Global Greenhouse Gas Emissions: 1990-2020 and Preliminary 2021 Estimates

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Tracking greenhouse gas (GHG) emissions across the 190+ Parties to the Paris Agreement provides valuable data for decision-makers in both public and private sectors as they develop strategies to meet global net-zero emissions goals. This data can inform policies and interventions that target the most carbon-intensive industrial and economic activities.

Every year, Rhodium Group provides the most up-to-date global and country-level GHG emissions estimates through the ClimateDeck. This year's update features final emissions estimates from 1990-2020 and preliminary estimates for 2021. This data includes estimates for all six Kyoto gases from across all sectors of the economy, consistent with UN reporting guidelines. In addition, this year, we add a new level of disaggregation in our emissions from industry by including historical estimates for process and thermal emissions from cement production by country.

Total global emissions increased 4.6% in 2021 based on preliminary estimates

In 2021, as countries and economies began to reopen and recover from the worst of the COVID-19 pandemic, global GHG emissions bounced back, but not quite all the way to pre-pandemic levels. Based on our preliminary estimates, global emissions—of the six Kyoto greenhouse gases for all sectors, including land-use and forests as well as international bunkers—increased from 47.3 gigatons of CO_2e in 2020[1] to 49.5 gigatons in 2021 (Figure 1). This marks an increase of 4.6% from 2020 levels, getting close to but not fully rebounding from the 5% reduction caused by the COVID-19 pandemic in 2020. The 2021 rebound was driven in part by a rise in the carbon intensity of the economy.

[1] Changes in magnitude differ from previous versions of our estimates for global greenhouse gas emissions data due to methodological improvements to account for methane from coal mines, HFCs, and agricultural emissions.

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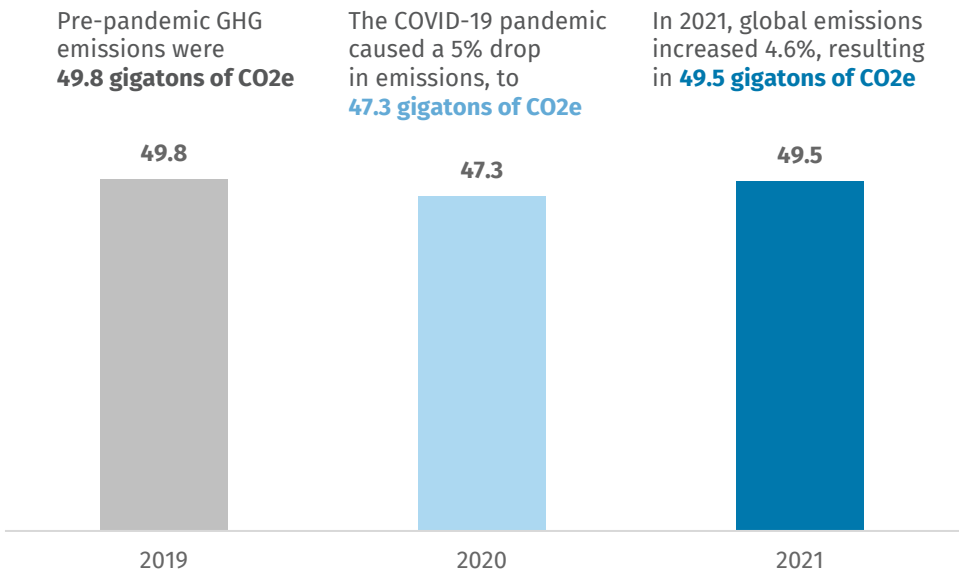
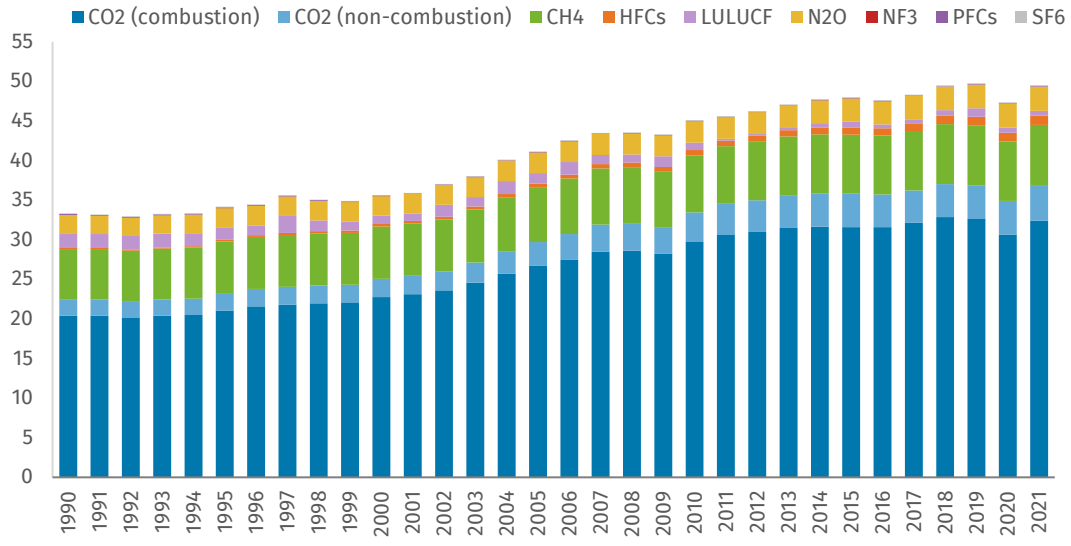
FIGURE 1
Preliminary estimates for 2021
Billion metric tons of CO_2e



Source: Rhodium Group

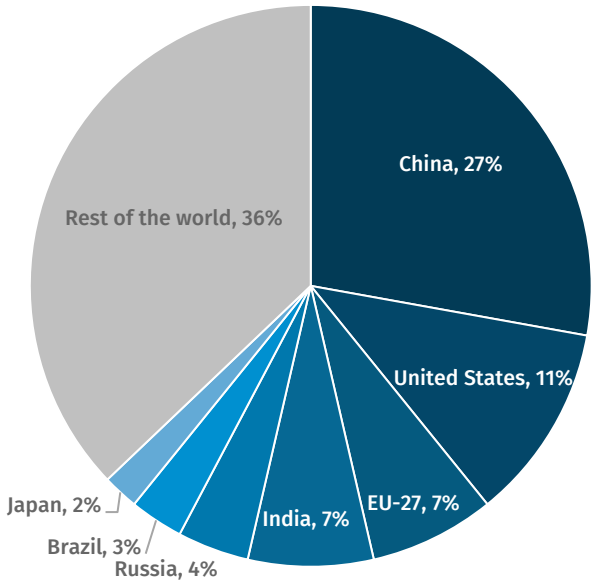
FIGURE 2
Global GHG emissions for 1990-2020 and preliminary estimates for 2021
Billion metric tons of CO_2e



Source: Rhodium Group

At the country level, nearly two-thirds of global emissions in 2021 came from only eight major economies (Figure 3). China remained the largest single-country contributor to global GHG emissions, with an overall share of 27% of global emissions, followed by the US at 11%, and the EU and India at 7%.

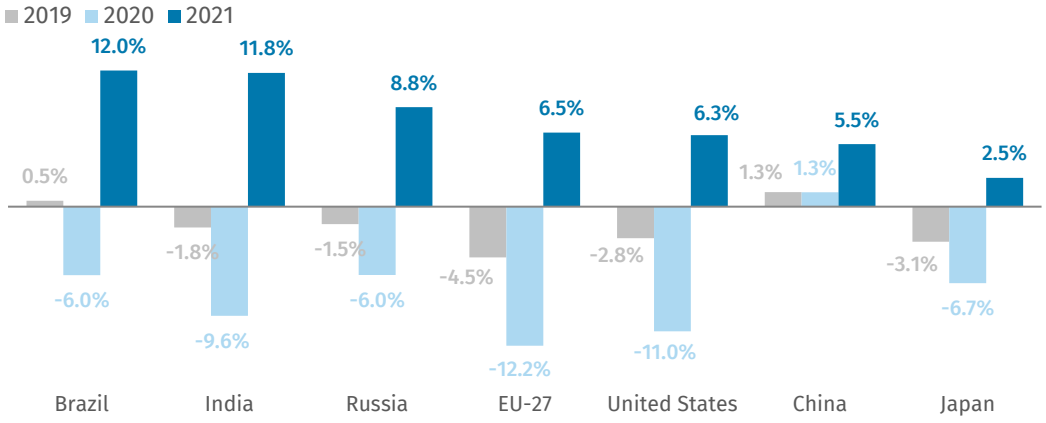
FIGURE 3
2021 net GHG emissions from the world's largest emitters
Percent share of global total



Source: Rhodium Group

CO_2 emissions from the combustion of fossil fuels increased in every major economy in 2021 compared to 2020 (Figure 4). In four major economies—Brazil, India, Russia, and China—emissions from fossil fuels rebounded above pre-pandemic levels in 2021. China, the only major economy where CO_2 emissions increased in 2020, increased its emissions again in 2021 by an estimated 5.5%. The most significant increase in CO_2 emissions from fossil fuels among major emitters was in Brazil, where emissions increased by 12% in 2021, compared with a 6% drop in 2020. Although emissions increased in both the US and EU-27 in 2021, by 6.5% and 6.3%, respectively, they did not fully reach pre-pandemic levels.

FIGURE 4
Change in annual energy CO2 emissions for the top emitters
Percentage change relative to the previous year



Source: Rhodium Group

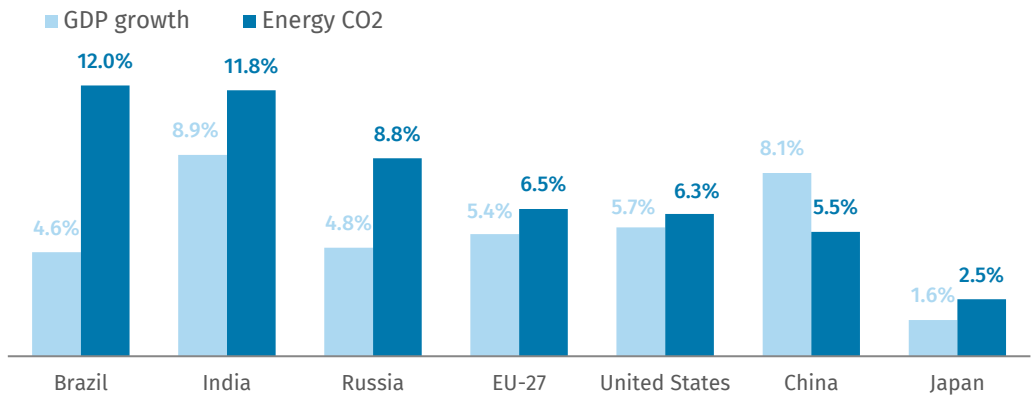
The major drivers of increased emissions in countries that bounced back to pre-pandemic levels differ across regions. Last year, Europe and Asia experienced a colder-than-average winter followed by a warmer-than-average summer, which increased the demand for coal and natural gas. Without a significant increase in supply, coal and natural gas prices rose around the world.

In India and China, where coal is cheaper than natural gas, coal consumption was the primary driver of their CO_2 emissions rebound in 2021. According to BP Statistical Review, coal consumption in dropped by 6% in 2020, but increased by 15% in 2021. In China, where coal comprises 66% of its fossil fuel consumption, coal consumption increased by 0.7% in 2020 and 4% in 2021.

Russia decreased its oil and natural gas consumption in 2020 (4.7% and 5.6 %, respectively) and rebounded with a 5.8 % increase in oil consumption and a 12% increase in natural gas in 2021. In Brazil, where 90% of its fossil fuels consumption comes from oil and gas, consumption dropped in 2020 (by 12% and 12.3%, respectively) and rose by 5.6% and 28% in 2021.

For every major emitter except for China, the 2021 rebound was driven by a significant rise in the carbon intensity of their economies, as fossil fuel demand rose faster than the economy as a whole. In Brazil, fossil fuel demand (and associated CO_2 emissions) increased nearly three times faster than GDP growth in 2021 (Figure 5). Similarly, Russia's CO_2 emissions grew 8.8%—nearly double the pace of overall economic growth (4.8%). India, where CO_2 emissions from fossil fuels increased by 11.8% in 2021, experienced an economic rebound of 8.9%. In the US and the EU, emissions increased roughly one percentage point higher than their economic growth. By contrast, China's CO_2 emissions from fossil fuels increased by 5.5%, while its economy grew 8.1%, driven primarily by the shift in consumption from coal to natural gas, a less carbon-intensive fossil fuel.

FIGURE 5
2021 energy CO_2 emissions and GDP growth
Percentage change relative to the previous year

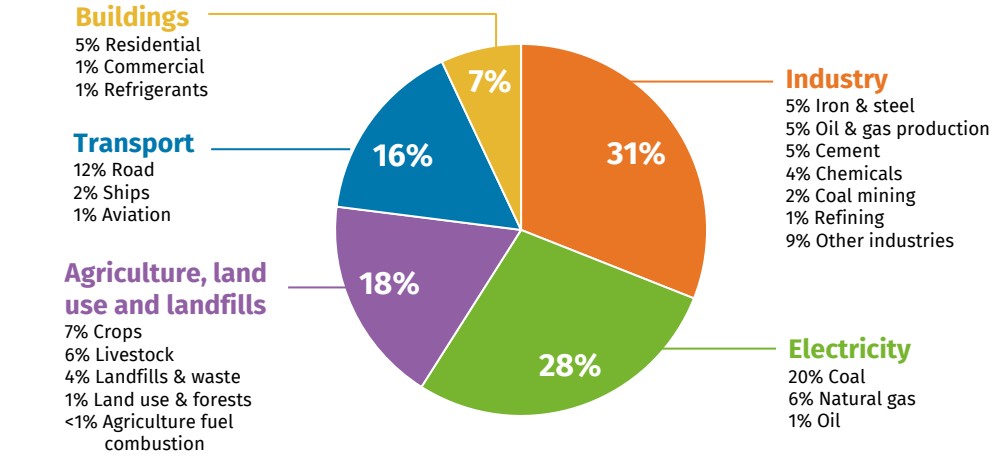


Source: Rhodium Group

Emissions by sector: Industry and electric power generate more than half of global emissions

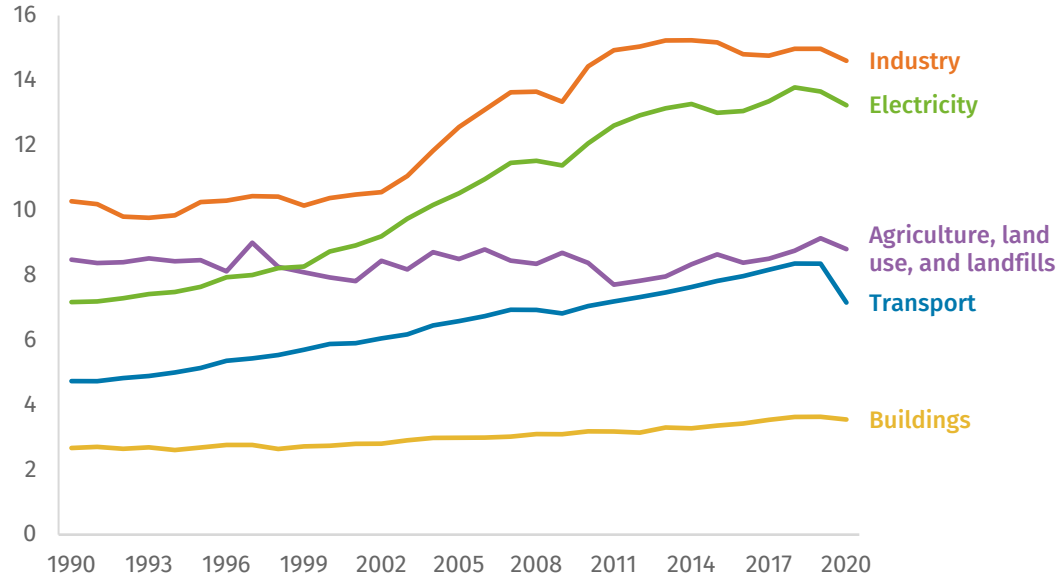
In 2020—the latest year for which there is sufficient data to provide sectoral level detail—industry remained the largest emitting sector, generating 31% of global emissions (Figure 6). Emissions from the electric power sector contributed 28% of global emissions, the vast majority of which came from coal combustion. Combined emissions from land use, agriculture and waste made up 18%, followed by transportation at 16% and buildings at 7% of the global total.

FIGURE 6
Global emissions by sector
Percent share of 2020 net GHG emissions



Source: Rhodium Group

FIGURE 7
Global GHG emissions by sector for 1990-2020
Billion metric tons of CO_2e



Source: Rhodium Group

All the data described here are available in Rhodium's ClimateDeck data platform. The ClimateDeck features GHG and energy data for all 190+ countries in the world and all 50 US states and provides users the ability 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.

Methodology

To estimate global and country-level GHG emissions, we take a bottom-up approach, which combines national inventories (where fully provided) with derived inventories (where national inventories are not provided or complete). For all Annex I countries, Rhodium's GHG estimates match those of official national inventory data from 1990-2020. For non-Annex I countries, we calculate derived inventories using a combination of national activity data (e.g. fuel combustion, industrial production) with sector- and fuel-specific emission factors. This method provides annual GHG emissions based on changes in socioeconomic activity at the country and sector level and is appropriate for tracking trends in emissions and emissions intensity over time.

In addition to our historical inventories, this year we also provide preliminary estimates for global emissions in 2021 for all countries. We estimate energy CO_2 using BP's 2022 Statistical Review of World Energy. For other gases, we estimate 2021 emissions based on relevant national activity and socioeconomic data.

Energy

To quantify country-level fuel combustion emissions, we source all Annex I countries' emissions from their most recent national emission reports to the UNFCCC (1990-2010). For most Non-Annex I countries, we derive our own estimates of energy-related emissions from IEA energy consumption flows (1990-2010) and IPCC emission factors. For 2021 estimates for all countries, we use growth rates derived from BP's 2021 Statistical Review of World Energy.

Not all Non-Annex I countries' energy consumption is accounted for in IEA's energy flows (i.e. there are 40-50 countries—mostly small-island nations and African countries—who consume a small amount of energy relative to the rest of the world, and whose aggregate annual emissions are less than 100 Mt CO_2). For these countries, we source emissions data from national reporting to the UNFCCC for available years and interpolate for years with no available data.

For fugitive emissions from oil and gas and coal mining, for most non-Annex I countries, we use IEA's database of world fugitive emissions (2022).

Industrial Processes

To quantify country-level industrial process emissions (non-combustion sources), we source all Annex I countries' emissions from the most recent national emission reports to the UNFCCC. We source Non-Annex I countries' non-CO_2 emissions from EPA (2019), and we derive their non-combustion CO_2 emissions based on fuel combustion emissions and production data by industry sub-sector.

This year, we calculate country-level cement thermal and process CO2 emissions. We follow the methodology specified by the IPCC guidelines, using USGS world cement production and clinker fractions from IEA.

Agriculture and Waste

To quantify country-level agriculture and waste emissions (non-combustion sources), we source Annex I emissions from UNFCCC inventories and non-Annex I countries' emissions from the UN Food and Agriculture Organization (FAO) (2021). Preliminary 2021 estimates are calculated using IIASA GLOBIOM 2021 projections.

Land-use and Forests

To quantify country-level land-use, land-use change and forestry (LULUCF) emissions and removals, we source Annex I countries' emissions from UNFCCC national emissions reports. We source Non-Annex I countries' emissions from FAO (2022).

For more information about the ClimateDeck, please email climatedeck@rhg.com.

Disclosure Appendix