Rhodium Group

Energy & Climate

Global Greenhouse Gas Emissions: 1990-2022 and Preliminary 2023 Estimates

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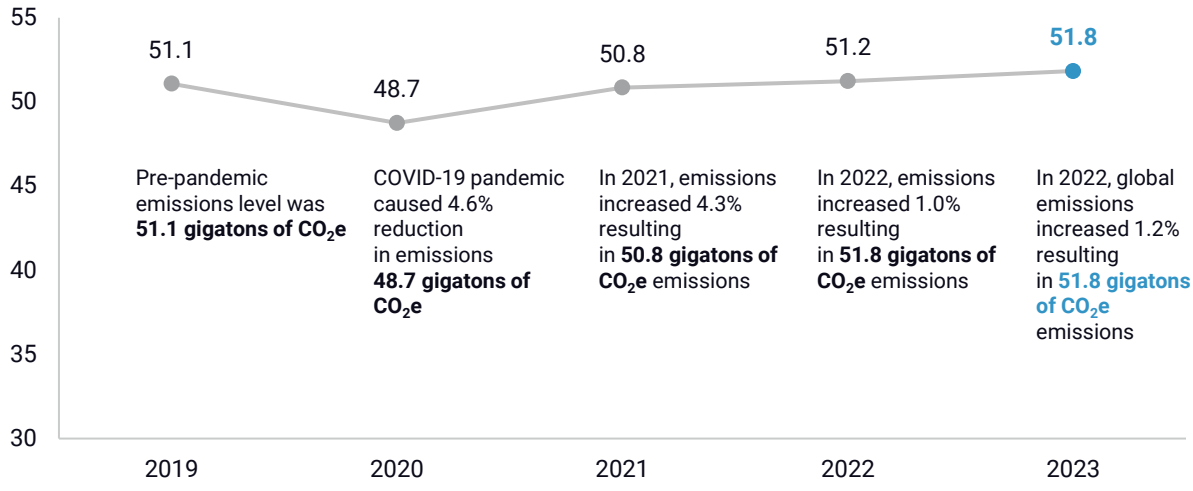
Each year, Rhodium Group provides updated estimates of greenhouse gas (GHG) emissions at the global and national levels, covering all six primary greenhouse gases and all sectors of the economy. Our preliminary estimates for 2023 indicate that global GHG emissions rose by 1.2% over the previous year, reaching 51.8 gigatons of CO_2-equivalent on net. This follows a 1.0% increase in 2022 as countries recovered from the COVID-19 pandemic disruptions of 2020. This modest yet steady growth reflects a persistent challenge in reducing emissions amid economic recovery. However, shifts in the energy landscape—including substantial investments in renewable energy—have allowed some of the world's largest emitters to achieve economic growth while cutting emissions.

FIGURE 1
Preliminary global GHG emissions estimates for 2023
Billion metric tons of CO_2e



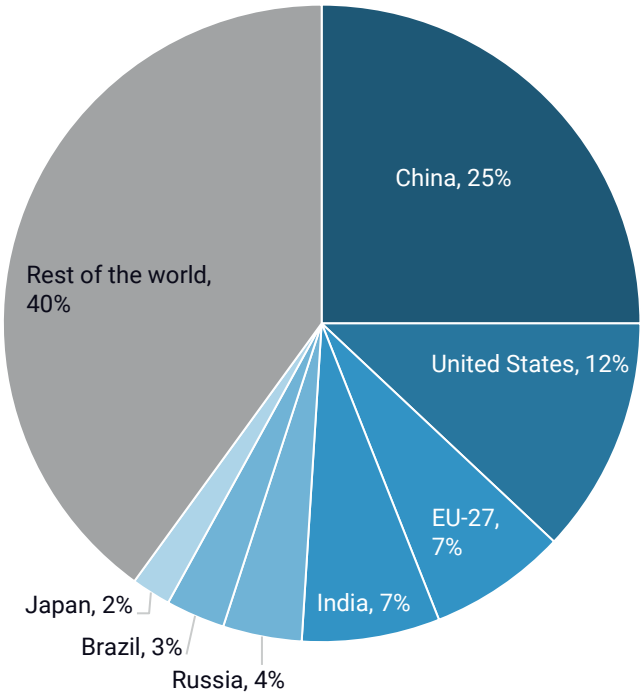
Source: Rhodium Group

Global emissions continue to grow amid energy market shifts

Rhodium's preliminary estimates for 2023 indicate a 1.2% increase in global emissions. This covers the six leading greenhouse gases emitted from every sector of the economy, including land use, forestry, and international bunkers. Emissions rose from 51.2 gigatons of CO_2-equivalent (CO_2e) in 2022 to 51.8 gigatons in 2023. This marks a slight acceleration from the previous year's 1.1% increase (Figure 1).

Seven economies were responsible for close to two-thirds of global emissions in 2023 (Figure 2). Relative emissions shares among the world's major economies remained the same as in previous years. China was the highest-emitting economy, contributing 25% of global emissions, followed by the US at 12% and the EU and India at 7%.

FIGURE 2
2022 net GHG emissions from the world's largest emitters
Percent share of global total



Source: Rhodium Group

CO_2 from the combustion of fossil fuels remains the largest source of global emissions and continues to underpin much of the global economy. However, the relationship between economic growth and energy CO_2 emissions in 2023 varied significantly among major economies (Figure 3). India and China experienced GDP growth of 8.4% and 1.5%, respectively, and recorded corresponding rises in energy CO_2 emissions of 8.8% and 5.1%, respectively, primarily due to their increased reliance on coal and natural gas to meet

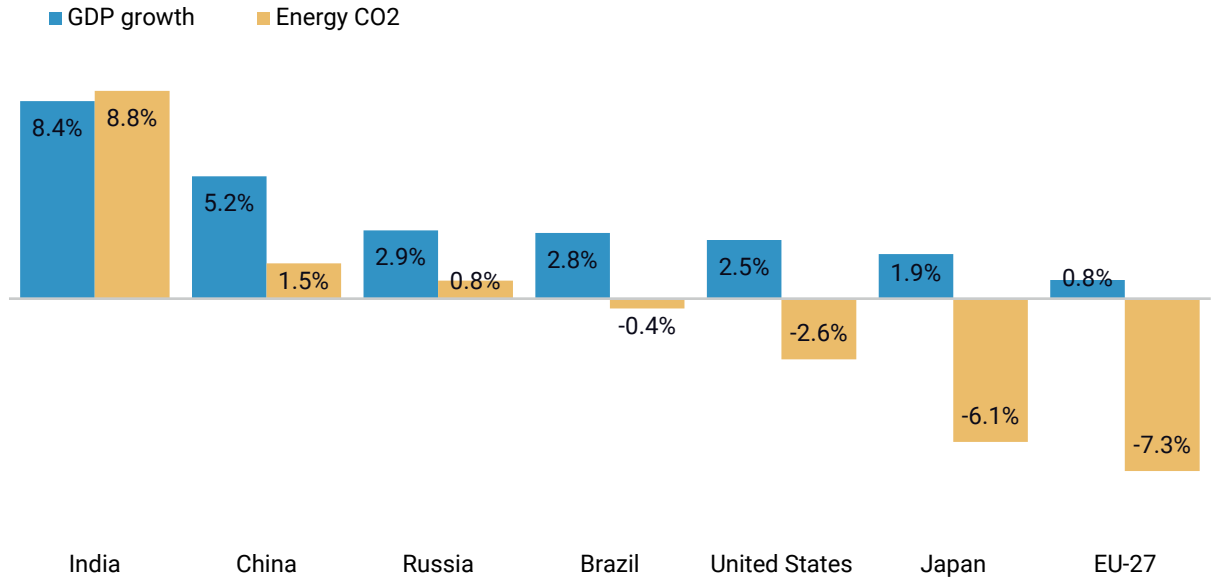
surging energy demand. Notably, China's emissions rebounded in 2023, reversing the modest decline of 0.3% observed in 2022 (Figure 4).

In contrast, the US achieved moderate economic growth (2.5%) while reducing energy CO_2 emissions by 2.6% as it continued to adopt cleaner energy sources. Similarly, Japan and the EU posted economic growth rates of 1.9% and 0.8%, respectively, while substantially reducing energy CO_2 emissions by 6.1% and 7.3%, driven by accelerated adoption of renewables and energy efficiency measures. Brazil and Russia demonstrated 2.8% and 2.9% GDP growth, respectively, but took different paths on emissions. Brazil's energy CO_2 emissions fell by 0.4%, building on a more significant 5.1% reduction the previous year. Russia, after a 2.0% decline in 2022, saw a modest 0.8% increase in 2023, as energy production partially stabilized following the disruptions of international sanctions. These trends underscore that some economies managed to decouple emissions from economic growth while others continue to face challenges, particularly those dependent on fossil fuels.

FIGURE 3

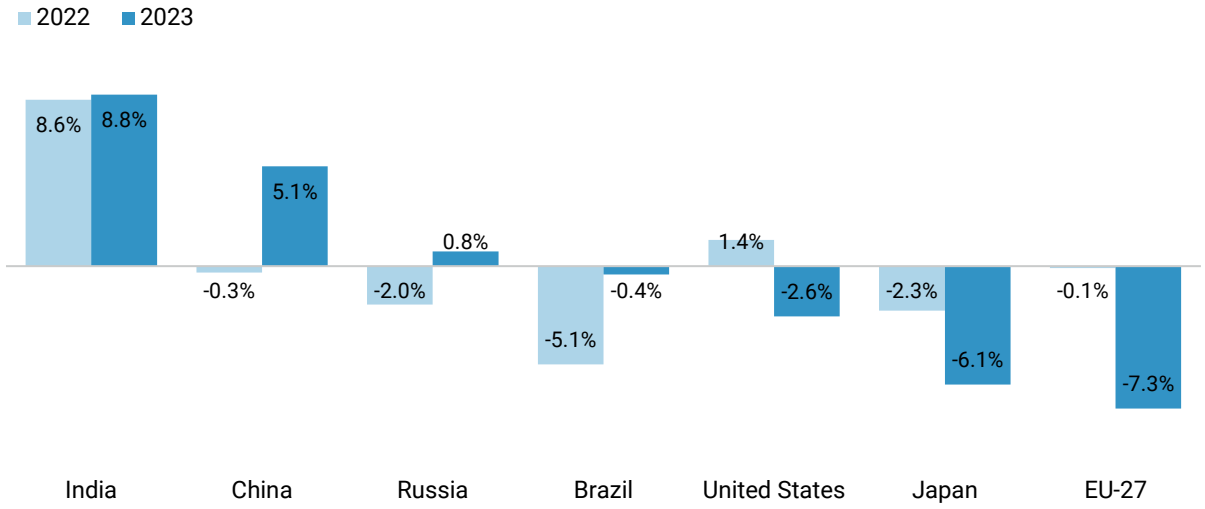
2023 Change in gross domestic product and net GHG emissions for the top emitters

Percentage change relative to the previous year



Source: Rhodium Group and World Bank

FIGURE 4
Change in annual energy CO_2 emissions for the top emitting economies
Percentage change relative to the previous year



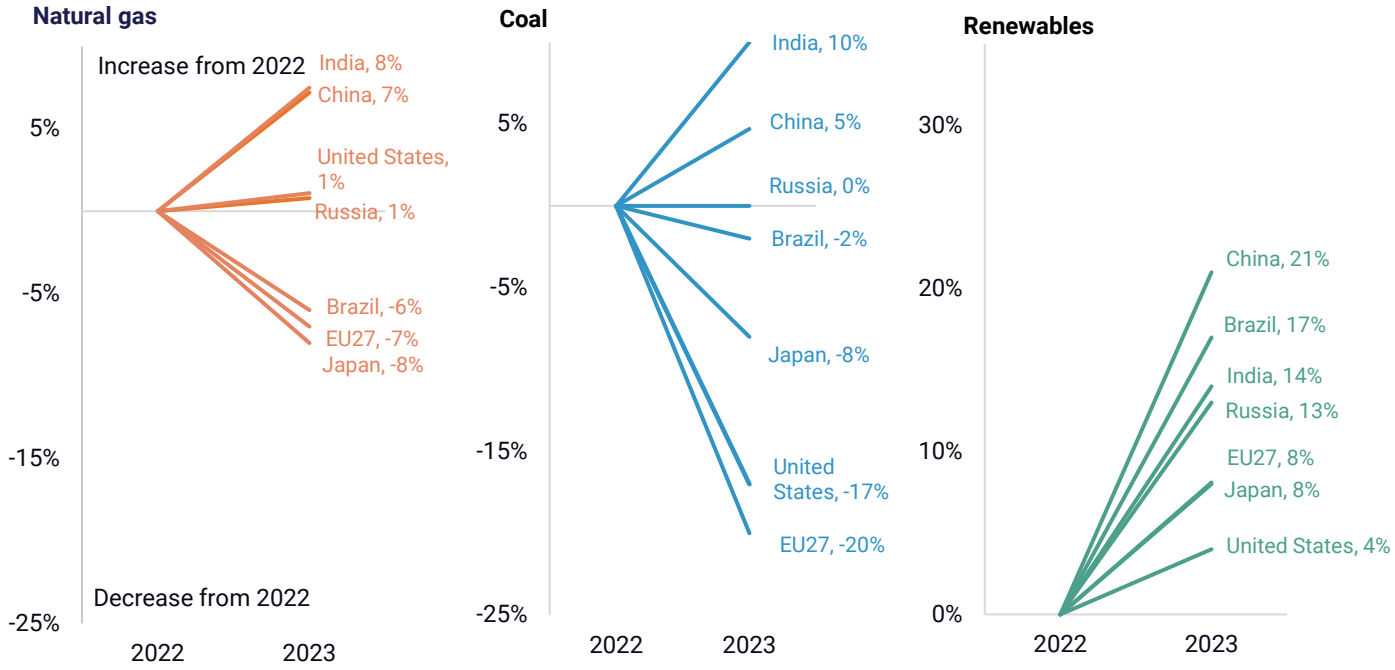
Source: Rhodium Group

Delving into the dynamics affecting energy CO_2 emissions in 2023, fuel markets underwent notable shifts, evolving in response to geopolitical factors and shifting energy strategies. Natural gas consumption showed divergent trends. India and China recorded significant increases in natural gas use, rising 8% and 7%, respectively, as their economies continued to expand (Figure 5). Meanwhile, the EU and Japan reduced their natural gas consumption by 7% and 8%, respectively, continuing efforts to diversify away from Russian energy sources and reduce reliance on imported gas. In Brazil, natural gas demand dropped by 6% as the country leaned more heavily on hydropower and renewables. The US saw a modest 1% increase in natural gas consumption, reflecting stable demand.

Coal consumption also varied by region. The EU led in reductions, slashing coal consumption by 20% as part of its accelerated transition to cleaner energy sources. The US followed with a 17% drop, driven by the competitiveness of renewables and natural gas. By contrast, coal use continued to climb in India and China, rising by 10% and 5%, respectively, as they deployed large quantities of clean and fossil power to meet rising energy demands. Japan and Brazil reduced their coal consumption by 8% and 2%, respectively.

Renewable energy saw widespread and accelerated growth. China led the surge with a 21% increase in renewable energy generation, followed by Brazil at 17%, India at 14%, and Russia at 13%. The EU and Japan also saw an 8% rise in renewables, while the US recorded a 4% increase. This global pivot toward renewables underscores ongoing decarbonization efforts by major economies, even as challenges persist in reducing reliance on fossil fuels for certain sectors.

FIGURE 5
Natural gas, coal, and renewable energy consumption
Percentage change relative to the previous year

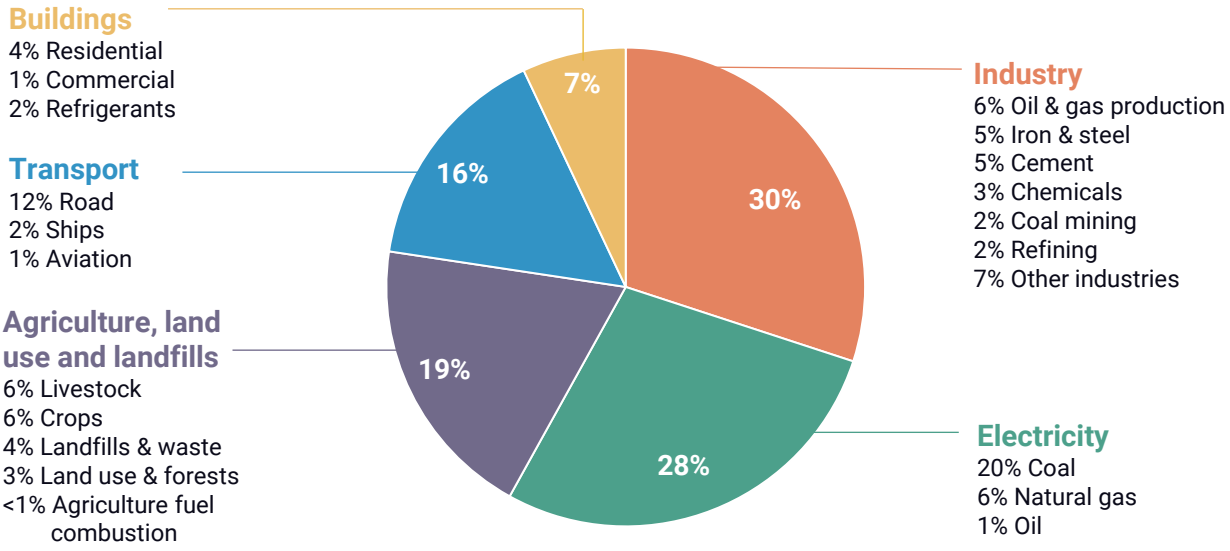


Source: BP Statistical Report 2024

Industry and power sectors at the forefront

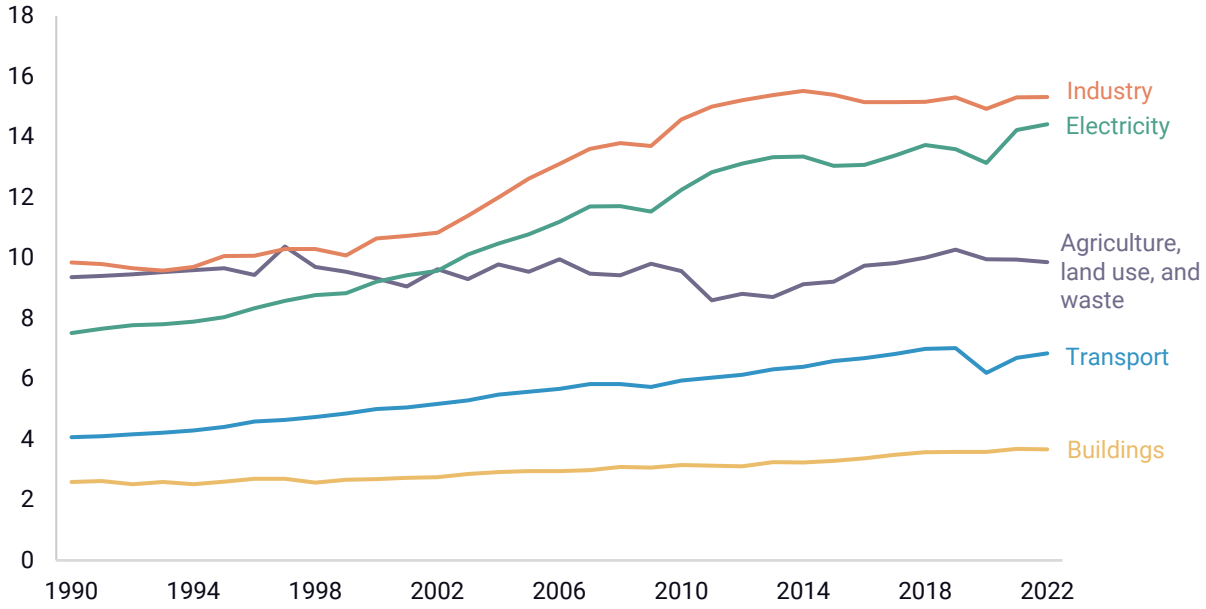
In 2022—the latest year for which there is sufficient data to provide sectoral level detail—industry and the electric power sector remained the dominant sources of global GHG emissions, together accounting for 58% of the total. Industry led with 30% of emissions, followed closely by the electric power sector at 28%, with a significant portion of these emissions stemming from coal and natural gas combustion. Agriculture, land use, and waste contributed 19%, reflecting emissions from agricultural practices and land management but excluding the impact of wildfires. The transport sector accounted for 16% of global emissions, driven by road and air transport demand, while buildings contributed 7%, largely due to space heating and cooling needs in commercial and residential buildings.

FIGURE 6
Global emissions by sector
Percent share of 2022 net GHG emissions



Source: Rhodium Group

FIGURE 7
Global GHG emissions by sector for 1990-2022
Billion metric tons of CO_2e



Source: Rhodium Group

Methodology

The data described here are available on Rhodium's ClimateDeck data platform, with support from Breakthrough Energy. The ClimateDeck provides GHG emissions and energy data for all 190+ countries and all 50 US states, with tools that allow users to filter by region, GHG, sector and sub-sector, as well as socioeconomic indicators (e.g., emissions per capita and per GDP) and full inventory tables for each country.

These estimates reflect several methodological updates that enhance the accuracy and consistency of our historical emissions data. Specifically, we have adopted the Global Warming Potentials (GWP) for non-CO_2 gases from the IPCC's Fifth Assessment Report (AR5), in alignment with UNFCCC reporting guidelines. Additionally, we transitioned to third-party datasets for Agriculture, Forestry, and Other Land Use (AFOLU) and energy CO_2 emissions to ensure methodological consistency across countries. As a result, our data may not fully align with self-reported UNFCCC inventory data, which can vary by country.

This year, we revised historical industrial emissions to include fuel consumption used in hydrogen production and non-CO_2 emissions from refining processes. By accounting for these previously unreported emissions sources, our estimates now provide a more comprehensive view of the industrial sector's contribution to historical emissions, with slight increases in certain years to reflect these additions.

In deriving our global and country-specific GHG emissions estimates, we incorporate data from IEA's energy consumption flows and BP's 2023 Statistical Review for fossil fuel CO_2. For AFOLU and waste emissions, our primary data source is FAOSTAT, with projections from IIASA's GLOBIOM 2021 included in our preliminary estimates for 2022. These estimates do not account for emissions from forest fires. For all other non-CO_2 gases, we use Annex I inventories and EPA's Global Non-CO_2 data.

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