating avoided premature mortality is provided in the Appendix C. In addition to the health burden analysis, we assessed the monetized benefits associated with avoidable premature deaths based on the value of statistical life. The methodology for calculating the value of statistical life and related economic impacts is aligned with Narain and Sall (2016) and is described in detail in Appendix D.

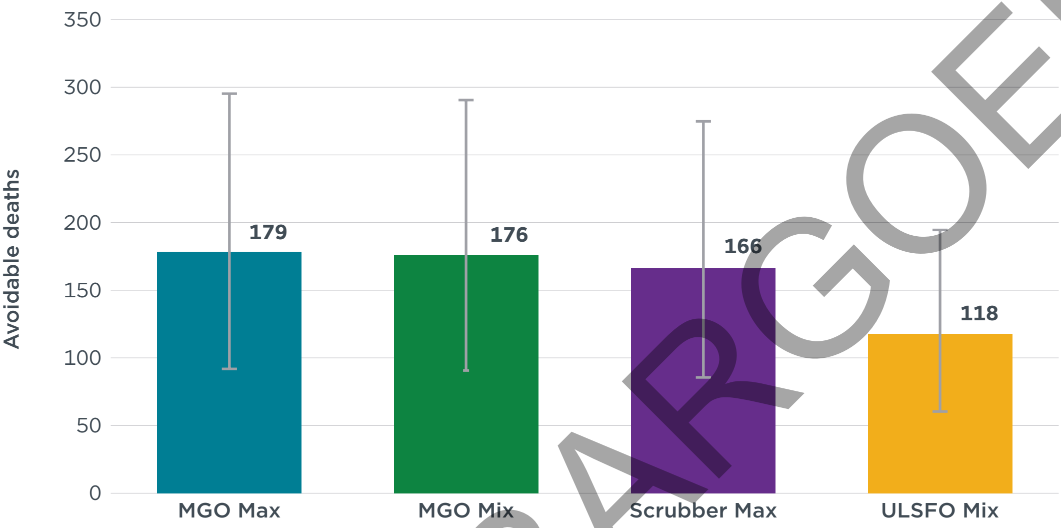
To provide a more complete picture of the long-term health benefits of implementing the AtlECA, we extrapolated the number of avoidable deaths and the economic value of these health benefits from 2030–2050 under our compliance scenarios. For the 2050 health impact forecast, we used a conservative approach and held the absolute reductions in pollutant exposure in 2030 constant through 2050. Since under a BAU scenario pollutant emissions and ship activity are projected to increase after 2030, using a constant reduction in pollutant exposure due to the ECA (based on the 2030 EMEP simulations) leads to an intentionally conservative cumulative estimate of health benefits through 2050.

Number of avoidable premature deaths

The total estimated avoidable premature deaths per scenario for 2030 and approximate cumulative avoidable deaths for 2030–2050 are shown in Figure 10 and Figure 11. Estimates of avoidable deaths by member state, type of disease, and pollutant are provided in Appendix E.

Figure 10

Estimated number of avoidable premature deaths in 2030 for different AtlECA compliance scenarios



Note: Error bars represent 95% confidence intervals.

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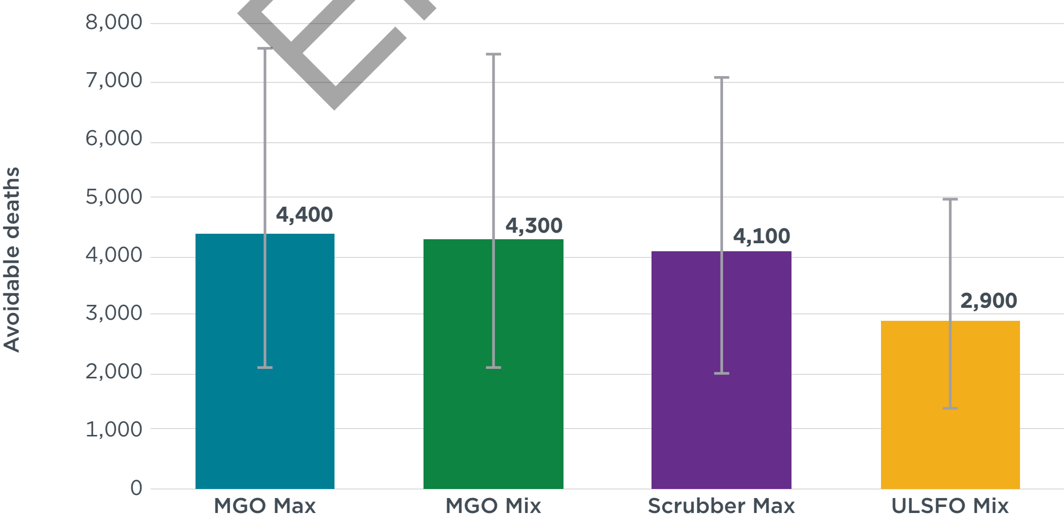
Figure 11

Estimated approximate cumulative number of avoidable premature deaths, 2030–2050, for different AtlECA compliance scenarios



Note: Error bars represent 95% confidence intervals. Numbers are rounded to the nearest hundred.

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Among the plausible compliance scenarios evaluated, the use of ULSFO (ULSFO Mix scenario) provides the lowest health benefits due to its higher sulfur content and higher primary $PM_{2.5}$ emissions compared with the use of MGO. It is projected to prevent 118 deaths in 2030 and approximately 2,900 deaths cumulatively between 2030 and 2050. In contrast, using MGO for compliance (MGO Mix scenario) provides greater benefits, with the potential to prevent 176 deaths in 2030 and 4,300 deaths cumulatively between 2030 and 2050. This shows that the benefits of the ECA are estimated to be approximately 50% greater if ships use MGO to comply instead of ULSFO (Figure 10 and Figure 11).

The extreme scenarios, although less likely to be used in practice, are included to present a more complete estimate of the range of potential health outcomes due to the AtlECA. We estimate that residual-fueled ships using only scrubbers for compliance could avoid 166 premature deaths in 2030, with a cumulative total of approximately 4,100 avoidable premature deaths from 2030 to 2050. Using only MGO (MGO Max scenario) would result in nearly the same benefits as the MGO Mix scenario because only a small proportion of the fleet is expected to use scrubbers by 2030 (13% of the energy consumed, as shown in Figure 6).

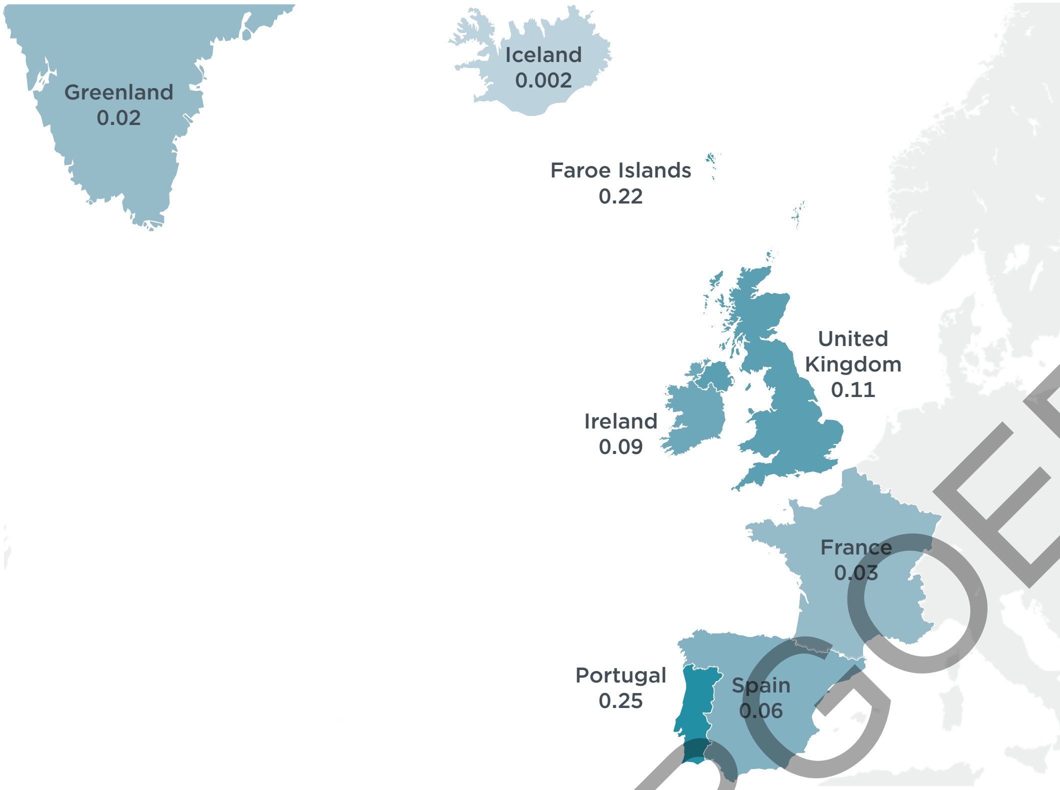
The estimated health benefits of the AtlECA vary greatly among member states due to differences in the proximity of shipping emissions to populated areas and demographic factors such as population size and age distribution. In absolute terms, the United Kingdom accounts for nearly half of the total avoidable premature deaths in 2030 across all scenarios, followed by Spain and Portugal (Appendix E). The United Kingdom is projected to account for 36% of the total population in the study area by 2030 (see Table 1).

When the number of avoidable premature deaths is normalized per population size (i.e., number of avoided deaths per 100,000 inhabitants), other member states also show substantial health benefits. The maps in Figure 12 show the number of avoided premature deaths per 100,000 inhabitants for the two plausible compliance scenarios, MGO Mix and ULSFO Mix. When adjusted for population size, the United Kingdom ranks third in avoided premature deaths, following the Faroe Islands and Portugal. Specifically, the Faroe Islands show 0.22–0.43 avoided premature deaths per 100,000 inhabitants, Portugal shows 0.25–0.39, and the United Kingdom shows 0.11–0.17 (see Appendix E).

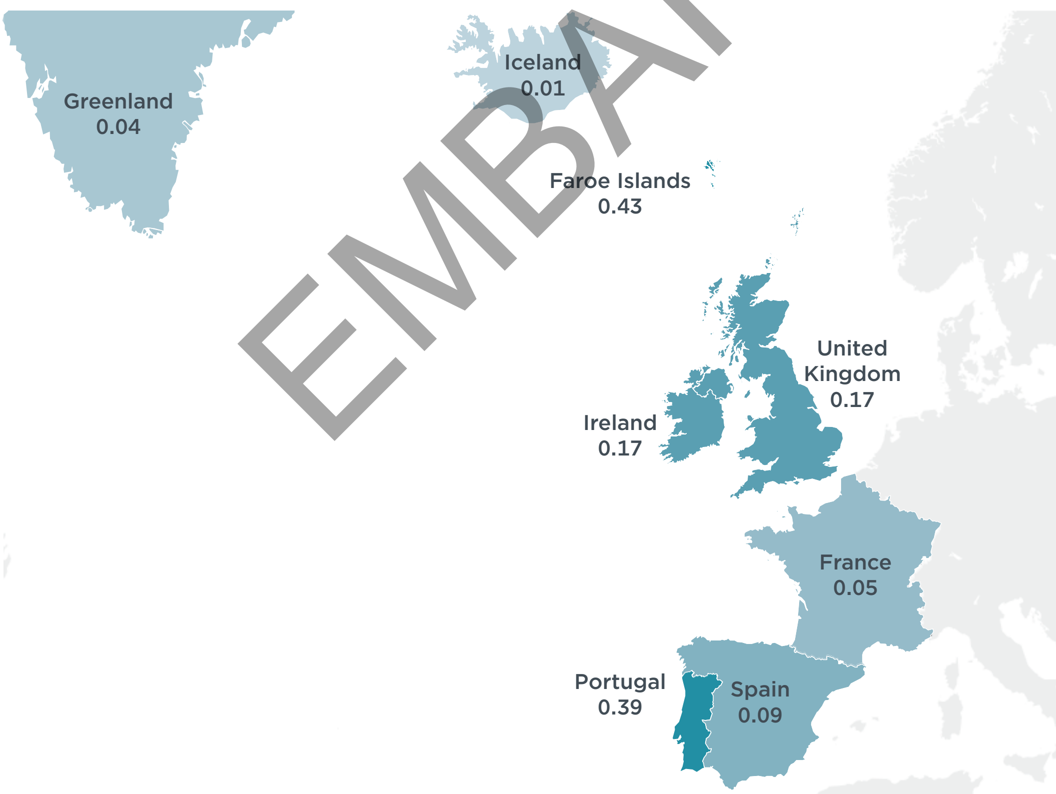
Figure 12

Estimated avoidable premature deaths per 100,000 inhabitants in 2030 under the MGO Mix and ULSFO Mix AtlECA compliance scenarios

Avoidable premature deaths per 100,000 inhabitants for the ULSFO Mix scenario in 2030



Avoidable premature deaths per 100,000 inhabitants for the MGO Mix scenario in 2030



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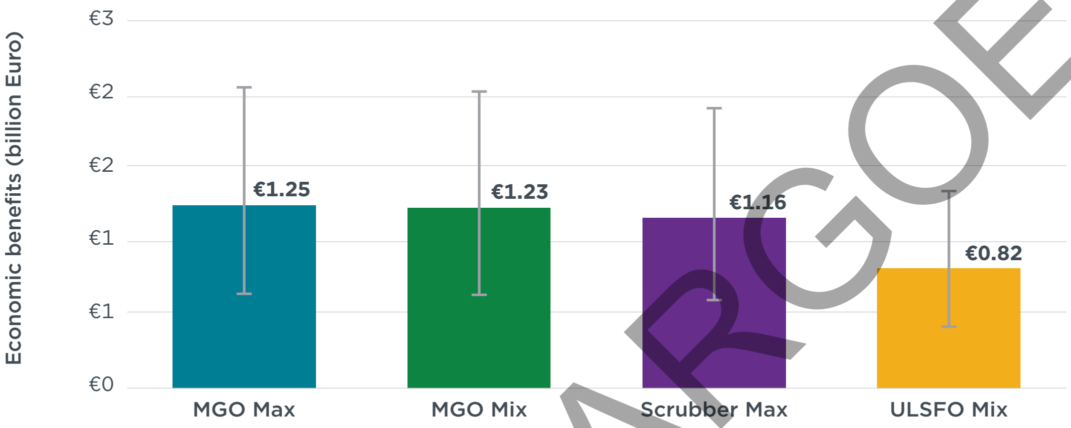
Health-related economic benefits

The monetized value of avoidable premature deaths for each compliance scenario in 2030 is presented in Figure 13, and approximate cumulative benefits from 2030–2050 are presented in Figure 14. These monetized health benefits, which are calculated as the product of avoidable premature deaths and country-specific values of statistical life, are estimated to be €0.82–€1.25 billion in 2030 (in 2021 Euro values), depending on the compliance scenario.[4] Focusing on the plausible scenarios, we estimate approximately €1.23 billion in benefits in 2030 under the MGO Mix scenario and €0.82 billion under the ULSFO Mix scenario. The true benefits are likely to fall in between these estimates, depending on the eventual fuel mix used to comply with the AtlECA. Between 2030 and 2050, the approximate cumulative monetized health benefits could reach €19.4–€29.1 billion under the plausible scenarios (in 2021 Euros), under the conservative assumptions described in Appendix D. The variation in monetized health benefits across scenarios is like the variation in estimated avoidable premature deaths, showing the highest benefits for the MGO Mix and MGO Max scenarios, and the lowest for the USLFO Mix scenario.

Figure 13

Estimated value of health benefits (in 2021 Euros) associated with avoidable premature deaths in 2030 under different AtlECA compliance scenarios



Note: Error bars represent 95% confidence intervals.

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Figure 14

Estimated approximate cumulative value of health benefits (in 2021 Euros) associated with avoidable premature deaths in 2030–2030 under different AltECA compliance scenarios

Note: Error bars represent 95% confidence intervals.

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4 The methodology for conversion to 2021 values is described in Appendix D. Since these estimates of approximate cumulative benefits are not discounted, discounting would need to be applied before comparing these to any estimates of cumulative discounted costs such as for a cost-benefit analysis.

In absolute terms, the United Kingdom has the highest estimated value of health benefits in 2030 (€446–€667 million), followed by Spain (€126–€179 million) and Portugal (€107–€165 million) (Table 2, plausible scenarios). Between 2030 and 2050, the approximate cumulative benefits are estimated to be €13.9 billion for the United Kingdom, €5.2 billion for Spain, and €4.6 billion for Portugal in the MGO Mix scenario (in 2021 Euros) (Table 3).

Table 2
Estimated value of health benefits (in € million) from avoidable premature deaths by member state in 2030 under different AtlECA compliance scenarios

	MGO Max	MGO Mix	Scrubbers Max	ULSFO Mix
Faroe Islands	1.4	1.4	1.2	0.7
France	147	146	140	101
Greenland	0.1	0.1	0.1	0.1
Iceland	0.3	0.2	0.2	0.0
Ireland	73	72	65	37
Portugal	168	165	154	107
Spain	186	179	170	126
United Kingdom	673	667	631	446
Total	**1,249**	**1,230**	**1,163**	**818**

Table 3
Approximate cumulative (2030–2050) health benefits (in € million) from avoidable premature deaths by member state under different AtlECA compliance scenarios

	MGO Max	MGO Mix	Scrubber Max	ULSFO Mix
Faroe Islands	26	26	23	13
France	3,600	3,500	3,400	2,500
Greenland	2	2	2	1
Iceland	6	5	4	1
Ireland	1,900	1,900	1,700	943
Portugal	4,600	4,600	4,300	3,000
Spain	5,400	5,200	5,000	3,700
United Kingdom	14,100	13,900	13,200	9,300
Total	**29,600**	**29,100**	**27,500**	**19,400**

Notes: Numbers greater than one thousand are rounded to the nearest hundred; others are rounded to the nearest integer.

ENVIRONMENTAL AREAS AT RISK FROM SHIP EMISSIONS

VULNERABLE ECOSYSTEMS AND CRITICAL HABITATS

Shipborne NO_x and SO_x emissions contribute to ocean acidification, which adversely affects the development of crustaceans such as decapods, isopods, and krill, leading to decreased survival rates, impaired calcification and growth, and reduced abundance of marine organisms (Hassellöv et al., 2013; Kroeker et al., 2013). Additionally, ocean acidification is shown to impact the sensory abilities of fish larvae, causing decreased response to external cues, and reducing their ability to locate habitats and avoid predators (Munday et al., 2009). NO_x emissions from shipping also contribute to the atmospheric deposition of oxidized nitrogen into the ocean, leading to increased eutrophication (Neumann et al., 2020). Overall, combined with other environmental stressors, climate and health related air pollutants cause reduced taxonomical diversity in marine ecosystems (Doney et al., 2020).

Mitigating the sources and impacts of air pollution is essential for preserving the structural and ecological integrity of vulnerable ecosystems. Osipova et al. (2024) demonstrated that the designation of an AtlECA would significantly reduce levels of SO_x and NO_x emissions, thus diminishing their detrimental impacts on natural and cultural heritage, as well as vulnerable ecosystems and habitats critical for species conservation. This positive effect would be particularly strong in areas with exceptional protection status, as described below.

Particularly Sensitive Sea Areas

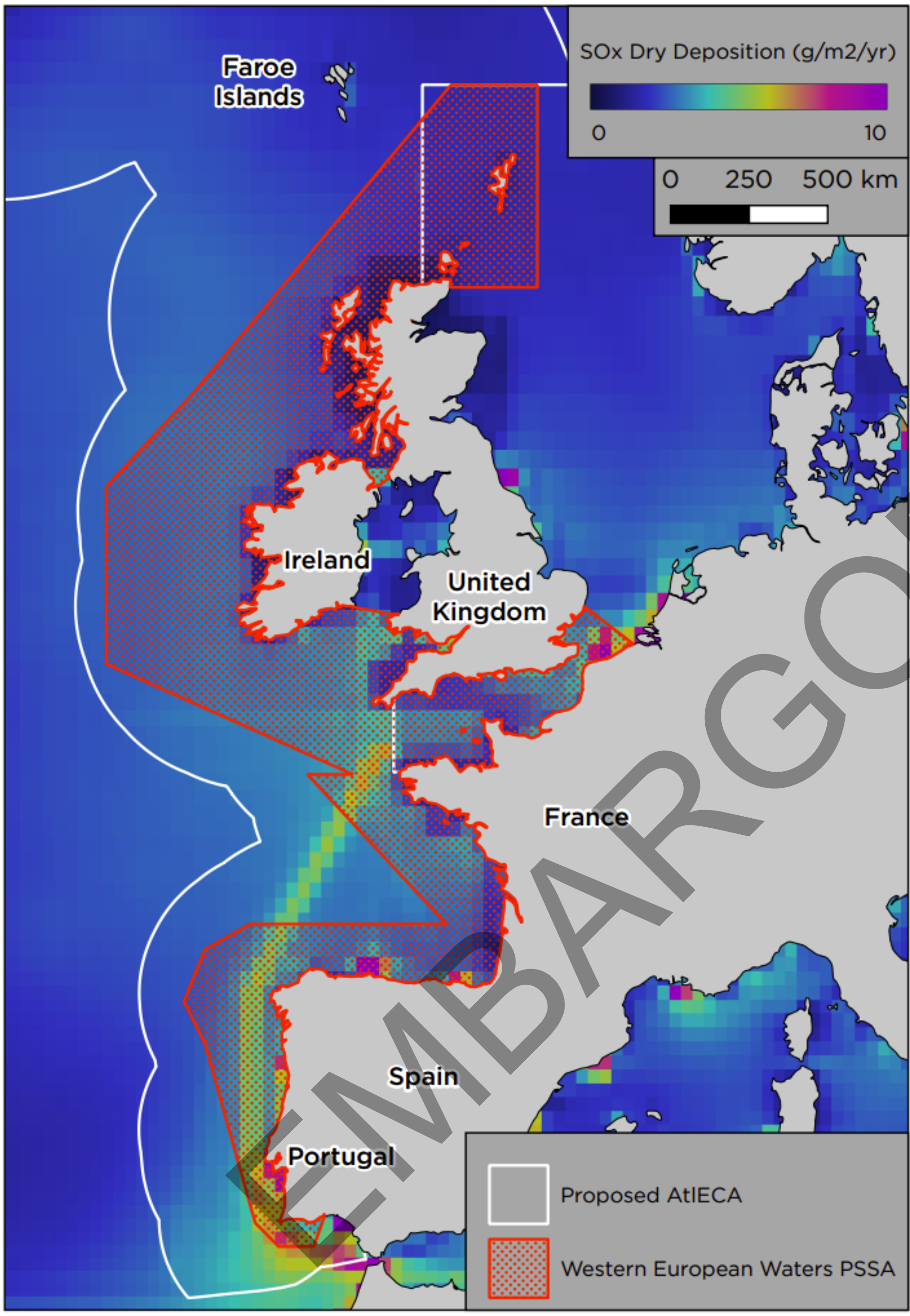
Particularly Sensitive Sea Areas (PSSAs) are regions that require special protection from international shipping activities due to their recognized ecological significance for or socioeconomic reasons. The IMO recognizes the rich marine biodiversity and ecological significance of specific marine regions and has adopted measures such as deep-sea routes, traffic separation schemes, vessel traffic services, areas to be avoided, and mandatory reporting schemes to protect these areas.

The proposed AtlECA overlaps with one of the largest PSSAs, the Western European Waters Particularly Sensitive Sea Area (Western European Waters PSSA), designated under MEPC.121(52) in 2004. The Western European Waters PSSA includes European waters near Belgium, France, Ireland, Portugal, Spain, and the United Kingdom (Figure 15). We estimated that 17% of the proposed AtlECA area falls into the PSSA.

Since the adoption of the Western European Waters PSSA, international shipping traffic has increased substantially. While existing measures aim to prevent oil spills by reducing the risk of accidents and subsequent environmental disasters, they do not address air pollution from shipping, which also threatens this sensitive region. Establishing the AtlECA could enhance protection by mitigating air pollution, thereby preserving this marine environment.

Figure 15

The Western European Waters Particularly Sensitive Sea Area overlaid on the proposed AtlECA, mapped over the predicted 2030 SO_2 shipping-related deposition



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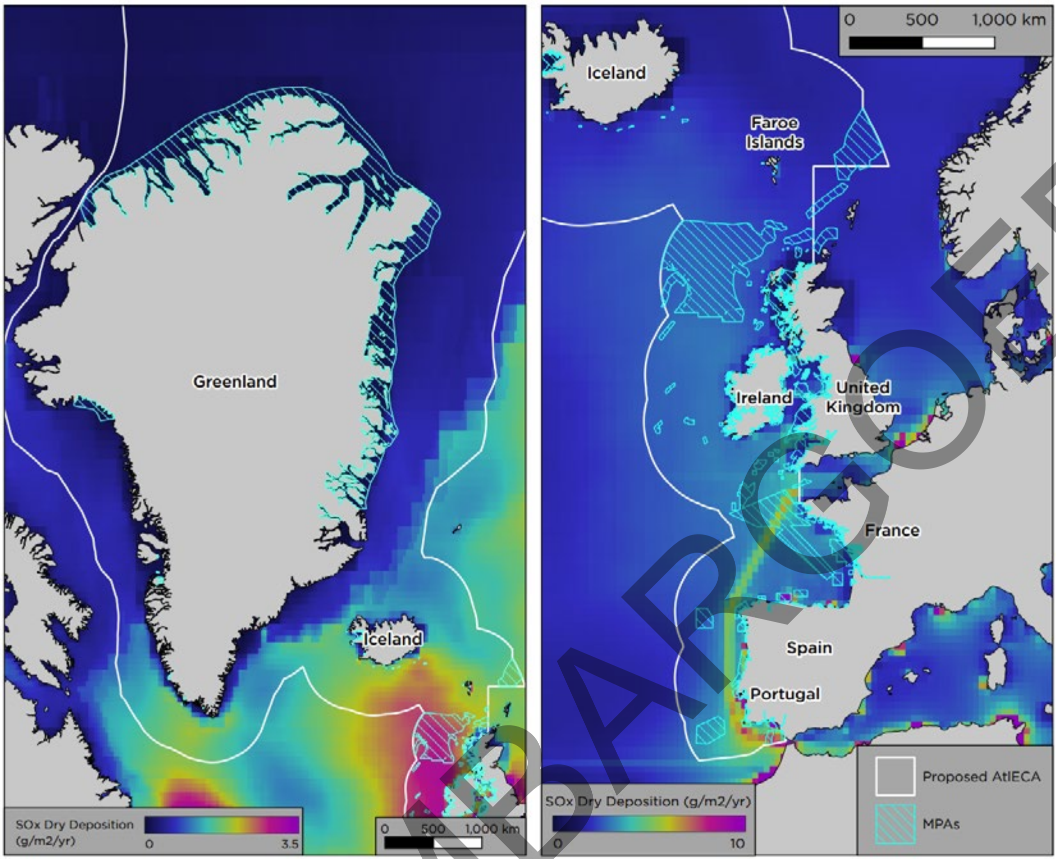
Marine Protected Areas

Marine Protected Areas (MPAs) are designated areas in marine environments where human activities are restricted to protect natural resources and biodiversity. The proposed AtlECA includes 1,693 MPAs, with 44% designated at a regional level, 51% at a national level, and about 5% at an international level. Of the 1,693 MPAs, 743 are in the United Kingdom, 252 in Spain, 250 in Ireland, 203 in France, 183 in Portugal, 48 in Iceland, and 14 in Greenland (UNEP-WCMC and IUCN, 2024) (Figure 16). These MPAs cover approximately 500,000 square kilometers, representing about 10% of the area of the proposed AtlECA. Additionally, the area is likely to expand, as the European Commission has pledged to increase MPA coverage in European waters from 12.1% in 2021 to 30% by 2030 (European Environment Agency, 2023). As part of the "Biodiversity Strategy for 2030," this initiative aims to reverse the degradation of ecosystems. The establishment of the AtlECA could help to achieve this goal (European Commission, 2020).

Figure 16

Marine Protected Areas identified in the proposed AtlECA, mapped over the predicted 2030 SO_2 shipping-related deposition



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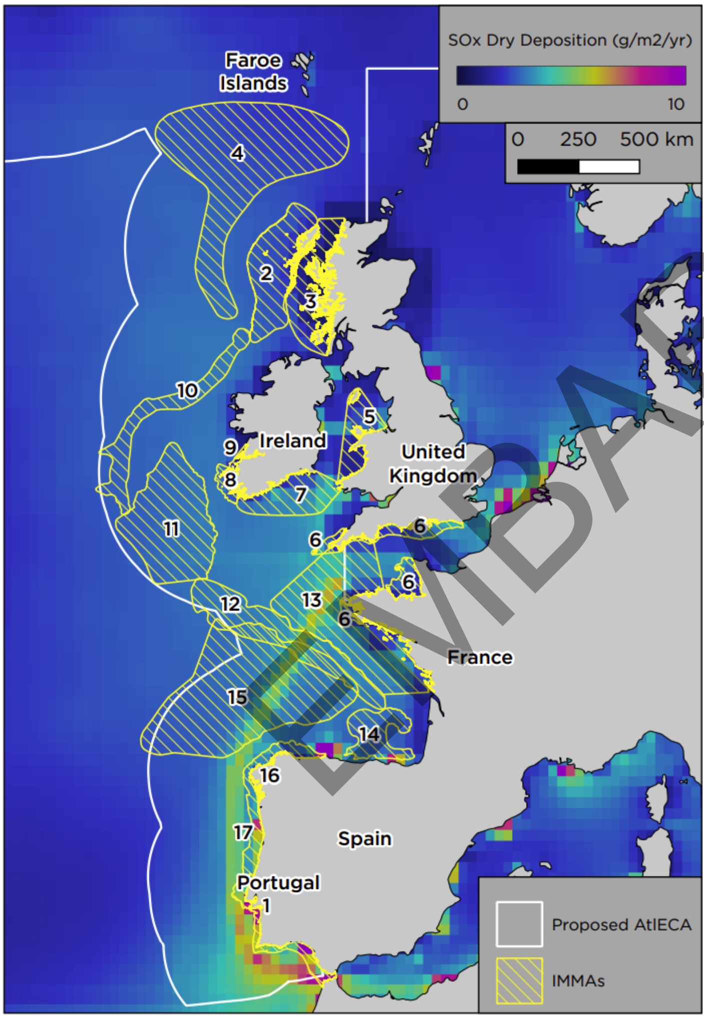
Important Marine Mammal Areas

Important Marine Mammal Areas (IMMAs) are discrete habitats important to marine mammal species, identified using criteria such as population vulnerability, distribution, abundance, reproductive areas, feeding areas, migration areas, distinctiveness, and diversity (IUCN-MMPATF, 2024).[5] IMMAs are established and agreed upon by the Marine Mammal Protected Areas Task Force, formed by the International Committee on Marine Mammal Protected Areas, the International Union for Conservation of Nature, and the Species Survival Commission.

The proposed AtlECA includes 17 IMMAs covering 800,000 square kilometers within the AtlECA region, 16% of the total proposed AtlECA area (Figure 17). Additionally, more candidate IMMAs were proposed during a regional workshop in 2024, therefore the list of IMMAs in the North Atlantic Ocean might be partly expanded to the seas around Iceland and Greenland (Marine Mammal Protected Area Task Force, 2024).

Figure 17

Important Marine Mammal Areas in the Northeast Atlantic Ocean overlaid on the proposed AtlECA, mapped over the predicted 2030 SO_2 shipping-related deposition



1. Sado Estuary IMMA
2. Monach Isles and Outer Hebrides Western Continental Shelf IMMA
3. Minches and the Sea of the Hebrides IMMA
4. Rockall Trough Seamounts and Banks IMMA
5. Central Irish Sea IMMA
6. Western English Channel IMMA
7. Celtic Sea IMMA
8. Dingle to Mizen Head IMMA
9. The Shannon (Sionna) Approaches IMMA
10. Southeastern Rockall Slope and Canyons IMMA
11. Porcupine Seabight and Bank IMMA
12. Biscay Shelf Edge and Slope IMMA
13. Northern Continental Shelf of the Bay of Biscay IMMA
14. Southern Biscay Canyon System IMMA
15. Biscay Abyssal Plain IMMA
16. Rias of Galicia IMMA
17. Atlantic Coast of the Iberian Peninsula IMMA

Note: The numbers on the map correspond to the number of the IMMAs in the AtlECA listed in Appendix C.

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5 Full criteria for the selection of IMMAs can be found on MMPATF's website: https://www.marinemammalhabitat.org/immas/imma-criteria/

The full list of all 17 IMMAs in the AtlECA, including the number and names of the key species, size, and jurisdiction, is presented in Appendix F. Among these 17 IMMAs, there are two areas of great significance for marine mammal habitats (#2 and #14 in Figure 17). These areas include the highest diversity of marine mammals, including vulnerable and endangered species. For instance, an endangered blue whale, with a total population of fewer than 1,000 mature adults in the North Atlantic, was observed in at least two IMMAs (#4 and #11 in Figure 17).

While the designation of an AtlECA in the North Atlantic Ocean could be highly beneficial to marine mammals due to the reduction of air pollution and the potential for residual fuel spills for ships that switch to distillate fuels, the continued use of scrubbers in the ECA presents a risk to marine life. Some components found in scrubber washwater, like heavy metals and polycyclic aromatic hydrocarbons, are not biodegradable and accumulate over time in the marine food web. High polycyclic aromatic hydrocarbons concentrations have been shown to correlate with the highest rates of cancer in beluga whales and orcas, while heavy metals negatively affect marine mammals' reproductive and immune systems (Georgeff, 2019; Georgeff et al., 2020).

Other sensitive and threatened ecosystems: Faroe Islands and Greenland

Greenland and the Faroe Islands, despite having the smallest number of MPAs among member states and no designated IMMAs, have ecologically sensitive ecosystems already impacted by human activities. The marine ecosystem around the Faroe Islands is one of the cleanest globally (Faroese Ministry of Foreign Affairs, Industry and Trade et al., 2018), making it highly vulnerable to environmental changes and pollution. Fishing activities pose the primary threat to this ecosystem, with mortality rates for some fish species exceeding sustainable levels (International Council for the Exploration of the Sea, 2024). Plankton production in this area is crucial for higher trophic levels, including marine species and seabirds (Gaard et al., 2002). The Faroe Islands are also vital breeding grounds for numerous seabirds, including vulnerable species such as the Horned Grebe (*Podiceps auratus*), and the Leach's Storm-petrel (*Hydrobates leucorhous*) (International Union for Conservation of Nature, 2024). According to the International Council for the Exploration of the Sea (2024), the seabird population in the Faroe Islands has decreased by more than 60% since the 1950s.

In Greenland, the ice sheet has been shown to exhibit increased melting due to anthropogenic air pollution (Vikrant et al., 2020). The rapid melting of glaciers has been a major contributor to global sea-level rise in recent decades (The IMBIE Team, 2020). Freshwater from melting ice alters the marine ecosystem by affecting water salinity and reducing ocean water mixing, which affects nutrient distribution and phytoplankton growth. Additionally, sediment from the ice sheet decreases water transparency, limiting light for photosynthesizing organisms. These disturbances are transforming Greenland's marine ecosystems, altering the distribution of marine species, and disrupting ecological balance (Intergovernmental Panel On Climate Change, 2019).

AREAS OF CULTURAL AND SCIENTIFIC SIGNIFICANCE

The North Atlantic region hosts numerous UNESCO World Cultural and Natural Heritage sites, recognized for their "outstanding universal value" and considered part of the common heritage of humankind (UNESCO World Heritage, n.d.). Of the 1,199 registered UNESCO World Heritage Sites listed in 2023, 148 (12.3%) are located within the proposed AltECA member states: 46 in Spain, 45 in France, 31 in the United Kingdom, 16 in Portugal, 3 in Greenland, 3 in Iceland, 2 in Ireland, 1 shared between Spain and Portugal, and 1 between Spain and France (UNESCO/WHC, 2023). The region also encompasses several scientifically important natural world heritage sites: the St. Kilda volcanic archipelago in Scotland is one of 43 dual (cultural and natural) world heritage sites, serving as a unique wildlife sanctuary for more than a million birds during their breeding season; the fast-moving glacier Ilulissat Icefjord in Greenland has helped scientists understand climate change and glaciology for the past 250 years; and the Surtsey Volcanic Island in Iceland, which formed after a series of volcanic eruptions between 1963 and 1967, is studied to learn how newly formed land becomes colonized by flora and fauna. These sites function as natural laboratories, providing unique opportunities for scientific research.

These sites may be at risk of degradation due to air pollution, including emissions from ships. The effects of air pollution on stone and buildings have long been studied, with SO_2 particularly linked to increased crust formation on stone structures, accelerating their rate of degradation (Graue et al., 2013; Reyes et al., 2011). Acid rain, resulting from pollutants such as SO_2 and NO_2, has also been extensively documented (Grennfelt et al., 2020). Acidification affects the chemical reactions on stone formations, generating defects and weakening structures, thereby posing a risk to UNESCO World Heritage Sites (Hou et al., 2023). Air pollution also has been shown to negatively affect natural heritage sites, such as the Ilulissat Icefjord (Vikrant et al., 2020). Similarly, anthropogenic air pollution could disrupt the pristine conditions at Surtsey Volcanic Island, potentially influencing the colonization processes of flora and fauna on this newly formed landmass. Therefore, imposing stricter regulations on shipping emissions within the AtlECA could help preserve UNESCO areas of cultural and scientific significance.

CONCLUSIONS

This study evaluated the environmental and health benefits of establishing a new emission control area in the North Atlantic to enforce stricter regulations on ship emissions of SO_X, NO_X, and PM under MARPOL Annex VI. We found that shipping substantially contributes to air pollution in the member states of the proposed AtlECA, which include the Faroe Islands, France, Greenland, Iceland, Ireland, Portugal, Spain, and the United Kingdom.

Among the 193 million people in the proposed AtlECA member states, young children and older adults, who are projected to make up 28% of the population by 2030, are particularly vulnerable to the adverse health effects of air pollution. Additionally, indigenous Greenlandic Inuit, who comprise about 90% of Greenland's population and reside in coastal areas, are especially vulnerable to air pollution due to limited access to healthcare infrastructure.

While all member states have implemented land-based air quality control measures that have improved air quality in most AtlECA regions, the contribution of shipping activity to air pollution remains mainly unaddressed. Our analysis shows that establishing the AtlECA in the proposed area has the potential to reduce shipping-attributable concentrations of SO_2 by 86%, $PM_{2.5}$ by 59%, and NO_2 by 3% in the AtlECA region, as well as approximately halve shipping-attributable population-weighted exposure to $PM_{2.5}$ in 2030 in the median member state.

Our analysis also shows that the establishment of the AtlECA could result in 118–176 premature deaths being avoided in 2030 alone in the plausible compliance scenarios (ULSFO Mix and MGO Mix, respectively), with potential approximate cumulative benefits of between 2,900 and 4,300 avoidable premature deaths from 2030–2050. Higher benefits are expected when MGO is used for ECA compliance, while lower benefits are expected when using ULSFO. Economically, the value of these health benefits is substantial. In two plausible compliance scenarios, the economic benefit based on the value of a statistical life is estimated to be between €0.82 and €1.23 billion in 2030 and approximately €19–€29 billion cumulatively from 2030–2050.

Establishing an AtlECA is also expected to result in positive environmental impacts. The proposed area includes more than 1,500 marine protected areas, accounting for 10% of the total area of the proposed AtlECA, and 17 important marine mammal habitats, which make up 16% of the area. Additionally, 17% of the AtlECA falls within the IMO-designated Western Particularly Sensitive Sea Area. The region also contains 148 UNESCO World Heritage sites, representing about 12% of the global total. Shipping emissions of SO_x and NO_x contribute to pollutants deposition and ocean acidification, harming marine biodiversity and UNESCO sites.

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APPENDIX A: EXISTING LAND-BASED MEASURES FOR THE CONTROL OF SO_X, NO_X, AND $PM_{2.5}$ EMISSIONS IN THE ATLECA MEMBER STATES

EUROPEAN UNION AND EUROPEAN ECONOMIC AREA: PORTUGAL, SPAIN, FRANCE, IRELAND, AND ICELAND

The European Union (EU) regulates air quality and emission limits from land-based sources through the Ambient Air Quality Directive (AAQD) (European Council, 2008) and by establishing member-state level reduction targets for air pollution via the National Emission Ceilings Directive (EU NECD) (European Council, 2016). Additionally, the EU has enacted several sector-specific emission standards, including the Industrial Emission Directive (European Council, 2010) and regulations for the transportation sector (European Council, 2022). National air pollution legislation in France, Ireland, Portugal, and Spain is harmonized with these EU legal provisions. Iceland, as a member of the European Economic Area, is also a signatory to the EU policymaking framework for main directives, ensuring alignment with its national regulations (European Free Trade Association, 2023; Iceland Environment Agency, 2020).

The Ambient Air Quality Directive

The AAQD sets the EU air quality standards for 12 air pollutants, including SO_2, NO_2, and $PM_{2.5}$ (European Council, 2008). The AAQD requires the EU and European Economic Area member states, to monitor, assess, and manage ambient air quality levels, ensuring that the pollutant concentration won't exceed the set threshold (European Council, 2008; European Free Trade Association, 2023). In 2023, the European Parliament adopted new amendments to the AAQD (European Parliament, 2023). The amendments set intermediatory 2030 targets and improved 2035 air quality standards to be more closely aligned with World Health Organization (WHO) guidelines (European Parliament, 2023; World Health Organization, 2021).

Based on the mean ambient air quality levels recorded in 2021, France, Iceland, Ireland, Portugal, and Spain did not exceed the AAQD air quality annual limits for SO_2, NO_2, and $PM_{2.5}$. However, except Iceland, Greenland, and Faroe Islands, none of the member states met the WHO air quality thresholds.

Table A1

EU Ambient Air Quality Directive and World Health Organization's air quality thresholds for SO_2, NO_2 and $PM_{2.5}$

Pollutant	Period	Concentration thresholds	
		European Union	World Health Organization
SO_2	1 hour	By 2030 – 350 µg/m³ By 2035 – 200 µg/m³	500 µg/m³ (10 min.)
	24 hours	By 2030 – 50 µg/m³ By 2035 – 40 µg/m³	40 µg/m³
	Annual	By 2030 – 20 µg/m³ By 2035 – 20 µg/m³	–
NO_2	1 hour	By 2030 – 200 µg/m³ By 2035 – 200 µg/m³	200 µg/m³
	24 hours	By 2030 – 50 µg/m³ By 2035 – 25 µg/m³	25 µg/m³
	Annual	By 2030 – 20 µg/m³ By 2035 – 10 µg/m³	10 µg/m³
$PM_{2.5}$	24 hours	By 2030 – 25 µg/m³ By 2035 – 15 µg/m³	15 µg/m³
	Annual	By 2030 – 10 µg/m³ By 2035 – 5 µg/m³	5 µg/m³

National Emission Ceilings Directive

The EU National Emission Ceilings Directive (NECD) sets 2020–2029 Member State emission levels and beyond-2030 reduction targets for five air pollutants, including SO_2, NO_x, and $PM_{2.5}$ (European Council, 2016). Under the EU NECD, each EU Member State must monitor and report their emissions levels compliance. The directive requires each Member State to adopt and implement the National Air Pollution Control Program, including policies and measures for meeting individual emission reduction commitments. France, Ireland, Portugal, and Spain currently comply with their set 2020–2029 reduction targets for SO_2, NO_x, and $PM_{2.5}$, while for targets beyond-2030, NO_x and $PM_{2.5}$ emissions are projected to exceed the post-2030 targets.

Iceland, being an European Economic Area member, implemented the initial emission reduction directive (2001/81/EC) in 2009. However, the revised EU NECD (2016/2284) is yet to be implemented within the European Economic Area agreement, after new national targets revisions (Iceland Environment Agency, 2023).

Table A2

2021 reduction levels compared with the 2005 baseline year for SO_2, NO_x, and $PM_{2.5}$ emissions for France, Ireland, Portugal, and Spain

	Reduction levels	France	Ireland	Portugal	Spain
SO_2 reduction compared with 2005	Target 2020–2029	55%	65%	63%	67%
	Target beyond 2030	77%	85%	83%	88%
	Actual levels 2021	**81%**	**84%**	**84%**	**90%**
NO_x reduction compared with 2005	Target 2020–2029	50%	49%	36%	41%
	Target beyond 2030	69%	69%	63%	62%
	Actual levels 2021	**62%**	**65%**	**56%**	**59%**
$PM_{2.5}$ reduction compared with 2005	Target 2020–2029	27%	18%	15%	15%
	Target beyond 2030	57%	41%	53%	50%
	Actual levels 2021	**44%**	**34%**	**21%**	**19%**

Note: Green shading indicates that the targets were met in 2021, while red shading indicates the limits were exceeded.

Key sector-specific EU emission standards

The Industrial Emissions Directive (IED – 2010/75/EU) recognizes large combustion plants as the single largest source of air pollution in the EU and imposes strict emission limits for SO_2, NO_x, and dust emissions (European Council, 2010). In 2015, the EU IED for large combustion plants was complemented by Directive (2015/2193/EU) covering emissions also from medium combustion plants (European Council, 2015).

In addition to the industrial sector, the road transport segment has also been recognized as a major contributor to air pollution in the EU (European Commission, 2022). The Euro 7 emission regulations (2022/3065/EU) adopted in 2024 set the specific emission limits for NO_x and PM emissions for road vehicles in the EU and the European Economic Area (European Parliament, 2024). The Euro 7 regulations will come into effect for new light-duty vehicles on July 1, 2025, and for new heavy-duty vehicles on July 1, 2027.

UNITED KINGDOM

The United Kingdom (UK) has a national legislative framework generally aligned with EU air pollution regulations. The UK Air Quality Standards Regulations (UK AQSR) set the allowed emissions thresholds for SO_2, NO_2, and $PM_{2.5}$, and it is fully harmonized with the EU AAQD (2008/50/EC) (UK Government, 2010; United Kingdom Department of Environment, Food & Rural Affairs, 2023). However, the UK AQSR did not adopt the EU AAQD amendments passed by the EU Parliament (2023). Therefore, the UK meets the SO_2, NO_2, and $PM_{2.5}$ UK AQSR emissions thresholds, but it does not meet the updated EU AAQD threshold for NO_2 emissions.

Similarly, the UK's National Emissions Ceilings Regulations (UK NECR) were adopted from the EU NECD in 2018, setting local goals for SO_2, NO_x, and $PM_{2.5}$ emissions reduction (UK Government, 2018). Additionally, the UK applies the EU laws of the Industrial Emissions Directive (2010/75/EU) and the Medium Combustion Plants Directive (2015/2193/EU) (UK Government, 2022). For the road transport sector, all vehicles registered in the United Kingdom must meet the EU standards (United Kingdom Department of Environment, Food & Rural Affairs, 2021).

Table A3
UK Air Quality Standard Regulations and World Health Organization air quality thresholds for SO_2, NO_2, and $PM_{2.5}$

Pollutant	Period	Concentration threshold	
		United Kingdom	World Health Organization
SO_2	1 hour	350 µg/m³	500 µg/m³ (10 min.)
	24 hours	125 µg/m³	40 µg/m³
	Annual	20 µg/m³	–
NO_2	1 hour	200 µg/m³	200 µg/m3
	Annual	40 µg/m³	10 µg/m3
$PM_{2.5}$	Annual	20 µg/m³	5 µg/m³

The UK successfully met its 2020–2029 reduction targets for SO_2 and NO_x but not the $PM_{2.5}$ reduction commitment. Moreover, between 1990–2021, SO_2 and NO_x emissions in the transport and non-transport sectors significantly declined in the UK. However, $PM_{2.5}$ emissions have plateaued since the mid-2000s; further policy improvements would help the UK meet the beyond-2030 thresholds for this pollutant (Ingledew et al., 2023).

Table A4

The 2021 reduction levels compared with the 2005 baseline year for SO_2, NO_x, and $PM_{2.5}$ emissions for the United Kingdom and NECD 2020–2029 and beyond-2030 targets

Scenario	Reduction levels	United Kingdom
SO_2 reduction compared with 2005	Target 2020–2029	59%
	Target beyond 2030	88%
	Actual levels 2021	**84%**
NO_x reduction compared with 2005	Target 2020–2029	55%
	Target beyond 2030	73%
	Actual levels 2021	**62%**
$PM_{2.5}$ reduction compared with 2005	Target 2020–2029	30%
	Target beyond 2030	46%
	Actual levels 2021	**28%**

Note: Green shading indicates that the targets were met in 2021, while red shading indicates that the limits were exceeded.

GREENLAND

Greenland is a self-governing autonomous territory and does not have obligations to comply with EU directives. Instead, it implements an independent regional environmental legislation policy (Danish Parliament, 2021; The Prime Minister's Office, 2024). Currently, land-based air pollution control in Greenland is regulated by the Environmental Protection Act, which addresses pollution from main industrial activities (Greenland Government, 2011), and the Mineral Resource Act, which sets air emission limits for the exploration and exploitation of mineral resources (International Energy Agency, 2023).

The Environmental Protection Act does not set any nationwide emissions limits; instead, it authorizes local governments to limit sector-specific pollution through specific air quality guidelines. In contrast, the Mineral Resource Act grants mineral exploitation licenses that require Environmental Impact Assessments, which set emissions threshold values based on its own air quality criteria for mining in Greenland (Greenland Government, 2009; International Energy Agency, 2023).

The 2021 data show that Greenland's annual mean ambient air concentrations are significantly lower than those for the EU and European Economic Area member states. Additionally, SO_2 emissions in Greenland have been decreasing over time, but at a slower and less steep rate than the emissions in other AtlECA member states, while NO_x emissions have increased.

Table A5

Greenland's SO_2, NO_2 and $PM_{2.5}$ criteria for the mining sector compared with EU AAQD 2030 and WHO air quality thresholds

Pollutant	Period	Concentration threshold		
		Greenland (mining)	EU AAQD 2030	WHO
SO_2	24 hours	125 µg/m³	50 µg/m³	40 µg/m³
NO_2	24 hours	100 µg/m³	50 µg/m³	25 µg/m³
$PM_{2.5}$	24 hours	30 µg/m³	25 µg/m³	15 µg/m³

THE FAROE ISLANDS

Like Greenland, the Faroe Islands do not apply EU directives, but instead enforce regional environmental legislation (Danish Parliament, 2021; Government of The Faroe Islands, 2024). The Faroe Islands Environmental Protection Act was legislated in 1988 and last amended in 2021. It requires an environmental impact assessment plan for heavily polluting industries, including an air pollution assessment (Government of The Faroe Islands, 2021). The sectors covered include mining, metal production (iron and steel) manufacturing, energy and power plants, chemical and fertilizer plants, waste incineration, agriculture, and transportation. Like Greenland's Environmental Protection Act, the Environmental Protection Act of the Faroe Islands does not establish specific nationwide limits but allows the Ministry of Environment to set sector-specific regulations for limiting and preventing air pollution. The Act emphasizes the importance of utilizing best practices for pollution prevention. Also, like Greenland, the Faroe Islands have annual mean air concentrations significantly below the EU and WHO-allowed emissions thresholds.

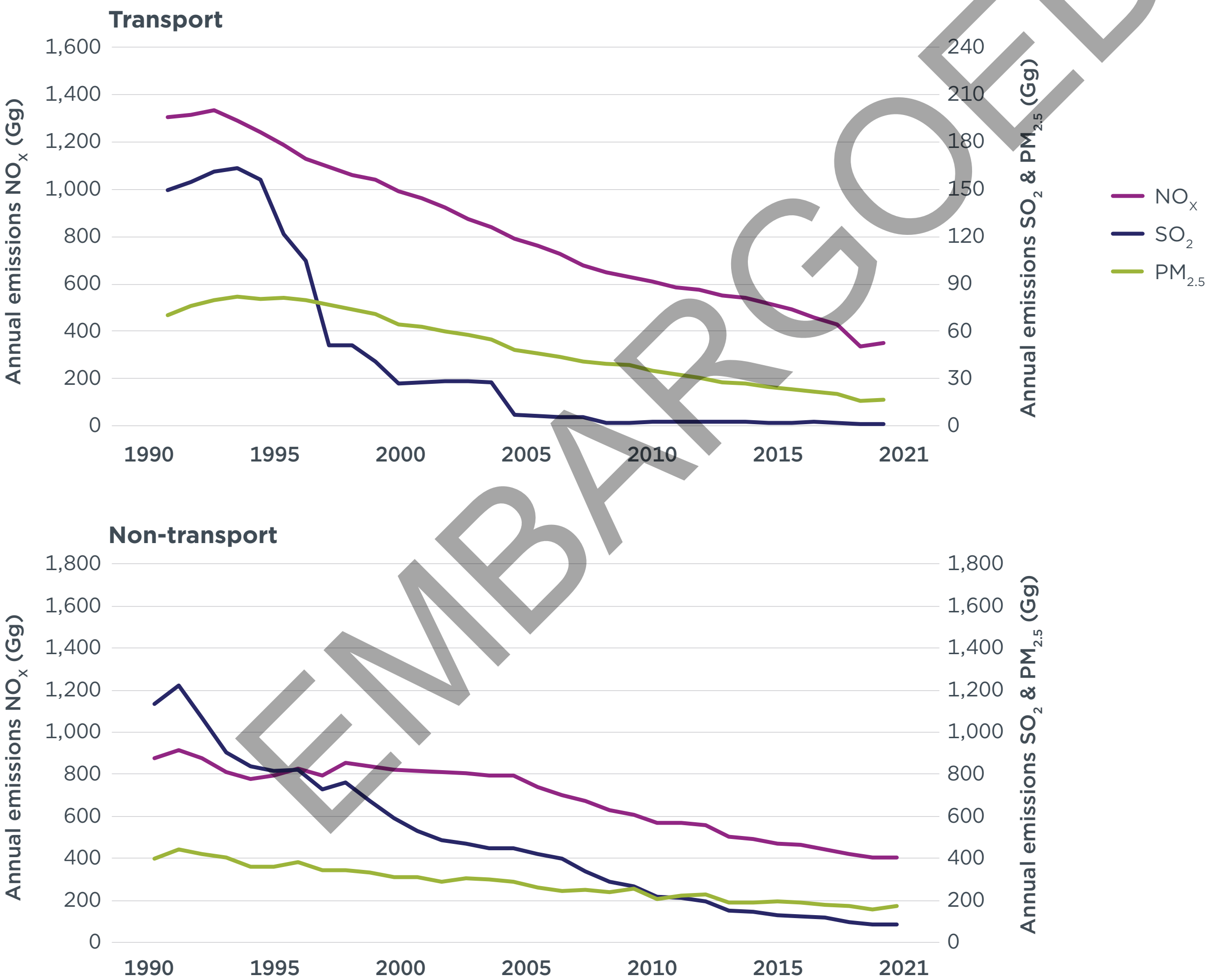
APPENDIX B: LAND-BASED ANNUAL EMISSIONS TRENDS (TRANSPORT AND NON-TRANSPORT) FOR ATLECA MEMBER STATES[6]

FRANCE

France experienced a 92% drop in non-transport-related SO_2 emissions between 1990 and 2021, attributed to a reduction in the sulfur content of fossil fuels and a shift towards renewable sources in major industrial sectors. The improved performance of residential heating appliances also contributed to a 45% reduction in $PM_{2.5}$ emissions between 2000 and 2021 (European Environment Agency, 2023c, 2023d). Between 1990 and 2021, transport-based NO_x emissions decreased by 73% due to Euro standards, which led to the gradual introduction of catalytic purification devices on road vehicles (European Environment Agency, 2023c, 2023d).

Figure B1

Transport and non-transport NO_x, SO_2, and $PM_{2.5}$ emissions in France



Source: European Environment Agency (2023a).

6 The Faroe Islands are not included in the emissions inventory due to the unavailability of relevant data.

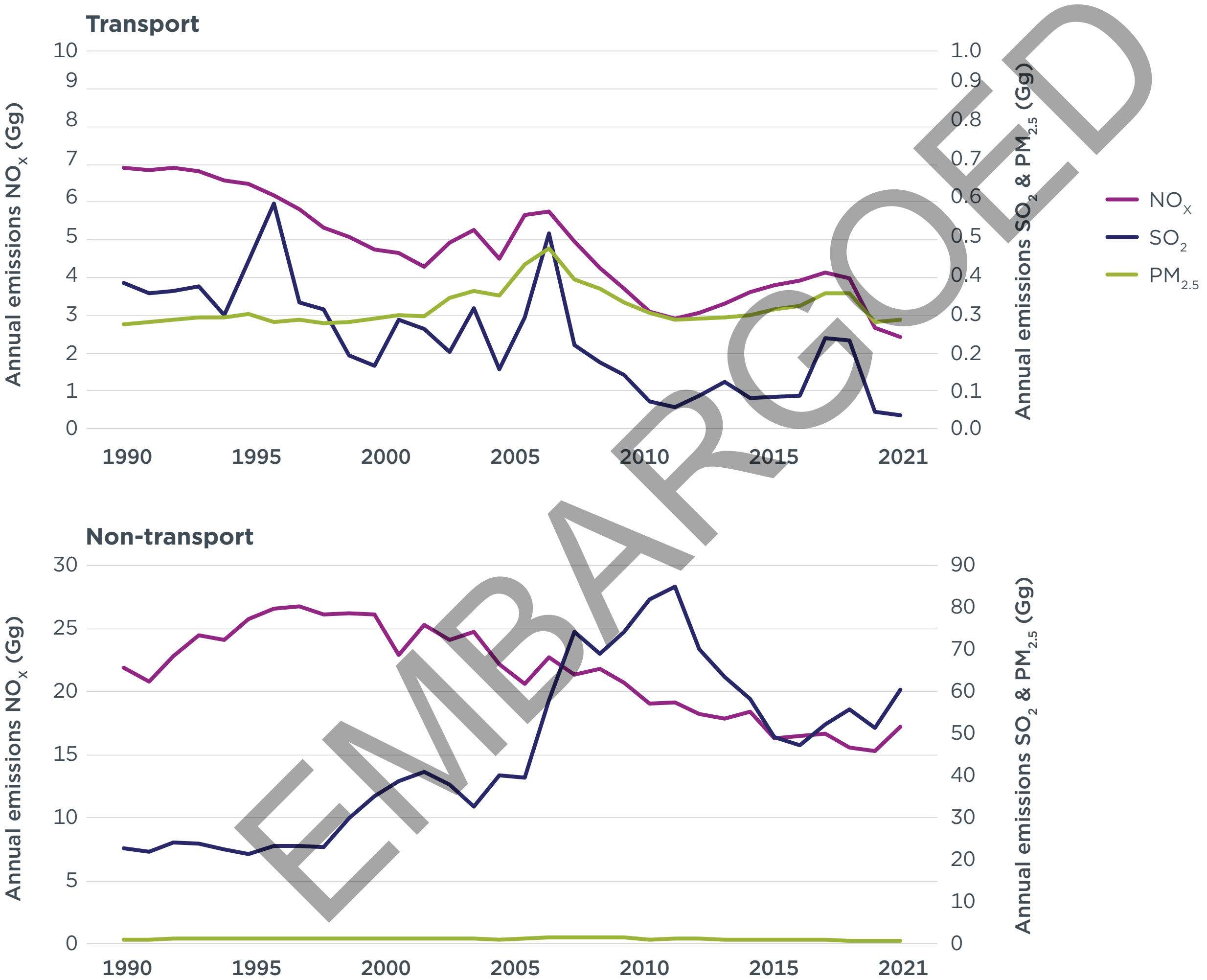
ICELAND

In Iceland, non-transport-related SO_2 emissions increased by 165% from 1990–2021, primarily due to expanded electricity generation from geothermal power plants and the growth of aluminum production facilities. $PM_{2.5}$ emissions fell by 40% from 2000–2021, largely due to decreased road construction activities, the elimination of open waste burning, and the reduction of emissions from heat plants (European Environment Agency, 2023c; Iceland Environment Agency, 2023).

Transport-based NO_X emissions decreased by 32% between 1990 and 2021, mostly attributed to the implementation of Euro standards in the road transport sector (European Environment Agency, 2023c; Iceland Environment Agency, 2023).

Figure B2

Transport and non-transport NO_x, SO_2, and $PM_{2.5}$ emissions in Iceland



Source: European Environment Agency (2023a).

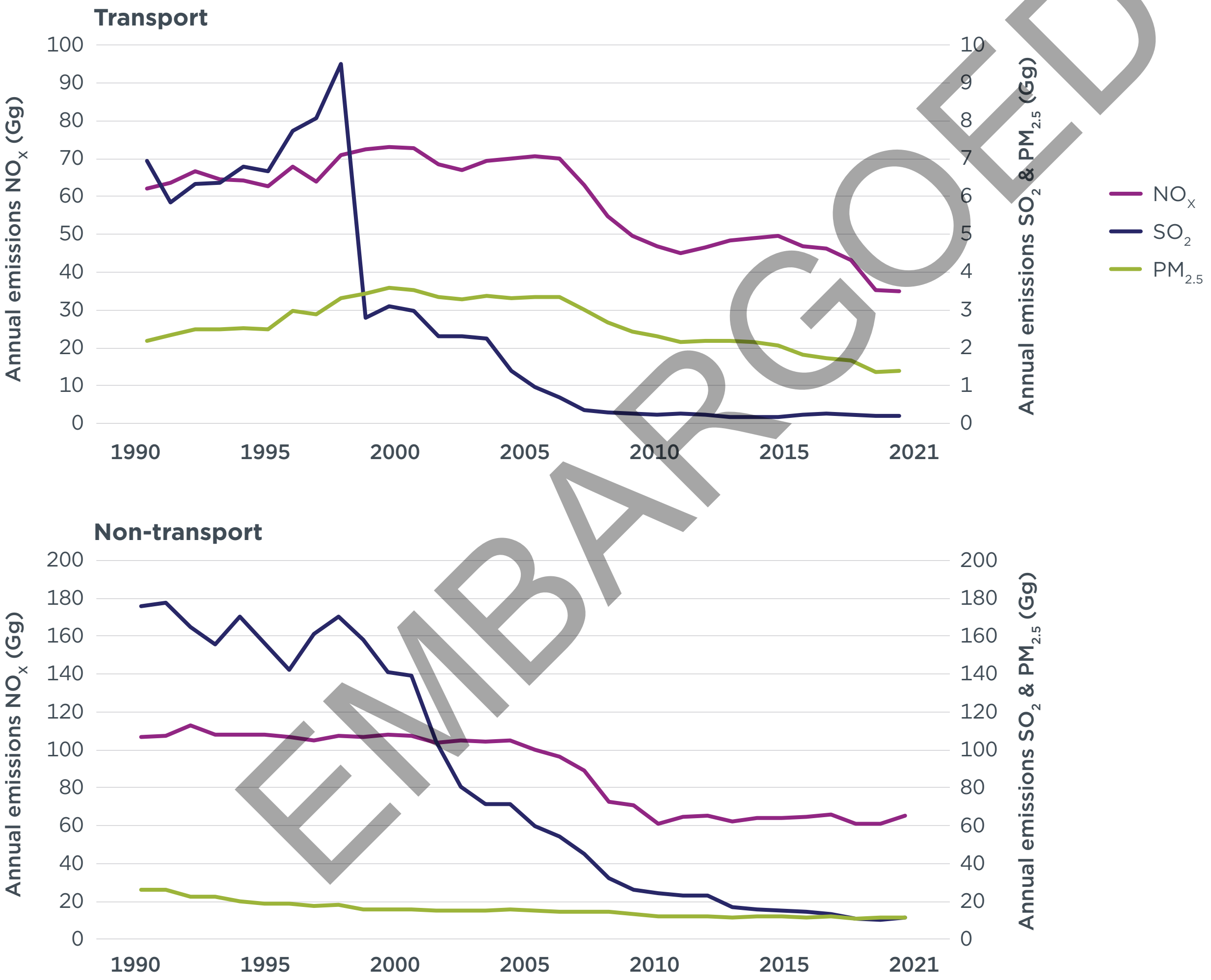
IRELAND

In Ireland, non-transport-related SO_2 emissions declined by 93% between 1990 and 2021 due to reduced consumption of coal, oil, and peat for electricity and heat production. Additionally, the switch from coal and peat to natural gas in the residential and commercial sectors played a major role in the reduction of $PM_{2.5}$ emissions, which decreased by 28% between 2000 and 2021 (European Environment Agency, 2023c; U.S. Environmental Protection Agency, 2023).

Transport-based NO_X emission trends in Ireland are relatively like those in Portugal, where the impact of implementing Euro standards became noticeable only in the mid-2000s. Overall, NO_X emissions dropped by 44% in 2021 compared with 1990 (Eurpean Environment Agency, 2023a; U.S. Environmental Protection Agency, 2023).

Figure B3

Transport and non-transport NO_X, SO_2, and $PM_{2.5}$ emissions in Ireland



Source: European Environment Agency (2023a).

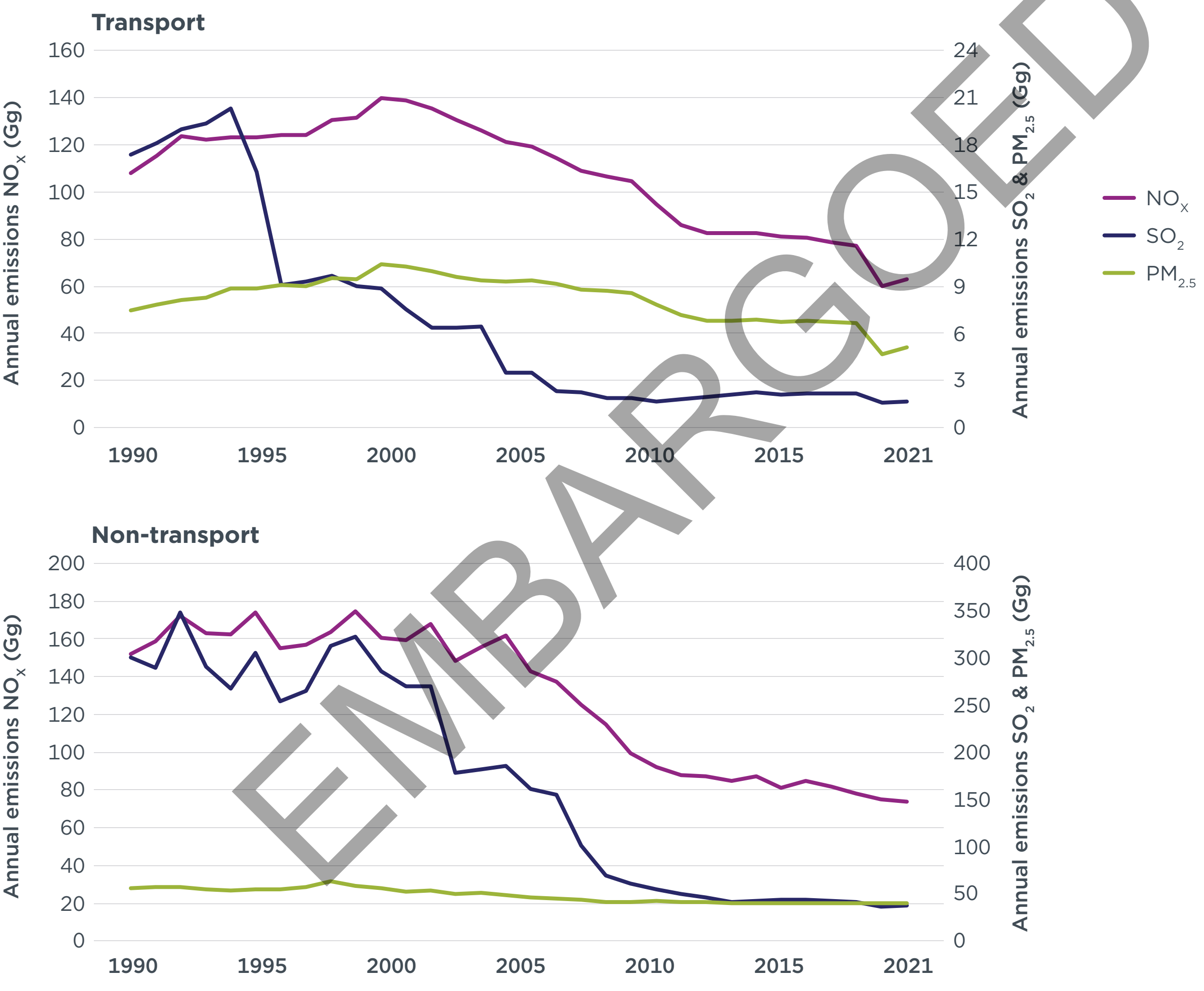
PORTUGAL

In Portugal, non-transport-related SO_X emissions decreased by 88% between 1990 and 2021, mainly due to the shift in grid energy mix from coal and oil towards gas and renewable sources (Pereira et al., 2023). NO_X emissions also reduced, while $PM_{2.5}$ emission levels remained mostly steady.

The reduction of NO_X and $PM_{2.5}$ emissions from road transportation in Portugal became apparent only after 2005 due to more stringent Euro standards, which had earlier been offset by vehicle fleet growth (Pereira et al., 2023). By 2021, transport-based NO_X emissions were reduced by 42% compared with 1990 levels, while $PM_{2.5}$ emissions in 2021 were reduced by 51% compared with the year 2000, which is the base year for PM measurements (European Environment Agency, 2023c).

Figure B4

Transport and non-transport NO_X, SO_2, and $PM_{2.5}$ emissions in Portugal



Source: European Environment Agency (2023a).

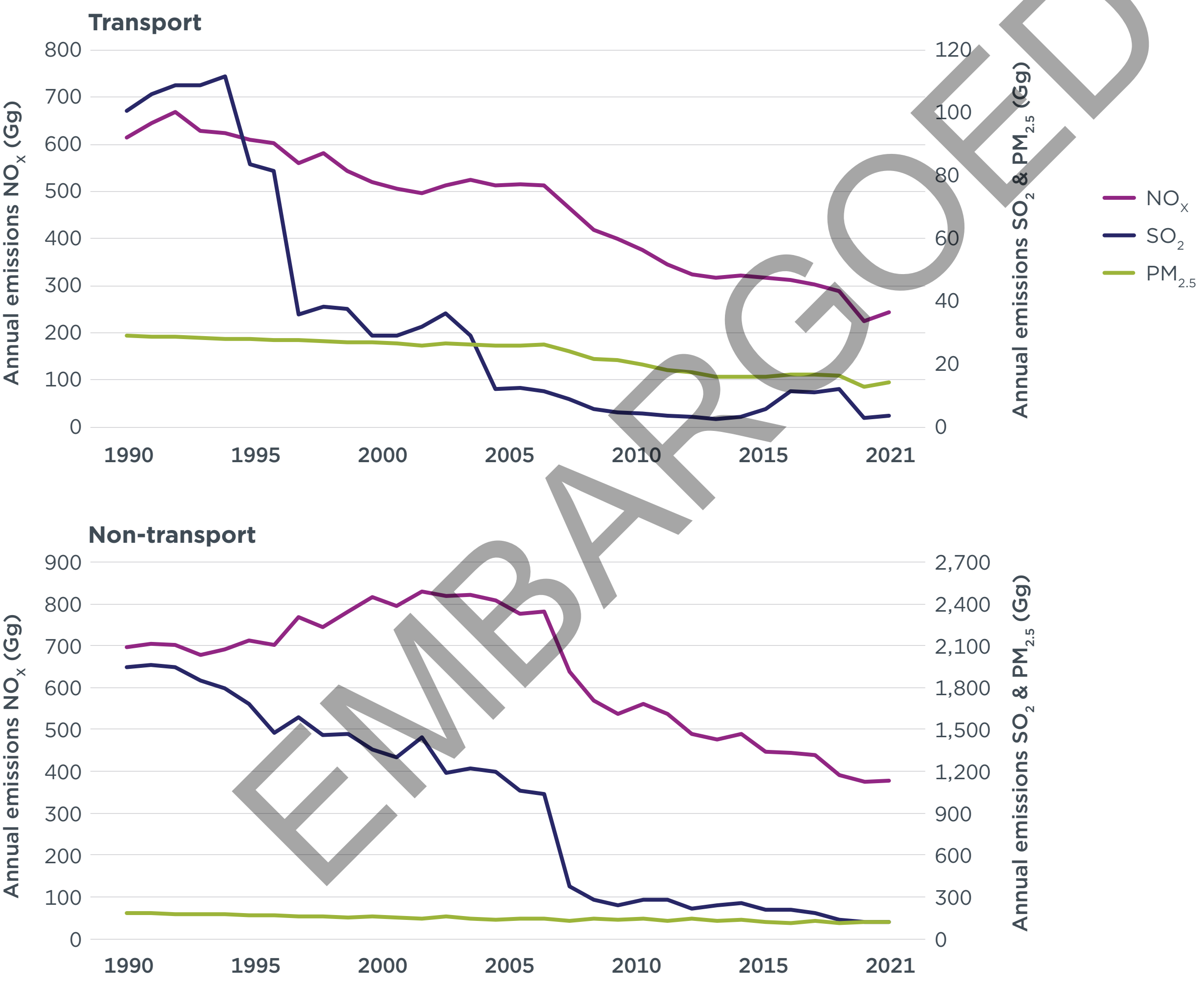
SPAIN

In Spain, non-transport-related SO_2 emissions were reduced by 94% between 1990 and 2021, driven by the progressive introduction of desulfurization techniques in thermal plants and the shift from coal-powered stations towards gas-fired plants. Abandonment of coal as fuel in the residential (stationary) combustion sector also helped reduce $PM_{2.5}$ emissions by 24% between 2000–2021 (European Environment Agency, 2023c; Ministerio para la Transición Ecológica y el Reto Demográfico, 2023).

The rollout of Euro standards for passenger cars, heavy-duty trucks, and buses reduced transport-based NO_x emissions by 60% between 1990–2021 (European Environment Agency, 2023c; Ministerio para la Transición Ecológica y el Reto Demográfico, 2023).

Figure B5

Transport and non-transport NO_x, SO_2, and $PM_{2.5}$ emissions in Spain



Source: European Environment Agency (2023a).

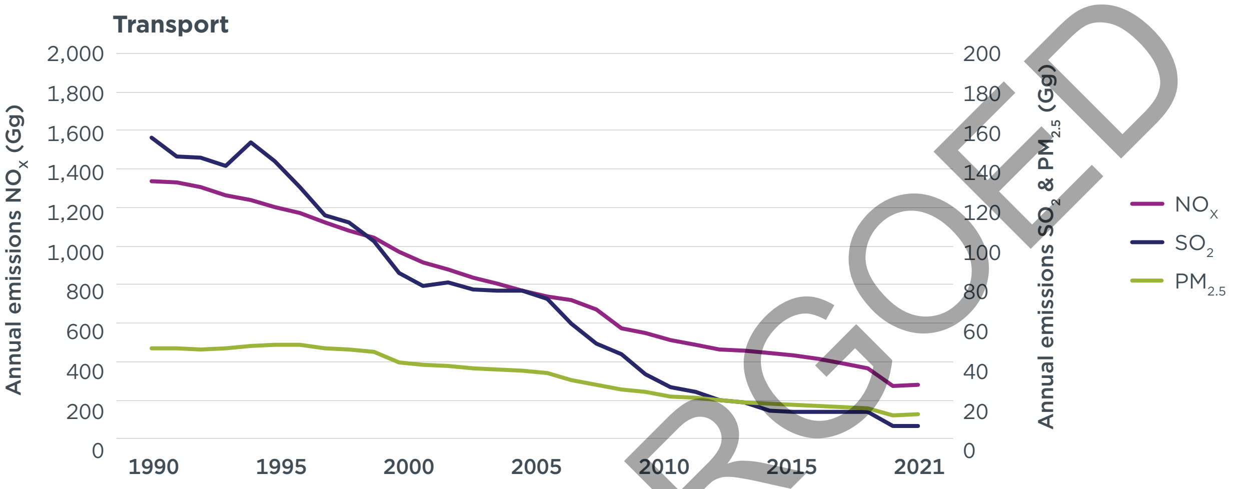
UNITED KINGDOM

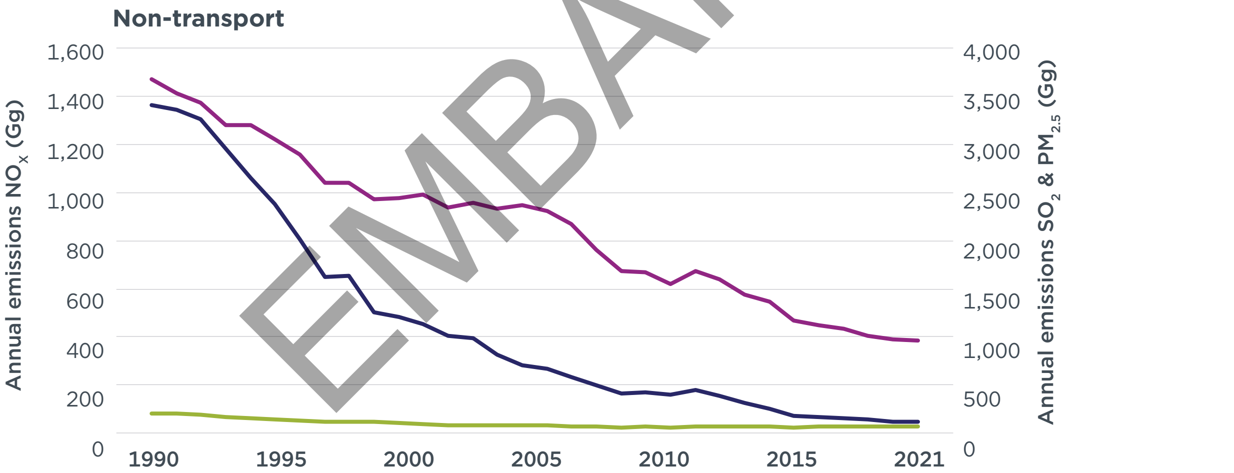
In the United Kingdom, non-transport-related SO_2 emissions declined by 96% between 1990 and 2021, as natural gas replaced coal in the country's grid and residential heating, with high-emitting sectors such as steelmaking and metal production relocating outside the country in the 1990s and early 2000s. Additionally, $PM_{2.5}$ emissions declined by 31% between 2000 and 2021, mainly driven by reduced use of coal for residential combustion (Ingledew et al., 2023; UK Government, 2024).

Transport-based NO_X emissions in the United Kingdom decreased by 79% between 1990 and 2021, largely due to the use of catalytic converters as part of the Euro standards (Ingledew et al., 2023; UK Government, 2024).

Figure B6

Transport and non-transport NO_X, SO_2, and $PM_{2.5}$ emissions in the United Kingdom





Source: UK Government (2024).

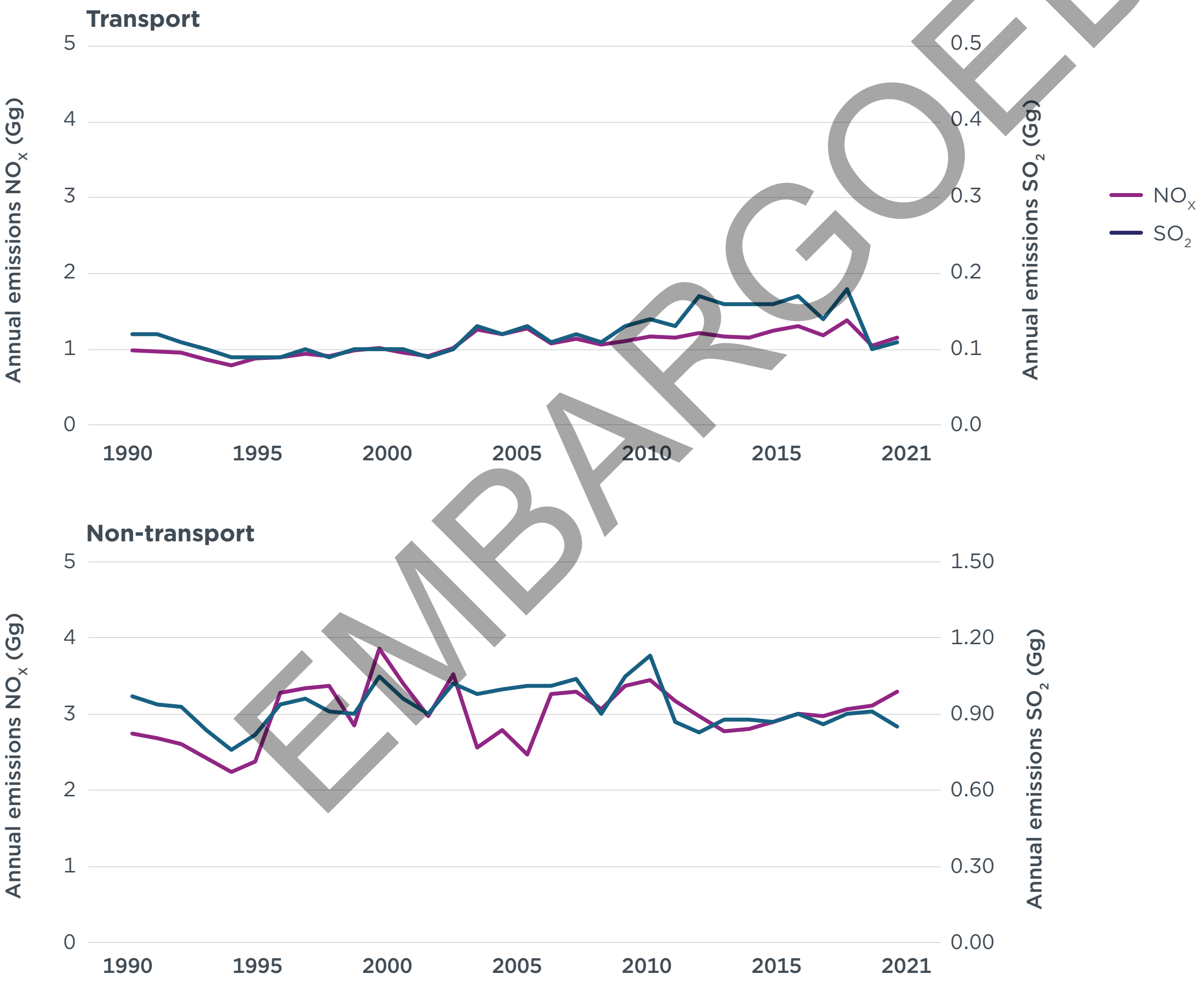
GREENLAND

In Greenland, non-transport-related SO_2 emissions increased by 16% between 1990 and 2011, reaching their peak in 2011. Since then, SO_2 emissions have been in steady decline, resulting in an overall reduction of 12% between 1990 and 2021. This improvement can largely be attributed to the increased use of hydropower for electricity production post-2010 and a decline in emissions from residential heating (European Environment Information and Observation Network, 2023; Statista, 2024).

Non-transport-related NO_x emission levels peaked in 2000 but have decreased by 14% by 2021. However, overall levels remain 20% higher in 2021 compared with 1990. Agriculture and forestry are the largest land-based sources of NO_x emissions in Greenland, with emissions increasing by 34% between 1990 and 2021, while transport-based NO_x emissions increased by 14% (European Environment Information and Observation Network, 2023).

Figure B7

Transport and non-transport NO_x and SO_2 emissions in Greenland



Source: European Environment Information and Observation Network (2023).

APPENDIX C: METHODOLOGY USED FOR ESTIMATING AVOIDABLE MORTALITY

The Fast Assessment of Transportation Emissions model (FATE) (International Council on Clean Transportation, 2023) evaluates the air quality and health impacts associated with present or future changes in air pollutant emissions from nine sectors and three transportation subsectors, including shipping sector. The tool estimates the national population-weighted ambient $PM_{2.5}$ exposure (annual average in µg/m³) for 181 countries, and ozone (O_3) exposure (6-month average of the 1hr or 8h daily maximum O_3 in ppb) for 19 individual G20 countries and 24 additional EU member countries.

The health burden in FATE is quantified by assessing a gridded population's exposure to $PM_{2.5}$ (both from primary and secondary formation) and ozone. The model also calculates the number of premature deaths and years of life lost associated with exposure to these two pollutants. Supplementary outputs of the tool include national baseline exposures to ambient $PM_{2.5}$ and O_3 and detailed health impacts by ambient pollutant, disease, and age group. Additionally, FATE assess the economic impacts of the premature mortality caused by those pollutants using the Value of a Statistical Life (VSL) approach.

The health impacts associated with exposure to the air pollutants in the AtlECA are calculated using methods consistent with the Global Burden of Disease (2019) (Murray et al., 2020). To estimate health impacts in future years, the tool considers projected changes in population, age distributions, and baseline disease rates. The diseases assessed by the model are stroke, ischemic heart disease (IHD), chronic obstructive pulmonary disease (COPD), lower respiratory infection (LRI), lung cancer, and diabetes mellitus type 2. For ozone, only cases of COPD are considered, following the Global Burden of Disease methods (Murray et al., 2020).

To estimate changes in exposure under the different shipping emissions scenarios, we used EMEP air quality impact models as input for the FATE model. Overall, we assessed five scenarios, following the Osipova et al. (2024) methodology: one assuming no ECA implementation by 2030 (BAU 2030), and four different compliance scenarios assuming that AtlECA has been designated: MGO Max, MGO Mix, USLFO Mix, and Scrubber Max.

For $PM_{2.5}$ we modeled the health outcomes of ischemic heart disease, stroke, chronic obstructive pulmonary disease (COPD), lower respiratory illness, type-2 diabetes, and lung cancer. The population-attributable fraction ($PAF_{a,h,l}$) for $PM_{2.5}$ has been estimated uses relative risk look-up tables based on the Global Burden of Disease (2019) and gridded $PM_{2.5}$ concentrations to relative risk values ($RR_{a,h,l}$) for each age group (*a*), mortality cause (*h*), and grid cell (*l*); the population-attributable fraction ($PAF_{a,h,l}$):

$$PAF_{a,h,l} = \frac{RR_{a,h,l} - 1}{RR_{a,h,l}}$$

Then, ($PAF_{a,h,l}$) values are used to estimate premature deaths (y_l):

$$y_l = m_{a,h,c} \times pop_{a,l} \times PAF_{a,h,l}$$

where:

y_l number of premature deaths;

$m_{a,h,c}$ country-specific (*c*) baseline mortality rates for each age group (*a*), mortality cause (*h*);

$pop_{a,l}$ age-stratified population size.

Baseline mortality rates and gridded population data for 2020 at 0.01° x 0.01° resolution were used from the GBD 2019 and WorldPop (Tatem, 2017). Age stratification was applied from GPWv4 data at the 0.25° x 0.25° resolution for ages 25 and older (Center for International Earth Science Information Network, n.d.).

The calculations of years of life lost from premature deaths we applied the following formula:

$$YLL = y_l \times \frac{(YLL_0)_{a,h,c}}{m_{a,h,c}}$$

where:

YLL	years of life lost;
y_l	the incidence of the death within a population;
$(YLL_0)_{a,h,c}$	baseline YLL (GBD 2019);
$m_{a,h,c}$	baseline disease rates

For calculating the PAF associated with COPD from ozone exposure, we applied a log-linear model, independent of age, following Jerrett et al. (2009) methodology:

$$RR_l = e^{\left(\beta(x_l - x_{cf})\right)}$$

where:

β	the concentration-response factor derived from a 1.06 increase in relative risk per 10 ppb taken from the GBD 2019;
x_l	the ozone concentration per a grid cell;
x_{cf}	the counterfactual concentration (32.4 ppbv; GBD 2019).

APPENDIX D: METHODOLOGY USED FOR ESTIMATING ECONOMIC BENEFITS OF AVOIDABLE MORTALITY

The concept of the Value of Statistical Life (VSL) is a decisive metric employed in economic evaluations to quantify the benefits of reducing mortality risks. VSL represents the monetary value individuals are willing to pay for marginal reductions in their risk of death, typically measured per statistical life saved. This metric is derived from studies that assess willingness to pay for small risk reductions, either through surveys (stated preference) or observed behavior in labor markets (revealed preference).

By applying the VSL in cost-benefit analyses, policymakers can estimate the total economic value of interventions that reduce mortality risks from air pollution (Lanzi et al., 2016). For instance, the reduction in deaths due to improved air quality can be multiplied by the VSL to assess whether the benefits of pollution control measures outweigh the costs. This approach helps prioritize interventions that yield the greatest health and economic benefits, ensuring efficient allocation of resources.

In FATE, the calculation of VSL is performed alongside the estimation of health burden. The model considers the influence of a nation's wealth on its ability to allocate resources for reducing the risk of premature death and considers projected growth in per-capita income over time (International Council on Clean Transportation, 2023). The methodology for calculating the VSL is described in Narain and Sall (2016), referred to as the "World Bank" method, and the Gross Domestic Product per capita for each country is updated according to the International Monetary Fund.

Since the default FATE VSL values are in 2020 U.S. dollars, we adjusted the economic benefits to 2021 values in Euros using a consumer price index inflation calculator from the Bureau of Labor Statistics (2024). According to their estimate, $1 in June 2020 had the same purchasing power as $1.05 in June 2021. This amount was then converted to Euros using the 2021 exchange rate from the European Central Bank (2024) (€1 = $1.19). VSL values were multiplied by the number of premature deaths generated by FATE's health impacts module for each scenario to estimate the associated welfare loss from premature death for each country, age category, and cause.

To project cumulative economic benefits based on the VSL between 2030 and 2050, we applied the same conservative assumptions used for estimating cumulative avoided deaths by 2030 and described above. We did not adjust for potential future changes in gross domestic product, as such projections involve significant uncertainty. This approach ensures that our estimates remain conservative and avoid overestimating potential benefits.

APPENDIX E: ESTIMATED AVOIDABLE DEATHS PER DISEASE, POLLUTANT, AND MEMBER STATE

Table E1

Avoidable deaths by cause and pollutant in 2030 compared with the Business-As-Usual scenario 2030

Cause Name	Species	MGO Max	MGO Mix	Scrubber Max	ULSFO Mix
COPD	O_3	1	1	1	2
	$PM_{2.5}$	31	31	29	20
Diabetes 2	$PM_{2.5}$	12	11	11	8
IHD	$PM_{2.5}$	47	47	44	31
LRI	$PM_{2.5}$	23	23	21	15
Lung Cancer	$PM_{2.5}$	33	31	30	21
Stroke	$PM_{2.5}$	32	32	30	21
Total		179	176	166	118

Table E2

Cumulative (2030–2050) avoidable deaths by cause and pollutant compared with the Business-As-Usual scenario 2030

Cause Name	Species	MGO Max	MGO Mix	Scrubber Max	ULSFO Mix
COPD	O_3	30	30	40	60
	$PM_{2.5}$	900	880	830	600
Diabetes 2	$PM_{2.5}$	300	300	280	200
IHD	$PM_{2.5}$	990	970	920	640
LRI	$PM_{2.5}$	750	740	697	490
Lung Cancer	$PM_{2.5}$	770	760	720	500
Stroke	$PM_{2.5}$	670	660	620	430
Total		4,400	4,300	4,100	2,900

Note: Numbers are rounded to the nearest tenth.

Table E3
Avoidable deaths per country in 2030 compared with the Business-As-Usual scenario 2030

Country/Territory	MGO Max	MGO Mix	Scrubber Max	ULSFO Mix
Faroe Islands	0.16	0.16	0.14	0.08
France	24	24	23	16
Greenland	0.02	0.02	0.01	0.01
Iceland	0.03	0.02	0.02	0.00
Ireland	6	6	6	3
Portugal	30	29	26	19
Spain	32	31	29	22
United Kingdom	87	86	82	58
Total	179	176	166	118

Notes: The avoidable number of deaths is based on statistical models and could lead to estimations smaller than one. In practical terms, it means that when we consider a cumulative period bigger than one year (in this case 2030), it is likely that the avoidable deaths will be bigger than one. Numbers are rounded to the nearest integer.

Table E4
Cumulative (2030–2050) avoidable deaths per country in 2030 compared with the Business-As-Usual scenario 2030

Country/Territory	MGO Max	MGO Mix	Scrubber Max	ULSFO Mix
Faroe Islands	4	4	3	2
France	580	570	550	400
Greenland	0.3	0.3	0.3	0.2
Iceland	0.7	0.6	0.6	0.1
Ireland	180	180	160	90
Portugal	680	670	630	430
Spain	830	800	760	560
United Kingdom	2,130	2,110	1,990	1,410
Total	**4,400**	**4,300**	**4,100**	**2,900**

Note: Numbers are rounded to the nearest tenth.

APPENDIX F: IMPORTANT MARINE MAMMAL AREAS IN THE PROPOSED ATLECA AND CRITERIA FOR THEIR DESIGNATION

Table F1

Important Marine Mammal Areas in the proposed AtlECA and criteria for their designation

	IMMA	Qualifying Species	Supporting Species	Species Count	Jurisdictions	Area, km²	Details
1	**Sado Estuary**	Tursiops truncatus	—	Qualifying: 1 Supporting: 0	Portugal	104	https://www.marinemammalhabitat.org/factsheets/sado-estuary-imma/
2	**Monach Isles and Outer Hebrides Western Continental Shelf**	Halichoerus grypus, Tursiops truncatus, Phocoena phocoena, Delphinus delphis, Grampus griseus, Lagenorhynchus albirostris, Lagenorhynchus acutus, Globicephala melas, Balaenoptera acutorostrata, Balaenoptera physalus, and others	—	Qualifying: 15 Supporting: 0	UK, Ireland	35,538	https://www.marinemammalhabitat.org/portfolio-item/monach-isles-and-outer-hebrides-western-continental-shelf-imma
3	**Minches and the Sea of the Hebrides**	Halichoerus grypus, Phoca vitulina, Tursiops truncatus, Phocoena phocoena, Delphinus delphis, Grampus griseus, Lagenorhynchus albirostris, Balaenoptera acutorostrata, Orcinus orca	Megaptera novaeangliae, Balaenoptera physalus, Balaenoptera borealis, Lagenorhynchus acutus Globicephala melas, Hyperoodon ampullatus, Mesoplodon densirostris	Qualifying: 9 Supporting: 7	UK, Ireland	28,858	https://www.marinemammalhabitat.org/portfolio-item/minches-and-the-sea-of-the-hebrides-imma
4	**Rockall Trough Seamounts and Banks**	Physeter macrocephalus, Hyperoodon ampullatus, Ziphius cavirostris, Mesoplodon bidens, Globicephala melas, Balaenoptera borealis, Balaenoptera musculus, Balaenoptera physalus, Megaptera novaeangliae	Lagenorhynchus acutus, Grampus griseus, Delphinus delphis, Stenella coeruleoalba, Tursiops truncatus	Qualifying: 9 Supporting: 5	UK, Ireland, Denmark	106,464	https://www.marinemammalhabitat.org/portfolio-item/rockall-trough-seamounts-and-banks-imma
5	**Central Irish Sea**	Tursiops truncatus, Phocoena phocoena, Delphinus delphis, Grampus griseus, Halichoerus grypus, Balaenoptera acutorostrata	Balaenoptera physalus, Megaptera novaeangliae, Globicephala melas	Qualifying: 6 Supporting: 3	UK	17,610	https://www.marinemammalhabitat.org/portfolio-item/central-irish-sea-imma/
6	**Western English Channel**	Tursiops truncatus, Phocoena phocoena, Balaenoptera acutorostrata, Grampus griseus, Laghenorhyncus albirostris, Delphinus delphis, Halichoerus grypus, Phoca vitulina, Balaenoptera physalus	Megaptera novaeangliae, Globicephala melas	Qualifying: 9 Supporting: 2	France, UK	26,139	https://www.marinemammalhabitat.org/portfolio-item/western-english-channel-imma
7	**Celtic Sea**	Balaenoptera physalus, Balaenoptera acutorostrata, Megaptera novaeangliae, Delphinus delphis, Phocoena phocoena, Grampus griseus, Globicephala melas, Halichoerus grypus, Phoca vitulina, Tursiops truncatus	Stenella coeruleoalba, Orcinus orca	Qualifying: 10 Supporting: 2	Ireland, UK	29,663	https://www.marinemammalhabitat.org/portfolio-item/celtic-sea-imma/
8	**Dingle to Mizen Head**	Phocoena phocoena, Tursiops truncatus, Halichoerus grypus, Phoca vitulina, Balaenoptera physalus, Megaptera Novaeangliae, Balaenoptera acutorostrata, Grampus griseus, Delphinus delphis	Orcinus orca, Globicephala melas, Hyperoodon ampullatus	Qualifying: 9 Supporting: 3	Ireland	4,460	https://www.marinemammalhabitat.org/portfolio-item/dingle-to-mizen-head-imma/
9	**The Shannon (Sionna) Approaches**	Tursiops truncatus	Delphinus delphis, Balaenoptera acutorostrata, Phocoena phocoena, Halichoerus grypus, Phoca vitulina	Qualifying: 1 Supporting: 5	Ireland	1,521	https://www.marinemammalhabitat.org/portfolio-item/shannon-sionna-approaches-imma
10	**Southeastern Rockall Slope and Canyons**	Physeter macrocephalus, Hyperoodon ampullatus, Ziphius cavirostris, Mesoplodon bidens, Globicephala melas, Balaenoptera borealis, Balaenoptera musculus, Balaenoptera physalus, Lagenorhynchus acutus, Tursiops truncatus	Pseudorca crassidens, Stenella coeruleoalba, Lagenorhynchus albirostris, Delphinus delphis, Phocoena phocoena, Balaenoptera acutorostrata ,Orcinus orca, Megaptera novaeangliae, Eubalaena glacialis	Qualifying: 10 Supporting: 9	Ireland, Areas Beyond National Jurisdiction	33,195	https://www.marinemammalhabitat.org/portfolio-item/southeastern-rockall-slope-and-canyons-imma/

11	**Porcupine Seabight and Bank**	Balaenoptera musculus, Balaenoptera physalus, Balaenoptera borealis, Balaenoptera acutorostrata, Physeter macrocephalus, Mesoplodon bidens, Globicephala melas, Tursiops truncatus, Delphinus delphis, Stenella coeruleoalba, Grampus griseus	Megaptera novaeangliae, Orcinus orca, Ziphius cavirostris, Hyperoodon ampullatus	Qualifying: 11 Supporting: 4	Ireland	87,621	https://www.marinemammalhabitat.org/factsheets/porcupine-seabight-and-bank-imma/
12	**Biscay Shelf Edge and Slope**	Stenella coeruleoalba, Delphinus delphis, Tursiops truncatus, Physeter macrocephalus, Balaenoptera musculus, Balaenoptera physalus, Balaenoptera borealis, Phocoena phocoena, Grampus griseus, Globicephala melas, Globicephala macrorhynchus, and others	—	Qualifying: 14 Supporting: 0	France, UK, Ireland	70,042	https://www.marinemammalhabitat.org/factsheets/biscay-shelf-edge-and-slope-imma/
13	**Northern Continental Shelf of the Bay of Biscay**	Delphinus delphis, Phocoena phocoena, Tursiops truncatus, Grampus griseus, Globicephala melas, Balaenoptera acutorostrata, Balaenoptera physalus , Stenella coeruleoalba, Halichoerus grypus, Ziphius cavirostris, Megaptera novaeangliae, Kogia sp.	—	Qualifying: 12 Supporting: 0	France, UK	123,155	https://www.marinemammalhabitat.org/factsheets/northern-continental-shelf-of-the-bay-of-biscay-imma/
14	**Southern Biscay Canyon System**	Ziphius cavirostris, Physeter macrocephalus, Balaenoptera physalus, Hyperoodon ampullatus, Mesoplodon bidens, Mesoplodon mirus, Delphinus delphis, Stenella coeruleoalba, Tursiops truncatus, Grampus griseus, Globicephala melas, and others	—	Qualifying: 19 Supporting: 0	France, Spain	29,906	https://www.marinemammalhabitat.org/portfolio-item/southern-biscay-canyon-system-imma
15	**Biscay Abyssal Plain**	Balaenoptera physalus physalus, Physeter macrocephalus, Stenella coeruleoalba, Delphinus delphis, Tursiops truncatus, Grampus griseus, Globicephala melas, Balaenoptera acutorostrata, Balaenoptera musculus, and others	—	Qualifying: 13 Supporting: 0	Spain, France, UK, Areas Beyond National Jurisdiction	216,173	https://www.marinemammalhabitat.org/portfolio-item/biscay-abyssal-plain-imma
16	**Rias of Galicia**	Tursiops truncatus	Balaenoptera acutorostrata, Phocoena phocoena, Delphinus delphis, Grampus griseus	Qualifying: 1 Supporting: 4	Spain	1,346	https://www.marinemammalhabitat.org/portfolio-item/rias-of-galicia-imma
17	**Atlantic Coast of the Iberian Peninsula**	Phocoena phocoena, Orcinus orca, Tursiops truncatus, Delphinus delphis, Balaenoptera physalus, Balaenoptera musculus, Stenella coeruleoalba, Grampus griseus, Globicephala melas, Balaenoptera acutorostrata, Globicephala macrorhynchus	—	Qualifying: 11 Supporting: 0	Spain, Portugal, Morocco	51,581	https://www.marinemammalhabitat.org/factsheets/atlantic-coast-of-the-iberian-peninsula-imma/

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