Journal of Marine
Technology and Environment
DOI:10.53464/JMTE.02.2025.10
ISSN (Print): 1844-6116
ISSN (Online): 2501-8795
https://www. jmte.eu

OVERVIEW STUDY ON GREENHOUSE GAS EMISSIONS IN ROMANIA

Mirela-Iuliana ŞUNDRI [1] & Feiza MEMET [2]

[1]Constanta Maritime University, Faculty of Naval Electro-Mechanics, 104 Mircea cel Batran Street, 900663, Constanta, Romania, e-mail address: iuliana_sundri@yahoo.com
[2]Constanta Maritime University, Faculty of Naval Electro-Mechanics, 104 Mircea cel Batran Street, 900663, Constanta, Romania, e-mail address: feizamemet@yahoo.com

Abstract: This study provides an overview of greenhouse gas (GHG) emissions in Romania between 1970 and 2023, highlighting long-term trends, sectoral contributions, and their implications for climate policy. Using data from the Emissions Database for Global Atmospheric Research (EDGAR), annual values of CO_2, CH_4, N_2O, and F-gases were analysed across eight major anthropogenic sectors. Results show that Romania experienced a peak of approximately 280 $MtCO_2eq$ in 1988, followed by a sharp decline after the political and economic transition in 1989. By 2023, emissions decreased to around 105 $MtCO_2eq$, representing a 62% reduction. This decline was largely driven by the restructuring of heavy industry, closure of inefficient energy facilities, and adoption of EU-aligned environmental policies. However, transport, agriculture, and waste sectors gained increasing relevance as industrial and power-related emissions fell. Despite progress, sustained challenges remain for achieving Romania's climate neutrality targets by 2050, particularly in transport decarbonization, agricultural emissions control, and methane capture from waste management.
Key words: carbon dioxide, climate change, greenhouse gas emissions, methane, Romania

1. INTRODUCTION

In the last century, the increase in global average temperature has been faster compared to its very slow changes in the past. This trend is caused by the burning of fossil fuels in various human activities [1], [2], [3], [4]. Global climate change, which is causing an increase in the average temperature in the world with dramatic consequences in the future, is due to the increasing emissions of CO_2, CH_4, N_2O and fluorinated gases (F-gases), generically called Greenhouse Gases (GHGs) [5], [6]. The concentration of GHGs in the atmosphere is also increasing due to deforestation and agricultural activities. This parameter has increased steadily in the 20th century [7].

The Paris Agreement aimed to combat global climate change by limiting the increase limit temperature increase below 2 degrees Celsius, preferably to 1.5 degrees above pre-industrial levels [8].

Most countries around the world have important strategies for planning actions to limit climate change. Approximately 140 countries, which are responsible for about 88% of current global greenhouse gas emissions, have jointly agreed to set a national target date by which they will become net zero emitters [9]. In this context, the European Union has set a target for 2030 of reducing greenhouse gases by 55%, with the ultimate objective of achieving climate neutrality by 2050 [10].

Despite international climate agreements, global greenhouse gas emissions continue to rise, increasing the risk of climate exceedances and more severe impacts, such as increased floods, droughts and heatwaves. Urgent and accelerated reductions in greenhouse gas emissions are needed to avoid exceeding the 1.5°C warming target and to manage the economic and health costs of increasing climate change. [10], [11], [12], [13], [14]. In 2023 the main GHG emitting countries in the world were China (30.1%), USA (11.3%), India (7.8%), Russia (5.0%) and Brazil (2.5%). EU contribution is only 6.1% but it is the sum of 27 country emissions. Among these top economies, the European Union's GHG emissions have had the most significant decrease, being 33.9% lower in 2023 than in 1990. For the same period, GHG emissions decreased only 4.0% in the U.S.A and 12.8% in Russia; but contrary, GHG emissions have increased about 311.2% in China and 199.0% in India [15]. Increased GHG emissions have led to an increase in the average global temperature which in 2024 was 1.55 °C higher than the average temperature in the last 50 years of the 19th century [16], [17].

Romania's Long-term Strategy for reducing greenhouse gas emissions sets forth the objective of attaining a 55% reduction in net emissions by 2030 and a 99% reduction by 2050, relative to 1990 levels, thereby achieving climate neutrality [18]. This strategic objective ensures Romania's compliance with the commitments undertaken at the level of the European Union in the field of environmental sustainability and climate change mitigation. The present study emphasizes the specific characteristics of greenhouse gas emission trends in

Journal of Marine
Technology and Environment
DOI:10.53464/JMTE.02.2025.10
ISSN (Print): 1844-6116
ISSN (Online): 2501-8795
https://www. jmte.eu

Romania between 1970 and 2023, and provides an assessment of the likelihood of achieving the envisaged targets.

2. MATERIALS AND METHODS

There are many international organizations monitoring information on GHG parameters, in collaborations with national/independent agencies acquiring environmental data.[19], [20], [21]

The aim of this paper is to use existing published data in order to illustrate the history of Romania's GHG emissions in different areas of human economic activity.

The present study uses data from "The Emissions Database for Global Atmospheric Research" (EDGAR) which provides GHG emissions time series for every country and for all anthropogenic sectors [7], to perform analyses and produce figures aimed at identifying the trend of the main GHG in Romania.

Inspecting original EDGAR data, it has been collected the annual values between 1970 and 2023 of the parameters CO_2, CH_4, N_2O and F-gases emissions, generated by diverse activities grouped in eight type of anthropogenic sectors: power industry (power and heat generation plants, public and auto-producers), industrial combustion (combustion for industrial manufacturing), transport (road and rail transport, domestic aviation, domestic shipping and inland waterway transport, international shipping and aviation), processes (industrial process emissions), buildings (small-scale non-industrial stationary combustion), agriculture (aerobic fermentation from waste livestock and manure management, soils fertilisers, direct soil emissions and indirect N_2O emissions from agriculture), waste (solid waste disposed of on land, composted or incinerated, storage and processing of hazardous solid waste, wastewater management), fuel exploitation (fuel extraction, transformation and refinery activities).

For each sector, will be comparatively analysed data of the main three GHG parameters: CO_2, CH_4, N_2O. Data for F-gases will be separately analysed. The quantities GHG emissions are measured in $MtCO_{2eq}$ (Mega tones of CO_2 equivalent).

3. RESULTS AND DISCUSSION

First analysed parameter, total greenhouse gas emissions is the sum of CO_2, CH_4, N_2O and F-gas emissions. The evolution of GHG emissions in Romania has a main particularity: end of year 1989 was a crucial moment in the history of the country, when the democratic revolution determined abolition of communist state. After this event, the whole activities, economic and social, suffered major transformations. Figure 1 illustrates the evolution of GHG emissions in Romania with a sharp increase from 1970 up to the late 1980s, and after the "1989 event" a decrease, with small fluctuations. Thus, during the analysed time period, GHG emissions decreased from a maximum of approximately 280 $MtCO_{2eq}$ recorded in 1988 to a minimum value of 105 $MtCO_{2eq}$ in 2023, which means a reduction of over 62% (Figure 1).

Until 1990, GHG emissions were dominated by the industrial combustion and the power industry sectors. This trend reflects the structure of the socialist economy, based on intensive industrial production and massive use of fossil fuels. After 1990, with the onset of economic transition, the sudden decrease in emissions is associated with the collapse of heavy industry, the closure of inefficient energy facilities, and the introduction of environmental policies aligned with European directives. Beyond this reduction, the sectoral structure shifted: transport emissions increased steadily, becoming a major contributor after 2000, reflecting the expansion of mobility and fuel consumption. Agriculture, waste, and industrial processes remained relatively stable sources but gained greater shares due to the decline of energy production related emissions. At present, the emissions profile is more balanced, yet climate challenges persist, requiring integrated measures for transport, agriculture, and waste management.

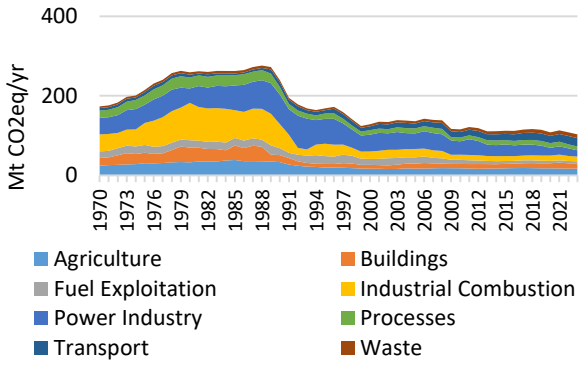

Figure 1 Total GHG emissions in Romania by activity type

The following evaluations, made for each type of activities mention above, are focused on the main three categories of pollutant emissions CO_2, CH_4, N_2O.

The activities of Power Industry mainly generate a large quantity of CO_2 (Figure 2). The trends of CO_2 and N_2O are similar, but CH_4 emissions is nearly constant in the last 30 years. It can be seen the decreasing tendency after 1992, mainly due to the policy to stop a lot of power and heat generating plants based on coal, petroleum and natural gases. The emissions of CH_4 and N_2O have very low levels of CO_{2eq} compared with CO_2 direct emission. There is an increase in direct CO_2 and CH_4 emissions from 1970 to 1992 by 93% and 144% respectively. Emissions corresponding to 2023 represented 19% and 32% respectively of the maximum recorded, and 37%, 78% compared to 1970. The maximum of N_2O emissions was recorded in 1989 at a level of 266% compared to 1970, then decreasing steadily to a value of 68% compared to the beginning of

Journal of Marine
Technology and Environment
DOI:10.53464/JMTE.02.2025.10
ISSN (Print): 1844-6116
ISSN (Online): 2501-8795
https://www. jmte.eu

the monitored period or 25.5% compared to the maximum value.

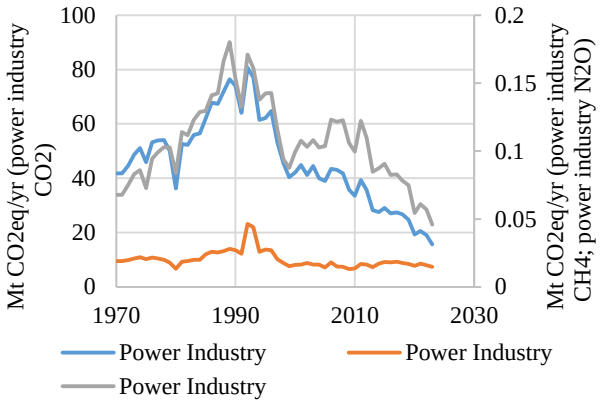

Figure 2 GHG emissions from power industry

During period 1990-1995 there was a drastic reduction of the industrial activities emitting large quantities of GHG resulting from direct combustion. The CO_2 direct emissions had a decrease from 80 $MtCO_{2eq}$ to 17 $MtCO_{2eq}$. After 1995 CO_2 had a slowly constant decrease due to the reduction of high energy consumer industrial activities, and the development of new factories and plants based on technologies of combustion which limit the spread of CO_2 in the environment (Figure 3).

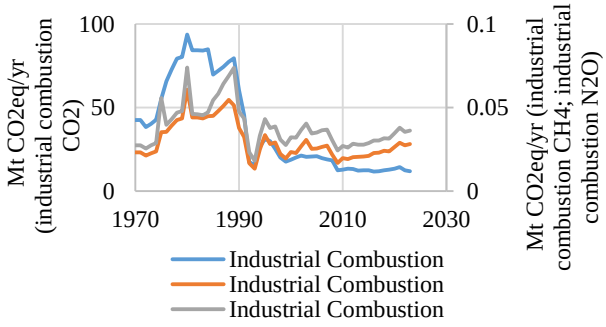

Figure 3 GHG emissions from industrial combustion

The emissions of CH_4 and N_2O were at low, nearly constant levels, between 1992 and 2010. After 2010 these emissions slowly increase, but the levels are neglected compared with CO_2. Direct CO_2 emissions in 2023 were at a level of 15% of the maximum recorded in 1989 or 28% if we compare to 1970. Although CH_4 and N_2O emissions decreased in 2023 to about 50% of their recorded maximums, their values still represent increases of 21% and 33% respectively compared to the beginning of the time period analysed in this study.

The GHG emissions generated by various types of transport activities constantly increased since 1990. This trend is normal due to the rapid grow of transportation all over the world, including Romania (Figure 4).

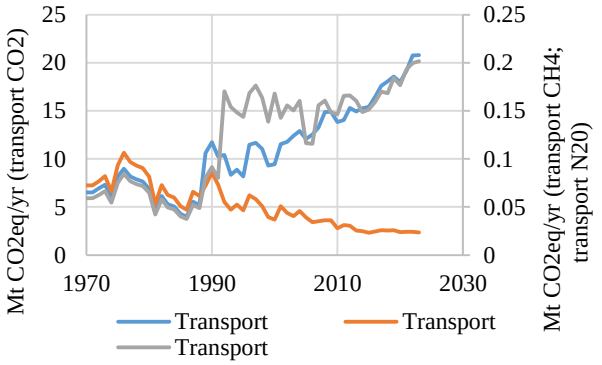

Figure 4 GHG emissions from transport (1970-2023)

The quantities of CH_4 and N_2O, expressed in CO_{2eq}, are small compared to the emissions from the sectors of activity discussed previously, but they are important pollutants of the air affecting the human health. For this reason, there are constant, important preoccupations of United Europe organizations to limit these poised emissions from transport activities. For example, today are in effect the EURO-6 normative applying to cars in Europe. Romania aligned to this European policy, starting limitations regarding very old cars, more technical revisions for cars with emission rating lower than EURO-4, financial facilities for acquisition of hybrid and pure electric cars. Despite concerns about limiting pollutants resulting from transport activities, in the last 30 years there have been increases 2.4 times in CO_2 emissions and 1.4 times in N_2O emissions. For CH_4 alone, emissions have been reduced by about 45%.

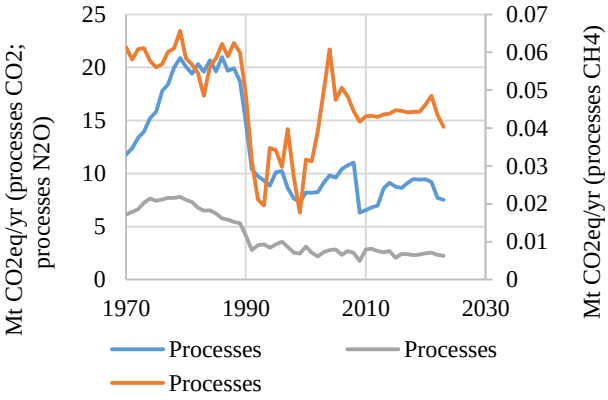

Figure 5 GHG emissions from processes (1970-2023)

In the “processes” activities area, after 1990, pure CO_2 emissions decreased by almost half, remaining at levels between 5 $MtCO_{2eq}$ and 10 $MtCO_{2eq}$ (Fig. 5). The levels of CH_4 and N_2O have a weak contribution to the total quantitative CO_2 budget. However, the CH_4 trend indirectly indicates the evolution of the process industry, which, after a significant reduction between 1992 and 2000, started to increase towards a constant level at present.

Journal of Marine
Technology and Environment
DOI:10.53464/JMTE.02.2025.10
ISSN (Print): 1844-6116
ISSN (Online): 2501-8795
https://www. jmte.eu

The trends in greenhouse gas emissions from buildings have a curious pattern, with a dramatic decrease since 1987 (Figure 6). It is worth recalling that in 1987, during the communist period in Romania, an order was issued to rationalize the consumption of gas and electricity by the domestic/civilian population. For two years, people began to use liquid fuels on a large scale for cooking and heating. After 2000, the natural gas network was expanded, which allowed the population to install more and more individual natural gas thermal units for heating and hot water. After 1990, solid fuels (coal, wood) were used less, so that direct CO_2 emissions remained low, between 7 and 12 $MtCO_{2eq}$. CH_4 emissions are low, approximately 1 $MtCO_{2eq}$, and N_2O emissions are negligible, even though they release slowly increasing quantities.

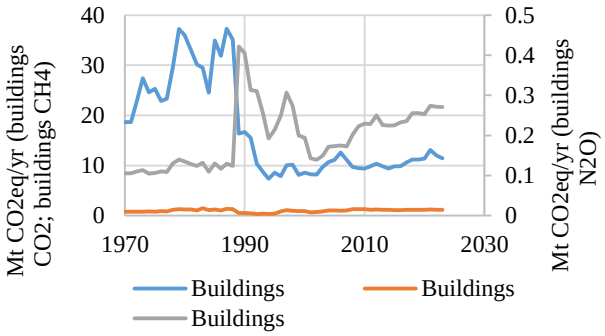

Figure 6 GHG emissions from buildings

Direct CO_2 emissions from agriculture are low, between 0.3 and 1.1 $MtCO_{2eq}$ (Figure 7). The main contributors to greenhouse gas levels from agriculture are CH_4 and N_2O. CH_4 has been steadily decreasing, but N_2O emissions are slowly increasing each year due to the increasing use of nitrogen-based fertilizers.

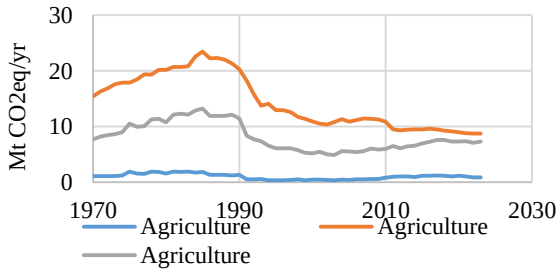

Figure 7 GHG emissions from agriculture

Direct CO_2 emissions from waste have very low levels since 2008, about 0.005 $MtCO_{2eq}$ per year. But between 1990 and 2005 this kind of emissions constantly grew up due to the fact that huge quantities of waste have been incinerated. This large-scale burning process has been stopped since 2008. Emissions of N_2O are almost constant, about 8÷9 $MtCO_{2eq}$, but from 2010 there is a slow decreasing trend, despite the natural trend of increasing the quantity of waste due to economic growth and increased consumption. The emissions of CH_4 have a minimum value in 1994, but since then, there was an upward trend, the value in 2023 being more than double value from 1994 (Figure 8). Capturing and transforming this CH_4 into biogas and then upgrading it to biomethane for energy use is a crucial strategy to prevent its release, turn it into a valuable renewable energy source, and simultaneously mitigate climate change. By not capturing and utilizing this methane, its harmful potential is realized, and the opportunity to generate clean energy is lost. This is a direction for improving Romanian waste management policy.

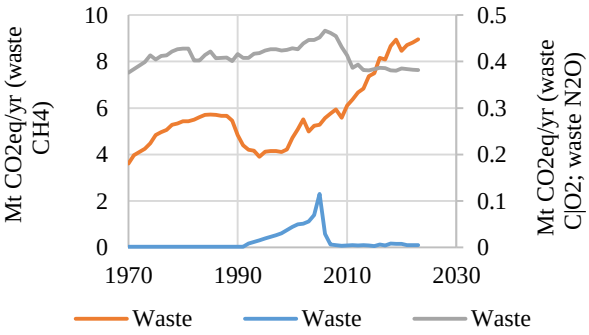

Figure 8 GHG emissions from waste

The amounts of N_2O emissions from fuel exploitation are very small compared to those of CO_2 and CH_4, but the trend is similar to that of CO_2, this characteristic being a particularity of oil and gas transformation and refining activities (Figure 9). After 1990, fuel exploitation has consistently used processes that generate less CO_2. All three types of emissions show a significant downward trend, also due to the fact that significant quantities of fuel are processed outside the country.

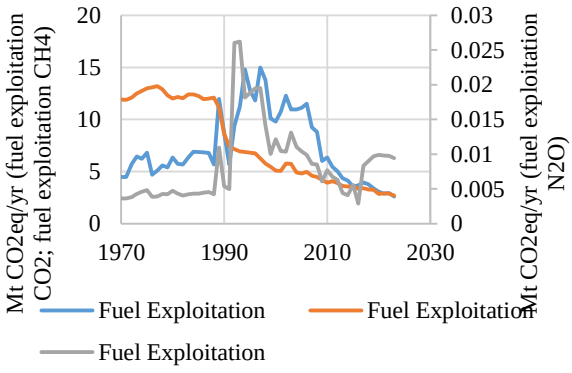

Figure 9 GHG emissions from fuel exploitation

The emissions of F-gases have a high global warming potential and are generated by all type of processes (Figure 10). But the quantities of this GHG are small in comparison with the other GHG gaseous emissions.

Journal of Marine
Technology and Environment
DOI:10.53464/JMTE.02.2025.10
ISSN (Print): 1844-6116
ISSN (Online): 2501-8795
https://www. jmte.eu

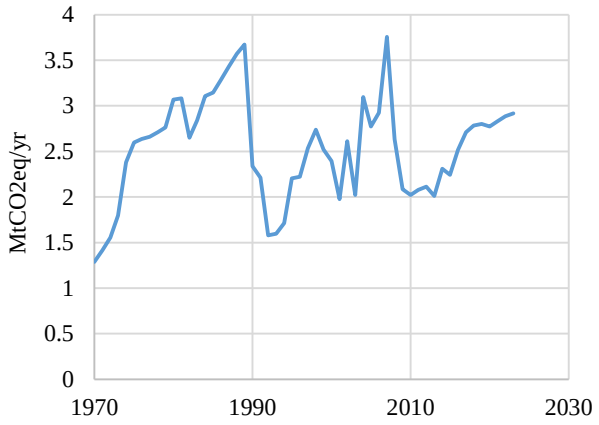

Figure 10 F-Gases emissions

Due to the diversity of the sources generating F-gases emissions in all sectors of activities, there are complex variations in time, but the values mainly remain between 1.5 – 3 $MtCO_{2eq}$ per year.

4. CONCLUSIONS

The analysis of Romania's greenhouse gas (GHG) emissions over the 1970–2023 period reveals profound structural transformations shaped by political, economic, and technological shifts. Emissions peaked in the late 1980s, when industrial combustion and the power industry dominated the national profile, reflecting the energy-intensive nature of the socialist economy. The post-1989 transition led to a dramatic reduction in overall emissions, with levels in 2023 more than 62% lower than the historical maximum. This decrease was primarily associated with the collapse of heavy industry, modernization of energy production, and gradual integration of European Union environmental standards.

Nonetheless, while emissions from industry and the power sector declined, transport, agriculture, and waste became increasingly significant sources. Transport emissions grew more than twofold due to rising mobility, while agricultural N_2O emissions remain problematic because of fertilizer use. Methane from waste management has also risen steadily, highlighting the need for effective methane capture and valorisations strategies. The persistence of these sectoral challenges suggests that Romania's future decarbonization efforts must shift from industrial restructuring toward comprehensive policies in mobility, sustainable farming, and circular economy solutions.

Romania has aligned its objectives with EU targets, committing to a 55% reduction in net emissions by 2030 and climate neutrality by 2050. Achieving these goals will require accelerating renewable energy deployment, promoting low-carbon transport, incentivizing sustainable agriculture, and implementing robust waste-to-energy systems. While significant progress has been made, maintaining momentum and addressing emerging sectoral challenges are crucial for Romania's contribution to global climate stability.

5. REFERENCES

[1] Mark Lynas et al 2021, *Greater than 99% consensus on human caused climate change in the peer-reviewed scientific literature*. Environ. Res. Lett. 16 114005. DOI 10.1088/1748-9326/ac2966

[2] Allen, M.R., O.P. Dube, W. Solecki, F. Aragón-Durand, W. Cramer, S. Humphreys, M. Kainuma, J. Kala, N., 2018, Chapter 1, titled *"Framing and Context,"* from the 2018 IPCC Special Report on Global Warming of 1.5°C. https://www.ipcc.ch/site/assets/uploads/sites/2/2019/03/SR15_SOD_Chapter1.pdf

[3] Nunes, L.J.R, 2023. *The Rising Threat of Atmospheric CO2: A Review on the Causes, Impacts, and Mitigation Strategies*. Environments 2023, 10(4), 66; https://doi.org/10.3390/environments10040066

[4] Kangyin Dong, Gal Hochman, Govinda R. Timilsina, 2020, *Do drivers of CO_2 emission growth alter overtime and by the stage of economic development?*, Energy Policy, Volume 140, 2020, 111420, ISSN 0301-4215, https://doi.org/10.1016/j.enpol.2020.111420.

[5] Hannah Ritchie, 2020 - *Sector by sector: where do global greenhouse gas emissions come from?* Published online at OurWorldinData.org. Retrieved from: 'https://ourworldindata.org/ghg-emissions-by-sector' [Online Resource]

[6] Mikalai Filonchyk, Michael P. Peterson, Lifeng Zhang, Volha Hurynovich, Yi He, 2024, *Greenhouse gases emissions and global climate change: Examining the influence of CO_2, CH_4, and N_2O*, Science of The Total Environment, Volume 935, 2024, 173359, ISSN 0048-9697, https://doi.org/10.1016/j.scitotenv.2024.173359.

[7] Crippa, M., Guizzardi, D., Pagani, F., Banja, M., Muntean, M., Schaaf, E., Monforti-Ferrario, F., Becker, W., Quadrelli, R., Risquez Martin, A., Taghavi-Moharamli, P., Köykkä, J., Grassi, G., Rossi, S., Melo, J., Oom, D., Branco, A., San-Miguel, J., Manca, G., Pisoni, E., Vignati, E. and Pekar, F., 2024, *GHG emissions of all world countries*, Publications Office of the European Union, Luxembourg, 2024a, doi:10.2760/4002897, JRC138862.

[8]https://www.un.org/en/climatechange/paris-agreement

[9]https://www.un.org/en/climatechange/net-zero-coalition

Journal of Marine
Technology and Environment
DOI:10.53464/JMTE.02.2025.10
ISSN (Print): 1844-6116
ISSN (Online): 2501-8795
https://www. jmte.eu

[10] European Commission: Directorate-General for Climate Action, 2019, *Going climate-neutral by 2050 – A strategic long-term vision for a prosperous, modern, competitive and climate-neutral EU economy*, Publications Office, https://data.europa.eu/doi/10.2834/02074

[11] Bevacqua, E., Schleussner, CF. & Zscheischler, J., 2025, *A year above 1.5 °C signals that Earth is most probably within the 20-year period that will reach the Paris Agreement limit*. Nat. Clim. Chang. 15, 262–265. https://doi.org/10.1038/s41558-025-02246-9

[12] United Nations Environment Programme, 2024, *Emissions Gap Report 2024: No more hot air ... please! With a massive gap between rhetoric and reality, countries draft new climate commitments*. https://wedocs.unep.org/20.500.11822/46404.

[13] International Energy Agency, Global Energy Review, 2025, https://www.iea.org/reports/global-energy-review-2025/co2-emissions

[14] Mikalai Filonchyk, Michael P. Peterson, Haowen Yan, Andrei Gusev, Lifeng Zhang, Yi He, Shuwen Yang, 2024, *Greenhouse gas emissions and reduction strategies for the world's largest greenhouse gas emitters*, Science of The Total Environment, Volume 944, 173895, ISSN 0048-9697, https://doi.org/10.1016/j.scitotenv.2024.173895.

[15] Deng, Z., Zhu, B., Davis, S.J. et al., 2025, *Global carbon emissions and decarbonization in 2024*. Nat Rev Earth Environ 6, 231–233. https://doi.org/10.1038/s43017-025-00658-x

[16] https://wmo.int/news/media-centre/wmo-confirms-2024-warmest-year-record-about-155degc-above-pre-industrial-level

[17] Jones, Roger N., 2024. *Evidence and Explanation for the 2023 Global Warming Anomaly*, Atmosphere 15, no. 12: 1507. https://doi.org/10.3390/atmos15121507

[18] https://energy.ec.europa.eu/system/files/2020-06/ro_final_necp_main_en_0.pdf

[19] Branza G., 2023. *Green shipping. study on regulations and sustainable options for decarbonisation*, Journal of marine Technology and Environment, Vol. 2, pp 12-15, Nautica Publish House, Constanta, Romania.

[20] IRENA, 2020a, *Reaching zero with renewables: Eliminating CO2 emissions from industry and transport in line with the 1,5^{0}C Climate Goal*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/-/media/Files/IRENAAgency/Publication/2020/Sep/IRENA_Reaching_zero_2020.pdf

[21] Royal Society, 2020, *Ammonia: Zero-Carbon Fertiliser, Fuel and Energy Store*, The Royal Society, London, https://royalsociety.org/-/media/policy/projects/green-ammonia/green-ammonia-policy-briefing.pdf